Flexible work and personal digital infrastructures

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Abstract: As flexible work arrangements such as remote working or digital nomadism are normalized, the structure of work, performance expectations, and employee-employer relationships fundamentally change, presenting both benefits and risks for workers. Currently, the design and management of ICT systems for work is still geared towards 'standard' organizational settings and traditional forms of work. However, Personal Digital Infrastructures (PDIs) emerge as alternative sociotechnical infrastructures that can help workers realize the opportunities of flexible work while avoiding challenges of precarious work. Building on extensive empirical work, we present PDIs as consumerized, connective, adaptive, and temporally hybrid systems which reflect and reinforce multiple dimensions of flexibility: spatial, temporal, organizational, and technological. We provide implications on how the design and management of ICT systems for work can be made more amenable to the needs of flexible workers.

Introduction

Flexible, contingent or 'agile', working arrangements provide workers with greater autonomy over when, where, or how to fulfill their responsibilities. In search of increased productivity and reduced absenteeism, organizations have increasingly turned to flexible work arrangements. Although access to flexible work arrangements are more prevalent among high-skilled workers, in the form of flextime or co-working, the past decade has also witnessed growth of independent contractors, flextime, digital nomadism, digitally-enabled crowdwork, online freelancing, and 'on-demand' platform labor[1].

Flexible work arrangements reduce commutes and can enable workers with care-responsibilities to stay in the workforce. Additionally, younger workers see flexibility as a top priority when considering career opportunities[2]. Flexible working arrangements can also be mutually beneficial, enabling organizations to scale dynamically. Specific skill sets can be accessed immediately by turning to freelancers to fill organizational gaps. A growing number of organizations and workers rely on short-term and project-based relationships, using online platforms such as Upwork or Fiverr to connect. However, flexible work arrangements often come entwined with precarity cloaked in emancipatory narratives[3]. Fixed salaries and benefits have given way to hourly rates and quantified ratings. Flexible workers frequently face unpredictability and uncertainty as they carry more risk, more responsibility, and are burdened with a great portion of administrative costs (i.e., overhead) associated with organizational support systems[4]. Flexible workers at Google, for instance, outnumber full time workers but face far more unpredictability[5].

Current formulations consider organizations as relatively fixed 'containers', which encapsulate the work performed and the ICT systems used to perform it [6]. However, flexible work arrangements take place outside of organizational containers. In this new sociotechnical dynamic, flexible worker interacts with a diversity of digital tools that defy centralized, top-down standardization or governance.

We capture this diversity of digital tools through the concept of Personal Digital Infrastructures (PDIs). PDIs denote an individualized assemblage of tools and technologies such as personal laptops,

smartphones, cloud services, and applications brought together by workers to perform their work tasks. Yet, flexible workers constantly reconfigure their PDIs as the technology landscape, client-relationship, and task requirements shift. For flexible work arrangements to be mutually beneficial, PDI integration in ICT systems for work is increasingly necessary, beyond a narrow focus on enterprise systems supporting standard work.

Our collective research on flexible work arrangements indicates that PDIs present non-trivial challenges, but a more effective design of ICT systems for work can facilitate the integration of these bottom-up infrastructures. The nuanced understanding of PDIs presented here, highlights their interplay with flexible work arrangements across key dimensions (spatial, temporal, organizational, and technological) and suggests key priorities for technology and platform developers.

Methods

These findings are based on 170 semi-structured interviews with flexible workers conducted between 2015 and 2019. This number included 11 digital nomads, 37 remote knowledge workers, 51 online freelancers (e.g., Upwork and Fivver), and 71 other types of on-demand workers (ride hailing, food delivery and task work). Participants' average age was 35. 104 were male and 66 were female. 107 resided in the US and 63 in Europe (Norway, Sweden, UK and Netherlands), including diverse nationalities and immigrant workers, particularly from India. Interviews were conducted both in person or online (over the phone or on Skype/WhatsApp/GotoMeeting). Our analysis highlighted a large diversity of tools and technologies for work used by the participants. Examples included digital labor platforms, personal laptops, mobile devices such as cell phone or tablets, applications such as Asana, Google drive, Google maps, and Zapier reflecting varying needs

Flexible Work Dimensions

Even though flexible work environments are becoming more common, our findings reveal a general mismatch between the dynamic requirements of flexible work arrangements and the current technological landscape. Workers often have to go to great lengths to configure PDIs to fit their needs. Designing more effective PDI necessitates a more nuanced understanding of the requirements of flexible work arrangements.

