

# Flexible work and personal digital infrastructures

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## Abstract:

As flexible work arrangements such as remote working or digital nomadism are normalized, foundational aspects in the structure of work and employee-employer relationships are altered, offering both benefits and risks for workers. The state of research and practice relative to the design and management of ICT for work is still geared towards 'standard' organizational settings. This article advances the concept of flexible work as an 'alternative work' arrangement by focusing on multiple dimensions of flexibility. It further directs attention to digital infrastructures as they reflect and reinforce the work arrangements they are created to support. Unlike the enterprise information systems designed to support traditional forms of work, Personal Digital Infrastructures (PDIs) are primary computational systems that undergird flexible work arrangements. This article presents key characteristics of PDIs as consumerized, connective, adaptive, and temporally hybrid sociotechnical systems, and provides multiple implications on how the design and management of digital infrastructures can be made more amenable to the needs of flexible workers. To avoid exploitative forms of precarious work, PDIs must provide adequate benefits for employees and employers while mitigating the risk.

## 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 turned to flexible work arrangements increasingly. 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 witnessed growth of independent contractors, flextime, digital nomadism digitally-enabled crowdwork, online freelancing, and 'on-demand' platform labor <sup>1</sup>. This has been particularly the case in the wake of the COVID-19 outbreak, which has resulted in an unprecedented reliance on remote work.

Individuals adopting flexible work arrangements often associate it with freedom from organizational politics, and higher social capital. Such arrangements, for example, can reduce commute times and enable workers with care-responsibilities to stay in the workforce. Additionally younger workers see flexibility as a top priority when considering career opportunities <sup>2</sup>.

Flexible working arrangements can be mutually beneficial, permitting organizations to dynamically scale. 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. Because of this, flexible workplaces have become a dynamic market of skills and needs, with employers and workers viewing one another through a transactional lens.

Flexible work arrangements, however, often come at the price of precarity. Fixed salaries and benefits have given way to hourly rates, quantified ratings, and emancipatory narratives. Flexible workers frequently face unpredictability and uncertainty. Workers carry most of the risk, more responsibility, and are burdened with administrative costs (i.e. overhead) associated with organizational support systems <sup>3,4</sup>. In the absence of organizational support systems, workers have to craft their own career trajectories, technical infrastructures, and rely on their own skills and networks to secure projects.

These work arrangements are enabled by Personal Digital Infrastructures (PDIs), an assortment of tools such as personal laptops, smartphones, cloud services and applications. Differing significantly from enterprise information systems designed for traditional, standard forms of work, PDIs can be understood as consumerized, connective, adaptive, and temporally hybrid sociotechnical systems.

Models informing the design of organizational ICT systems are still largely grounded in the practices of 'standard' employees in 'standard' work arrangements <sup>5</sup>. Current conceptualizations consider organizations as relatively fixed 'containers', which encapsulate the work performed and the ICT used to perform it <sup>6</sup>. However, the nature of flexible work and the use of PDIs takes place outside organizational containers; individual technology use does not fit neatly within conventional notions of how organizational ICT systems are adopted. In this new sociotechnical dynamic, flexible workers deal with the challenges of their work by interacting with a large diversity of digital tools that defy centralized, top-down standardization or governance. While digital technologies enable work flexibility and autonomy, they also pose challenges that may undermine flexible work by adding to its precarity and vulnerability. These challenges may require workers to develop strategies to adapt and configure the technology to work flexibly and independently.

Skilled workers in more autonomous working environments can generate and curate their own PDIs to make flexible working arrangements work to their benefit. However, this involves 'articulation work,' the critical activities beyond core work tasks that must be performed to enable core work <sup>7</sup>. In this case, workers must invest additional effort to ensure that they have all the digital tools necessary, notwithstanding the required access to and upkeep of physical computing machinery. However, workers in precarious work settings on many on-demand platforms, are usually subject to the PDIs imposed from above. Rather than enabling greater flexibility, such PDIs are levied to increase technical managerial control and restrict worker freedoms <sup>8</sup>.

Building on our years of research and 170 interviews with remote workers, digital nomads, online freelancers, crowdworkers and independent contractors, we provide a nuanced definition of the concept of work flexibility, its key dimensions, and how it is supported by PDIs.

