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32 Infrastructures

Abstract: Infrastructures, both traditional and digital, are critical to society's functioning, with digital advancements improving efficiency but introducing challenges like cybercrime. Their study reveals the complex, interconnected sociotechnical systems formed through evolving technologies, practices, and regulations. Understanding these infrastructures is crucial for addressing contemporary digital crimes and shaping future crime control strategies.

Keywords: sociotechnical assemblage, digitalization, work practice, large-scale

Introduction

Infrastructures are critical resources for our society. Traditional infrastructures like waterways, roadways, communication lines, and electricity are foundational building blocks for today's wellbeing. In the last decades, these infrastructures have become increasingly digital, leveraging another global digital infrastructure, the internet. Simultaneously, new digital infrastructures have emerged. On the one hand, this process has arguably enabled better and more efficient services. On the other hand, it has opened new challenges in terms of protecting and securing these infrastructures from criminal threats. For example, new forms of crime such as cybercrime have emerged exploiting breakdowns in traditional (analog) and digital infrastructures (see Cybercrime by Holt and Holt).

Digital technologies have transformed enormously over the years. Born as isolated, bounded systems used in specific contexts, they have grown to encompass inter-organizational global networked 'systems of systems' which rely upon a complex set of communication standards and protocols, integration solutions, layers of hardware and software, and multiple user interfaces and use practices (Monteiro et al., 2013). The study of *infrastructures* has brought attention to how such technologies have developed over time, why and how they come into being and spread to large scale and across contexts, as well as how and by whom they are designed, made to work, cultivated, maintained, and disrupted. Studies of infrastructure have also shown what the un/intended consequences of connections making are, and they have drawn attention to the implications of the inner workings of infrastructures as knowledge generating machines (Monteiro, 2022). In addition, infrastructures are shown to be fundamentally sociotechnical and require "thinking (…) not only in terms of human versus technological components but in terms of a set of interrelated social, organizational, and technical components or systems (whether the data will be shared, systems interoperable, standards proprietary, or maintenance and redesign factored in)" (Bowker et al., 2010: 99).

In light of this, the understanding of digital technologies as infrastructures is critical for criminologists. Digital infrastructures simultaneously underpin and concern al-

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most all activities relevant to criminologists, ranging from financial surveillance to predictive policing, drug markets, and hacking. As a consequence, there is a need to understand digital (see Digital by Wernimont)—as well as analog—infrastructures if we want to grasp contemporary and future practices of digital crimes and crime control.

Several research fields, such as Science and Technology Studies, Information System research, Computer Supported Collaborative Work, Media Study (and also computer science, information science, communication, organization theory, cognitive science) are interested in these issues, and have developed their understanding of infrastructure. Infrastructure studies originated in the study of large sociotechnical systems, especially the work of Hughes (1987) who researched the creation/invention of the electric light and power systems/grids from the perspective of the 'infrastructure builders.' In his study, Hughes showed how infrastructure work became the site at which tensions arose, were contested and resolved. As the electricity infrastructure emerged, power shifted gradually toward those who had control of financial, material, and knowledge resources. Since the 1990s, infrastructure studies grew in importance with the advent and spread of the internet as global information infrastructure (Hanseth et al., 1996). Seminal work on infrastructures has been conducted by Star and her colleagues in the 1990s (Star and Ruhleder, 1996; Bowker and Star, 1999: 4) on research infrastructures such as infrastructures used by scientists to collaborate across research institutions. A seminal study by Star and colleagues looked at the Worm Community System, a network for geographically dispersed community of geneticists (Star and Ruhleder, 1994). One important contribution of these early studies has been to foreground the undervalued and often invisible articulation work needed to keep infrastructures reliable. In other words, as Star as pointed out infrastructure is relational, that is, the daily work of one person is the infrastructure of another (Star and Ruhleder, 1996). Over the years, infrastructure studies spread over many research fields and empirical cases from health infrastructure at hospital, regional, and national level (e.g., Ellingsen and Monteiro, 2006), to infrastructure for climate modeling (Edwards, 2013), research infrastructures, and environmental monitoring infrastructures (Parmiggiani et al., 2015).

In sum, infrastructure studies bring a unique sensibility to the understanding of digital technologies and digitalization processes and can contribute to the field of criminology by bringing a novel perspective to digital crime and crime control. In this view, students and researchers in digital criminology are offered a lens that bring attention to the opaque interdependencies across systems, people, and practices, and the resulting vulnerabilities over time and across scales (see Vulnerability by Ranchordas and Beck). In addition, infrastructure studies could inspire new investigative and research methods based on innovative data collection approaches and provide improved understanding of where, when, and why crime might occur.