Not all flexible work arrangements are flexible in the same way. As a useful framework for understanding the intersection of technologies and flexible work, we propose that flexible work arrangements diverge from standard work arrangements along three key dimensions: 1) organizational attachment (the extent to which workers are under the control of the organization); 2) temporal attachment (the extent to which workers are employed long-term by one organization); and 3) physical attachment (the extent to which workers are in physical proximity to the organization) [7]. Our collective research suggests that flexible work also diverges along a fourth dimension: technological flexibility, referring to the extent to which workers are able to self-curate their own personal digital infrastructure (PDI) to support their work. These flexibility dimensions are not mutually exclusive and flexible workers often operate across multiple dimensions. Table 1 summarizes the four dimensions, documenting the role of the current technological landscape in enabling and constraining different dimensions of flexible work environments.

Table 1 is also helpful for understanding the nature of flexibility since flexible work arrangements render workers less dependent on organizations. However, labels such as remote working or flex timing do not fully capture the complexity of flexible work[8], and hence are a poor basis for design of PDIs and can lead to confusing, even abusive, employer-employee relationships.

Dimension of flexibility	Definition	Common examples of work arrangements presenting flexibility dimension	Examples of supporting digital technologies	Examples of technological constraints
Spatial flexibility	The extent to which workers can detach themselves from specific locations and workspaces	Nomadic work	• Portable computational equipment; • Non geo-restricted access to systems; • Adequately reliable and affordable Internet connectivity; • Access to charging stations and/or long battery life	• Fixed computational equipment • Geo- restricted access to systems • Lack of access to reliable or affordable Internet connectivity • Lack of access to charging stations and/or low battery life
Temporal flexibility	The extent to which workers can detach themselves from specific work schedules	Temporary work; Part-time work; Flextime	• Complex time and task management systems • Personal cloud services (e.g., Google drive); • Asynchronous Communication platforms and norms	• Blurring of work-life boundaries • Digital distractions; Inflexible time and task management systems
Organizational flexibility	The extent to which workers can detach themselves from organizations' administrative control	Gig work; Contract work; Freelance work	• Digital labor platform; • Bespoke employment/engagement contract. • Digital accounting mechanisms • Community-developed add-ons and plug-ins (e.g., scripts)	• Policies restricting the external use of enterprise systems • Technical management norms
Technological flexibility	The extent to which workers can self-curate the infrastructure that supports their work	All types of flexible work arrangements	• Ownership of personal IT (e.g., personal devices and cloud); • Systems that operate across platforms and devices	• Lack of interoperability of enterprise applications/ task management software/file formats

Table 1: Different dimensions of flexible work environments

Each dimension of work flexibility presents workers with both opportunities for and challenges to their autonomy, efficiency, and effectiveness. It is these opportunities that PDI technologies must magnify and mitigate.

Spatial Flexibility

Spatial flexibility refers to the extent to which workers can detach themselves from specific locations and workspaces.

Opportunities: The ubiquity of networked infrastructures allow flexible workers to be increasingly mobile. Modern norms of digital communication have created an environment where workers can be reached just as quickly half a world away as they can be in the next office. Our research participants who worked primarily online could 'get to work' wherever they were, though sometimes bound by geo-restrictions in terms of which tasks they could fulfill. Spatial flexibility was characterized by being able to work from home, but participants would still utilize extra-domestic spaces such as co-working spaces, hotel rooms, and coffee shops. More pervasive cellular network coverage also contributed to the possibility of working remotely or on-the-move. Several participants had embraced this opportunity, becoming 'nomadic', traveling long distances and even setting themselves up wherever a stable internet connection was available. Self-identifying global digital nomads are the best examples of high spatial freedom unleashed by digital connectivity.