## Flexible Work Dimensions

Flexible work arrangements render workers less dependent on organizations (spatially, temporally, and administratively). As such, flexible work diverges from traditional, standard work arrangements along three dimensions: 1) organizational attachment (the extent to which workers are under the control of the organization); 2) temporal attachment to the organization (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) <sup>9</sup>. Our

findings suggest that flexible work also diverges along a fourth dimension: infrastructural flexibility, whereby workers are able to self-curate an assemblage of digital technologies to support their work. Table 1 summarizes the four dimensions in greater detail. These dimensions are not mutually exclusive and flexible workers often operate axially across multiple dimensions. For example, the work of digital nomads often embodies all the four dimensions of work flexibility.

<b>Dimension of flexibility</b>	<b>Definition</b>	<b>Examples of work arrangements presenting flexibility dimension</b>	<b>Examples of supporting digital technologies</b>	<b>Examples of technological constraints</b>
<b>Spatial flexibility</b>	The extent to which workers can detach themselves from specific locations and work spaces	Remote work; 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
<b>Temporal flexibility</b>	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
<b>Organizational flexibility</b>	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
<b>Infrastructural flexibility</b>	The extent to which workers can self-curate the infrastructure that support 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

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**Table 1: Different dimensions of flexible work environments**

## **Spatial flexibility**

The ubiquity of networked infrastructures today means that flexible workers are increasingly mobile, expanding the potential spaces where work is conducted. Modern norms of digital communication have created an environment where workers can be reached just as quickly in the next office as they can be a half a world away. Depending on the work-modality, workers can ‘get to work’ with minimal requirements assuming they’re not bound by geo-restricted systems. For many workers, spatial flexibility is characterized by being able to work from home, but increasingly, common spaces such as co-working spaces, hotel rooms, and coffee shops are associated with flexible work arrangements. More pervasive cellular network coverage, in particular, has contributed to the possibility of working remotely. Many workers have embraced this opportunity, becoming ‘nomadic’, traveling long distances and setting themselves up wherever a stable internet connection is available.

Spatial flexibility is, however, 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, as well as much articulation work, in negotiating continued access to a workspace, or information infrastructure. The cost of access to co-working spaces, for instance, can eat up much of the profit gained from remote work. Moreover, for high-intensity microwork, most profits go to workers with stable and highly ergonomic home-office set-ups rather than those working remotely and using mobile devices<sup>10</sup>.

## **Temporal flexibility**

Temporal flexibility ranges from workers shifting their set ‘working hours’ more flexibly within a defined set of parameters (flextime practice observed more frequently in standard work settings), to workers having complete freedom in choosing when and how long to work (as exemplified by creative freelance work). In both cases, complex task and time management systems enable workers to achieve temporal flexibility. Workers typically employ a variety of tools in parallel to manage a fluid temporal work rhythm. For example, Google Drive offers flexibility in creating, accessing, and manipulating information across time. Asynchronous communication platforms such as Slack, also affords workers temporal flexibility in communicating with peers (even across time zones).

Yet, temporal flexibility requires either high-trust levels from an organization, or high-autonomy for workers. Temporal flexibility is relatively incompatible with inflexible and technical management styles, or with time-sensitive work norms. One of the most prominent challenges is the conflation of personal time and work time. Mobile technologies have rendered the boundary between the two 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**

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. 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. Digital contracting, mediated through online platforms, and digital accounting software are key facilitators of organizational flexibility.

On the other hand, more closed '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, such as close geo-spatial monitoring.

### **Infrastructural flexibility**

Flexible work is not a new phenomenon. However, the advent of digital technologies has rendered flexible work more central within labor markets and among more high-skilled work. Flexible work is largely enabled by the convergence of multiple technological paradigms, such as technology consumerization, the proliferation of smart mobile devices, and the platform economy. In particular, personal tools have penetrated the workplace, and flexible workers typically enjoy a high level of flexibility in bringing their own devices and tools to work, a trend which is captured through Bring Your Own Device (BYOD) programs and IT individualization.

On the flip side, the diversity of tools used by flexible workers can result in a lack of enterprise interoperability between various platforms, systems, and file types. Whereas Apple Macbooks are preferred tools for creative and design work, their lack of interoperability with more standard Windows-based systems and software can create many problems. Even small details such as missing fonts, or graphic packages can create adversarial scenarios and potentially lost income and client-dissatisfaction for flexible workers.