Challenges: Spatial flexibility is, however, challenging as workers have to constantly navigate and prepare for unpredictability of new and changing work environments. For example, spatial flexibility is often stymied by the lack of an adequate or reliable Internet connection or charging station. Although the stereotype of the coffeeshop nomad holds true, workers face potentially high and unforeseen overhead costs in negotiating continued access to workspaces and essential information infrastructure. One participant noted: "The biggest kind of uncertainty is that I can't guarantee there will be a strong connection when I do go to coffee shops." The cost of co-working spaces can eat up much of the financial profit gained from remote work. As a result, for high-intensity digital work, such as semantic sequencing or video editing, most profits go to workers with stable and highly ergonomic home-office set-ups rather than those working remotely and using mobile devices[9].

Temporal Flexibility

Temporal flexibility refers to the extent to which workers can detach themselves from specific work schedules.

Opportunities: Temporal flexibility ranges from workers setting their 'working hours' more flexibly within a defined set of parameters (i.e., flextime), to workers having complete freedom in choosing when and how long to work (i.e., creative freelance work). In both cases, digital task and time management systems aided this temporal flexibility among our participants, who employed a variety of tools in parallel to manage fluid temporal work rhythms. Communication platforms such as Slack, afforded temporal flexibility in communicating with peers, asynchronously and across time zones. Personal cloud services such as Google Drive or Dropbox also enabled flexibility in creating, accessing, and manipulating information across time. Those affiliated with larger organizations also used independent cloud services as the shared repository of asynchronous collaboration, in tandem with enterprise resources.

Challenges: Temporal flexibility requires high-trust levels from an organization and/or high-autonomy for workers. Temporal flexibility is also relatively incompatible with traditional micro-management styles or

with time-sensitive tasks. One of the most prominent challenges that our participants faced was the conflation of personal and work times. A participant puts this succinctly: “When you’re in your office, people assume you’re in the office, you’re available. You’re out of the office, maybe not as available. And now technologies made [us] available 24/7. People think, ‘Wait a minute, I sent you an email. Why didn’t you respond?’” Mobile technologies have rendered the boundary between the two spheres even less distinct and being able to work at any time increases pressure to be ‘always on’ and always available to respond to messages. Communicative affordances such as read receipts or the ‘seen’ function in messaging, means that workers face a pressure to respond immediately.

Organizational Flexibility

Organizational flexibility refers to the extent to which workers can detach themselves from organizations’ administrative control.

Opportunities: Along with changing norms of work, such as project-centrism, flexible workers can find and execute projects on a global scale by using digital labor marketplaces facilitated by online platforms. Online labor platforms provide key facilitators of organizational flexibility through mechanisms digital escrow, digital accounting software and digital contracting. Through manual selection or more complicated algorithmic matchmaking mechanisms, these platforms lower transaction costs for the service recipient (increasingly an enterprise) and the worker. More open platforms, such as Upwork, enable workers to pick and choose clients based on their own preferences. Several of our research participants left standard work arrangements and became dedicated freelancers because they saw the diversity of projects and tasks offered by online freelancing platforms as a source of learning and raising social capital. Without a formal employment contract, workers can engage in multiple projects and organizations can decide about which contracts they want to take. For instance, one of our US-based participants forwent full-time employment, a steady revenue stream and health insurance benefits (as a cancer survivor), because he found working on a large number of system administration projects from different organizations a more fulfilling learning experience than being attached to a single firm with limited diversity of technical challenges.

Challenges: On the other hand, ‘gig economy’ platforms such as UberEats and Deliveroo, provide algorithmic matching mechanisms between clients and workers, but provide limited choice over which micro-contracts to take and limited organizational information (such as total length of delivery) which might enable workers to choose their tasks more profitably. Indeed, even though flexible workers may enjoy a higher administrative flexibility, they may find their work to be fraught with different restrictive policies or requirements set by the organizations. For example, a participant described his work laptop as “locked down” as he “can’t use any type of Google platform, can’t use Skype, and can’t use any Open Source, because it’s [considered to have] security issues” by the employer. Along the same line, several participants noted how installing applications on the work laptop, or a smartphone is not possible without going through a tedious bureaucratic process. Therefore, workers in these settings can usually be subject to the restricted work systems imposed from above. Without careful design, the same systems that enable greater flexibility, can also be used to increase technical managerial control and restrict worker autonomy [10].