## **Characteristics of Personal Digital Infrastructures (PDI)**

Many workers, whether flexible or not, will enact a Personal Digital Infrastructure (PDI),

selectively using some digital tools and devices more than others. However, flexible workers also bring together PDIs to enable flexibility along different dimensions, as noted above. They configure these sociotechnical systems to support largely individual, creative, operationally resilient, and problem-driven work <sup>11</sup>. In what follows, common characteristics of PDIs in the context of flexible work are introduced.

## **Consumerized**

To achieve infrastructural flexibility, PDIs involve ensembles of personal, consumer-based devices, end-user tools, digital platforms, and ubiquitous infrastructures (e.g., local WiFi networks). Yet, many such digital technologies being used for work are not owned by an organization, even if the worker is affiliated with a larger organization. Flexible workers increasingly build on what is available in the consumer technology market. Drawing on consumer market technology ensures versatility and flexibility of work practices. Workers can quickly bring in and adopt the latest technological options that can support flexible temporal and spatial work practices. However, the cost of purchasing and maintaining such devices falls on the worker and can generate problems in instances of interoperability or reduced device security and privacy.

## **Connective**

While heterogeneity among digital technologies enables workers to adapt to the diverse needs of flexible work environments, this diversity simultaneously creates a key problem: 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 stretch multiple tools, PDIs have to 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.

## **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, flexible workers may dedicate great efforts to articulation work, and have to rely on personal learning and development, rather than receiving dedicated training <sup>1</sup>.

## **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 workers, based on the empirical data collected, it was difficult to demarcate between tools and services that define and support personal and work-related uses. For instance, social media messaging systems, such as WhatsApp, are used by workers to communicate with friends, family, clients, and former clients. The result has been a changing temporal rhythm of flexible work that has further blurred the line between personal time and work.

In response to these challenges, some workers 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, workers may have 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. Some workers also use time management tools to ensure family time is not infringed upon by overworking.

## **Adaptable**

PDIs are organizationally adaptive. While operating in a liminal space between different organizations and projects, flexible workers 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 (e.g., the requirement to use certain IPs or devices to access enterprise resources), 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..

PDIs are also locally adaptive. Flexible workers may work from different places or even on the move. Therefore, an awareness of local infrastructures enable workers to ensure digital connectivity, which is a central element of digital work. Spatial mobility may sometimes require significant physical effort and planning for technological use across different spaces, as a form of articulation work.

## **Implications**

The organization of flexible work is fluid and transient which requires a new mindset. In the following pages we detail ways that system design and management can address precarity of flexible work by promoting fairness, self-determination, and worker autonomy and help organizations more effectively harness the benefits of flexible work. Only by helping firms, workers, and digital labor platforms navigate the conflicting consequences of flexibility can personal digital infrastructures (PDIs) support the emergence of new effective, sustainable contingent work arrangements.

## **Strike a balance between generativity and control**

Platform designers and managers of systems for work need to strike a balance between two competing needs of generativity and control. Flexible work draws on systems that can be generative to diverse and flexible uses but simultaneously reinforce integrity and viability of transactions. In particular, the tradeoff between security and convenience is manifested 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.

Tools that facilitate such a balance can focus on better controlling and managing projects while

facilitating personal 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 locally on the worker's personal storage systems to provide the worker certain freedoms and autonomy.

### **Mobilize enterprises**

Enterprise information systems now have to adapt to a workforce that is less attached to a single physical location. 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. 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.

### **Facilitate a plug-and play participation**

Even though many flexible workers have grown independent of organizational spheres of control, they still have to constantly work with multiple organizations and their internal information systems in capacities such as clients, or subcontractors. Evidence points to the invisibility of this workforce <sup>4</sup>. For example, even though flexible workers occupy a dynamic relationship with enterprises and enterprise information systems, many of these systems are designed for standard, full-time employees. 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.

### **Reduce system ambiguity**

Technology design can intensify or reduce work precarity. AI based systems have made use of on-demand workers to provide services that are unattainable with AI alone (what Jeff Bezos called 'artificial artificial intelligence'). However, these collaborations between flexible workers and AI systems are often geared towards creating task efficiency rather than meaningful work environments. Critical information that could help flexible workers make sense of their work on digital platforms is often withheld for the purpose of fostering overall efficiencies of matchmaking. Future system design should take into account this information asymmetry and provide workers with more information about how key decisions are made by algorithms. For instance, Upwork uses the Job Success Factor (JSS) as a central measure to determine freelancer's ranking in the search results. The way JSS is calculated and aggregates various performance measures is not completely clear to many freelancers, and therefore adversely affects their interaction with the platform <sup>8</sup>.



Beyond information asymmetry, system design can be more mindful towards power asymmetries between workers and organizations. There is value in designing tools that not only benefit clients or platform owners but also workers. Recent explorations into work practices of successful crowd workers, and their interactions with the algorithms helped develop intelligent tools that gradually automate repetitive aspects of crowdwork, helping workers redirect their attention to more meaningful aspects of their work <sup>12</sup>.

## Facilitate collective learning

Flexible work is a largely independent pursuit, so the preponderance of risk falls on the worker. These workers are typically entrepreneurial and the high uncertainty of their work requires self-enhancement through collective knowledge-sharing. Traditional firms, as well as digital on-demand platforms, can contribute to building collaborative structures through which workers help each other. Airbnb, for example, offers a wide range of collective learning opportunities to its hosts on its Airbnb Community pages.

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 AMT; and most effective ways of presenting skills on Upwork profiles). An example of such community-based systems is turkopticon<sup>1</sup>, a browser plugin, which enables MTurkes to provide mutual aid by sharing reviews of individual employers.

## 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 is still concerned with 'standard' organizational forms, but as the future of work is increasingly characterized by flexibility, computing professionals must learn more about the relationship between ICT and work flexibility. As such, 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. To avoid exploitative forms of precarious work, PDIs must provide adequate benefits for employees and employers while mitigating the risk.

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## References

1. Hagel, J., Schwartz, J. & Bersin, J. Navigating the future of work: Can we point business,

1 <https://turkopticon.ucsd.edu/>

- workers, and social institutions in the same direction? *Deloitte Review* (2017).
2. Burnford, J. Flexible Working: The Way Of The Future. *Forbes*  
<https://www.forbes.com/sites/joyburnford/2019/05/28/flexible-working-the-way-of-the-future/#609f10ee4874> (2019).
  3. Kalleberg, A. L. & Vallas, S. P. *Precarious Work: Causes, Characteristics, and Consequences*. (Emerald, Bingley, UK, 2018).
  4. Wakabayashi, D. Google's Shadow Work Force: Temps Who Outnumber Full-Time Employees. *NY Times* <https://www.nytimes.com/2019/05/28/technology/google-temp-workers.html> (2019).
  5. Barley, S. R., Bechky, B. A. & Milliken, F. J. The Changing Nature of Work: Careers, Identities, and Work Lives in the 21st Century. *Academy of Management Discoveries* **3**, 111–115 (2017).
  6. Winter, S., Berente, N., Howison, J. & Butler, B. Beyond the organizational 'container': Conceptualizing 21st century sociotechnical work. *Information and Organization* **24**, 250–269 (2014).
  7. Strauss, A. The Articulation of Project Work: An Organizational Process. *Sociol. Q.* **29**, 163–178 (1988).
  8. Jarrahi, M. H., Sutherland, W., Nelson, S. B. & Sawyer, S. Platformic Management, Boundary Resources for Gig Work, and Worker Autonomy. *Comput. Support. Coop. Work* 1–37 (2019).
  9. Ashford, S. J., George, E. & Blatt, R. Old Assumptions, New Work: The Opportunities and Challenges of Research on Nonstandard Employment. *Acad. Manag. Ann.* **1**, 65–117 (2007).
  10. Newlands, G. & Lutz, C. Crowdwork and the mobile underclass: Barriers to participation in India and the United States. *New Media & Society* 146144482090184 (2020)  
doi:10.1177/1461444820901847.

11. Sawyer, S., Crowston, K. & Wigand, R. T. Digital assemblages: evidence and theorising from the computerisation of the US residential real estate industry. *New Technology, Work and Employment* **29**, 40–56 (2014).
12. Savage, S., Chiang, C.-W., Saito, S., Toxtli, C. & Bigham, J. Becoming the Super Turker: Increasing Wages via a Strategy from High Earning Workers. in *WWW: The Web Conference 2020* (2020).