Technological Flexibility

Technological flexibility refers to the extent to which workers can self-curate the infrastructures that support their work. Technological flexibility represents the convergence of multiple technological paradigms, such as consumerization, the proliferation of smart mobile devices, and the platform economy.

Opportunities: Our research makes it clear flexible work is largely enabled by technological flexibility. Personal digital tools have penetrated the workplace, and many of our participants enjoyed a high level of flexibility in bringing their own devices to work, a trend which is captured through Bring Your Own Device (BYOD) programs and IT individualization. The ability to select their own work tools, rather than being picked and imposed by the employer, help workers create PDIs that are tailored to their needs and dynamic work environment.

Challenges: On the flip side, the diversity of tools used by flexible workers can result in a lack of interoperability between various platforms, systems, and file types. Whereas Apple Macbooks are preferred tools among workers with creative and design tasks, their lack of interoperability with Windows-based systems and software creates many problems. Even small details such as missing fonts, or graphic packages can create adversarial scenarios, lost income and client-dissatisfaction for these workers. Several of the research participants, for instance, who use Gmail do not want to integrate Google Drive for cloud storage. A participant noted, “I use Google Drive, mostly because Google kinda forces you to use Google Drive.” Another lamented, “I’m having trouble with making all the technologies work. Google wants to take over. It wants Google Calendar to be your calendar.” Since platform organizations impose their dominance, cross platform coordination becomes difficult for workers who wish to take advantage of technological flexibility.

Characteristics of Personal Digital Infrastructures (PDI)

PDIs are strategies employed by flexible workers to realize the opportunities and mitigate the risks that come with flexible work arrangements. Workers, whether flexible or not, will selectively use some digital tools and devices more than others, configuring these sociotechnical systems to support largely individual, creative, operationally resilient, and problem-driven work [11]. In what follows, we discuss the characteristics of PDIs which enable them to play this complex enabling role for flexible work.

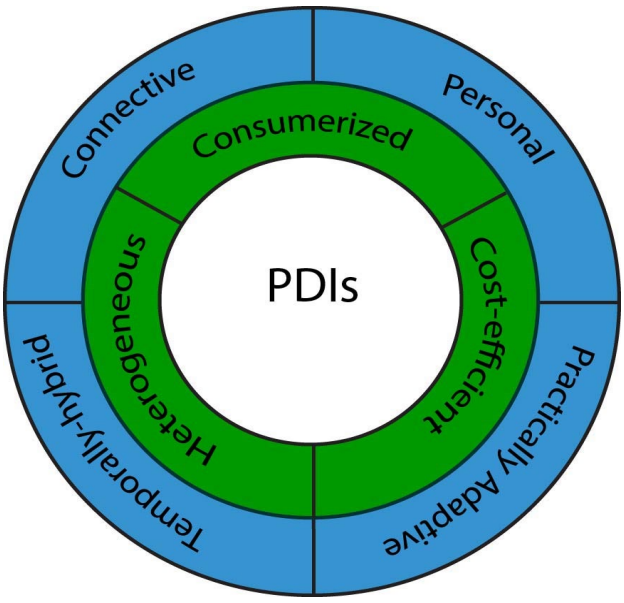

Figure 1: Technological and social layers of PDIs

PDI Technological Layer: Heterogeneous, Consumerized, and Cost-Efficient

PDI's build on fundamental technical characteristics of heterogeneity, low-fixed cost, and technology consumerization to create the conditions for realizing the benefits of flexible work arrangements. To achieve technological flexibility, PDIs are heterogeneous and involve ensembles of personal, consumer-based devices, end-user tools, digital platforms, and ubiquitous infrastructures (e.g., local WiFi networks). Yet, such digital technologies are often not owned by an organization, even if the worker is affiliated with a larger organization. Rather, our research participants built on what is available in the consumer technology market to remain versatile and retain control over the parameters of their work. The cost of purchasing and maintaining such devices, however, falls on the worker and can generate problems in instances of interoperability and reduced device security. Our participants were cognizant of these costs and had to find strategies to keep them under control. As a freelance journalist, one participant managed to use Dropbox for free (beyond the normal capacity of free accounts): “through absolute pure stinginess to avoid paying for Dropbox, I do everything they offer to keep bumping up my limit, and the latest thing was if you store your photos on Dropbox we’ll give you an extra 3 gigs. So I said sure.”

PDI Social Layer

Building on the foundational technologies, PDIs are connective, adaptive, and temporally hybrid sociotechnical systems, reflecting and reinforcing multiple dimensions of flexibility.

Connective

While the heterogeneity of digital technologies enables workers to adapt to the diverse needs of flexible work environments, this diversity simultaneously creates a key challenge: lack of interconnection and interoperability among various technologies and competing consumer-based ecosystems (e.g., Microsoft vs. Apple). Therefore, to effectively support work practices that often stretch multiple tools, PDIs connect various ecosystems and enterprise information systems, often through gateway practices (activities that bring together competing systems), VPNs, or integration tools such as Zapier or IFTTT. Some of this work is done manually, requiring extra work on the part of the workers. For example, one participant receives new legal cases from clients through an organizationally-sanctioned document management service called NetDocuments. However, in order to use his preferred cloud-based document management system (Box.com), he downloads and manually uploads each case separately.

Personal

Flexible workers often enjoy higher organizational flexibility and therefore assemble collections of digital resources from personal, public and corporate elements based primarily on personal preferences. PDIs reflect personal and specific work situations, and the worker is personally responsible for making these collections of technology function. As such, our participants may dedicate great efforts to maintain PDI, and have to rely on personal learning and development, rather than receiving dedicated training [1]. This often requires a great deal of experimentation and situated learning. For example, a web developer in our sample figured through trial and error that he could leverage inflight WiFi without having to pay for it. He is able to develop applications while his computer could still communicate with the client company’s development server.

Temporally Hybrid

Due to temporal flexibility, PDIs often span the personal and professional lives of flexible workers. Using personal devices and tools for work may often result in the intrusion of work contacts and projects into personal IT systems. For most participants it was difficult to demarcate between tools and services that define and support personal and work-related uses. For instance, participants used social media messaging systems, such as WhatsApp, to communicate with friends, family, clients, and former clients. The result has been a changing temporal rhythm of work that has further blurred the line between personal time and work. In response to these challenges, some participants have adopted specific strategies and tools to impose boundaries. They may use time management tools and offline working hours to demarcate between work and personal life, or to avoid digital distractions. For example, some had to clarify to their collaborators and clients that they would not reply to emails or messages after a certain time, even though they are on a flexible work schedule. A participant clearly communicated to work-related contacts: “I never check my email after 6 pm” or another has told clients when she is traveling, “I’m not available. I won’t be responding.”

Practically Adaptive

PDIs are organizationally adaptive. While operating in a liminal space between different organizations and projects, participants often have to accommodate the differing, sometimes contrasting, technological requirements of multiple client organizations, projects, and collaborators. These workers are often cognizant of organizational constraints as they directly impact their technology practices, and they make sure their PDIs also connect with others to support collaborative information sharing, serving not just as individual resources but also collective infrastructures. A couple of participants highlighted restricted access to clients’ enterprise information based only on specific IP addresses (in clients’ offices or predetermined locations). They, however, often used workarounds, such as emailing the documents to themselves so that they had the flexibility to work on information resources outside of the designated locations.

PDIs are also locally adaptive. Flexible workers may work from different places or even on the move. Therefore, an awareness of local infrastructures enables workers to ensure digital connectivity, which is a central element of digital work. Spatial mobility may sometimes require physical effort and planning for technological use across different spaces. For example, a highly mobile worker in our sample used WiFi Analyzer applications to gauge the available networks in a neighborhood and assess their relative signal strength before choosing a public place to work. Others would carry assemblages of devices such as external batteries, power splitter or USB-powered firewall (that provides a secure use of WiFi) to create reliable mobile digital offices in different locations.

Implications

In what follows, we detail ways that organizational system design and management can help redress the precarity of flexible work by reinforcing benefits of flexible work and ameliorating its challenges. In doing so, we emphasize the need for better integration and facilitation of personal digital infrastructures (PDIs). This helps organizations, workers, and platforms navigate the consequences of flexibility and better support the PDIs that underlie effective and sustainable contingent work arrangements.

Integration of PDIs in work systems

Flexible workers, across different capacities, must dynamically relate their PDIs with traditional managerial structures and processes such as allocating, evaluating and coordinating work. Since PDIs are assembled by workers in a bottom-up fashion, replication of traditional expectations would curb key dimensions of flexibility. Rather, organizations must meet their flexible workers half-way, by tolerating and facilitating technological diversity. Organizations need to identify priority points where technological cohesion among the workforce is essential, such enforcing universally readable file types or requiring certain smartphone operating systems. On-demand delivery platforms, for instance, require that workers' smartphones have functional GPS, sufficient mobile data and battery, and can support the latest worker-facing App updates[12]. On the other hand, organizations must also identify where technological cohesion is not essential but merely desirable, since our findings indicate that workers not provided with enough technological flexibility may resort to tedious workarounds or even to sabotage of formal work systems.

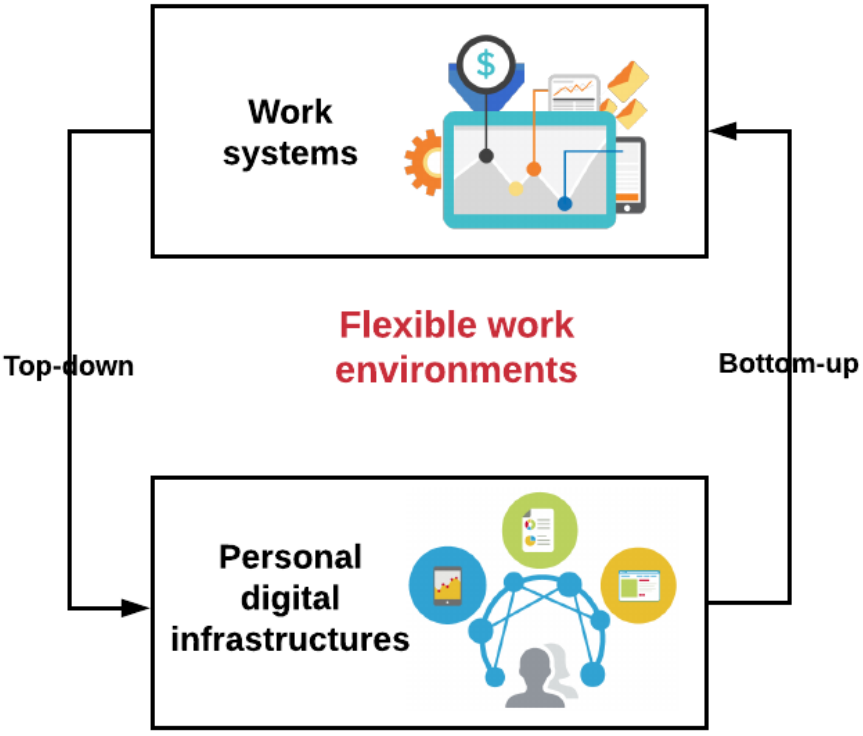

Figure 2: Flexible work environment shaped at the interplay between work systems and PDIs

Flexible work takes place in a hybrid space shaped by both work systems and PDIs (see Figure 2). Flexibility inexorably creates more complexity, and a higher need for negotiation and transparency. In an optimal approach, both employers and workers negotiate the top-down influence of work systems against the bottom-up force of PDIs. Through these negotiations, organizations can assure their goals are fulfilled and workers could meet their needs. PDIs enable workers to draw on systems that can be generative to diverse and flexible uses. Platform designers and managers of systems for work need to recognize PDIs as infrastructure of flexible work as workers strive to bring in their own personal technologies while firms seek to balance these uses against the need for an integrated and secure system that serves as the backbone of the organizational processes and meet regulatory and compliance rules. Via negotiations, expectations of both parties should be made clear. For example, workers need to know the boundaries for flexibility and non-negotiable areas so they can act upon it in enacting PDIs.

Tools that facilitate a more cohesive integration of PDIs into work systems help both workers and organizations control and manage projects while relating personal flexible routines. Integrative management platforms, for example, can help flexible workers smoothly navigate and work across personal data and enterprise resources. Such a platform provides versatile privacy configurations by dynamically learning what data should be shared with the organization for effectively managing work projects or kept on the worker's personal storage systems (locally or personal clouds) to provide the worker certain freedoms and autonomy.

Beyond the integration of flexible PDIs, enterprises must also facilitate flexible participation. Even though flexible workers occupy a dynamic relationship with enterprises and enterprise work systems, many of these systems are designed for standard, full-time employees and evidence still points to the invisibility of this workforce [5]. The design of these systems has to be mindful of a contingent, agile workforce that can scale up on-demand and dynamically facilitate plug-and play type participation (e.g., connecting with or disconnecting from certain enterprise resources). In addition, these systems must provide greater flexibility for remote, flexible access; something that has become even more paramount during the Covid-19 pandemic.

Facilitating construction and uses of PDIs by flexible workers

Flexible work is a largely independent pursuit and constructing complex PDIs is often done by each individual worker. However, community support and collective learning can complement centrally-provisioned organizational support (e.g., help desk support). Organizations can expand the scope of support towards a hybrid model by encouraging community-based support, which work in concert with formal IT support. Traditional firms, as well as digital on-demand platforms, can contribute to building collaborative structures through which workers help each other. Furthermore, the design and management of systems can promulgate community-based learning, which stands in contrast to the implicit design of many on-demand platforms that discourage workers' community building activities. Flexible workers can greatly benefit from connecting with other workers who go through similar challenges (e.g., securing the most profitable hits on Amazon Mechanical Turk; and most effective ways of presenting skills on Upwork profiles). An example of such community-based systems is turkopticon[1], a browser plugin, which enables MTurkes to provide mutual aid by sharing reviews of individual employers.

Another key challenge PDIs is spatial constraints. Workers often have to go to great length to make PDIs locally adaptive. Spatial flexibility often requires workers to grapple with spatial constraints such as a lack of access to information or tools held centrally and the need to navigate multiple contextual barriers that stem from their work over unfamiliar territories. System design therefore needs to be mobility sensitive and strive to mitigate these challenges in creation and use of PDIs. One example would be a Firewall and VPN that provides secure WiFi connections in public locations. Non-technological strategies that facilitate mobilizing the workforce can focus on providing local resources for more geographically mobile workers by, for example, partnering with local co-working spaces across different cities to ensure productive work environments and reliable infrastructural access.

[1] https://turkopticon.ucsd.edu/

Conclusion

PDIs are of growing importance to all workers, but especially workers who must adopt and adapt practices to enable multi-axial modes of flexibility. The state of research and practice relative to the design and management of ICT for work largely focuses on one of the two extremes -- either the organizationally embedded work technologies or the individually-used consumer technologies. Addressing the needs of flexible workers and organizations using flexible work arrangements will necessarily require research, development, and deployment of PDIs that bring these two models together in a way that helps all parties realize the opportunities and challenges of flexibility. To avoid exploitative forms of precarious work, PDIs must provide adequate benefits for employees and employers while mitigating the risk. Yet, by helping organizations and workers navigate the conflicting consequences of flexibility, the design and management of digital infrastructure can support the emergence of new effective, sustainable work arrangements and PDIs that undergird these arrangements.

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