Infrastructure as a lens

Infrastructure is an approach to the study of digital technologies and processes of digitalization. It is a lens to understand these phenomena as evolving sociotechnical *assemblages.* For instance, a system for electronic monitoring in prisons rather than being considered a discreet technology becomes part of a larger and evolving surveillance assemblage (Haggerty and Ericson, 2017). In this view, the multiple and different components and the practices they support come to coalesce into an assemblage with far reaching arms and effects well beyond those of each of the separate components. In this section, some pillars of infrastructure studies are introduced, followed by some methodological points on how to study infrastructure. This chapter does not have the ambition of covering all research on infrastructure, rather it points to some key concepts and key studies spanning fruitful crossovers between research fields and scholarly traditions.

Infrastructure studies favor a long-term perspective and examine how infrastructural connections are made, what shapes them and their long-term consequences. An infrastructure for sharing criminal record data for instance is complex and not built in short time. The components and connections constituting it are shaped by pre-existing decisions taken before such infrastructure is put in place. For instance, regulatory frameworks must be followed as well as technological compatibility with already installed digital tools, and existing record keeping practices. In addition, the way the infrastructure is configured will have consequence for its future development and adaptations (for instance related to novel methods for data encryption). Thus, the lens focuses on how infrastructures grow through adaptation over time and the enabling and constraining role of the existing installed base, that is, the existing and established resources, systems, practices, structures, and norms as in the criminal record infrastructure example. The concept of installed base is therefore a core construct in infrastructure studies as it points to the dependencies between past evolution and future development (Aanestad et al., 2017). Accordingly, Monteiro et al. explain infrastructure design as follows: “infrastructure design needs to serve as a link forward towards future anticipated users/uses” (2013: 580).

These processes of infrastructure development stretch beyond traditional IT projects. As an illustrative example, digital infrastructures supporting collaboration across police forces have usually been developed over time through the implementation of various information and communication technologies (see Policing by Wilson). These systems have often been procured in an uncoordinated way to address local needs of single departments and specialized tasks (such as drug enforcement, border security, or predictive policing in urban areas), and at a later point integrated into a larger supporting technological infrastructure to address issues of information fragmentation, reliability, and security (Brayne, 2020). Thus, the existing information and communication practices in the various user organizations, their structures, and regulations of professionals have shaped the technologies selected, integrated, and put into use. These

in turn will shape the future development of the infrastructure as systems are embedded into work practices. In the long term, this creates a dynamic called path dependency, that is, a tendency in which the installed base restricts the future evolution of infrastructures to specific directions, for instance by locking it with certain technological solutions and vendors (Hanseth and Lyytinen, 2010).

Infrastructures are fundamentally political. The design, development, and use of infrastructures is not neutral. Rather it is a process involving several stakeholders negotiating their divergent and often conflicting interests and aims. For instance, in a seminal study Hanseth and Monteiro (1997) have examined the politics in the making and implementation of technical standards constituting the technical backbone of an information infrastructure. Standards, they argue, are not ready made nor neutral but inscribe use behaviors. More recently Waardenburg investigated the development and implementation of new predictive policing tools in a Dutch municipality (Waardenburg et al., 2021). She found that a new profession of 'knowledge brokers' emerged with the role to translate opaque system-generated predictions into a format that was understandable and actionable for police officers. In this role, knowledge brokers acquired power in the form of more in-depth knowledge of how system-generated predictions worked and could be prepared. Similarly, Kaufmann and colleagues have shown the politics inherent in assigning form to information in digital prediction practices according to specific narratives of how crimes are committed, where to find crime, and where to send police patrols (Kaufmann et al., 2019).

In sum, these studies show how decisions that appear as technical in nature are the result of negotiations processes between different interests and between powerful and marginalized actors. Through technology design, these interests are then inscribed into durable configurations and connections that have long-lasting effects, cause tensions, and can lead to technology failures (Knobel and Bowker, 2011).

How to study infrastructures

How can infrastructures be studied given the characteristics outlined above? In other words, how does one shift focus from bonded systems (intended as artefacts, such as one computer system for predicting crime in a neighborhood) to infrastructure (intended as a complex network of systems, people, practices, norms)? In addition, how to study infrastructures which typically exist in the background, are invisible, and frequently taken for granted—while being critical to people, work, and society (Star and Ruhleder, 1994)? Also, how to tackle scale (infrastructures are typically large-scale and long-term), technical complexity and diversity (number and type of systems, their interconnections and use practices), distribution (across locations and communities of users), and not the least access? To engage in such research effort might feel overwhelming. How to find a good entry point to such complex assemblages?

In terms of scale, infrastructures have the characteristic of being simultaneously large and small—in the sense that they become visible and accessible when in contact

with daily routines and work practices. As a result, an important means to study infrastructures is to understand how they emerge in practice, that is in connection with activities and structures.

Key questions to address for researchers are: how do tensions between local and global concerns, or between individual versus community needs emerge? And how are an infrastructure's qualities distributed between the local and the global? For instance, to what extent is a metadata standard designed generic enough to represent a domain ('reach or scope") while aiming at fitting local structures, social arrangements, and technologies ('embeddedness')? A useful device to address these questions is the concept of *infrastructural inversion* (Star and Bowker, 2006) inviting researchers to shift attention from the interactions between a user and a system toward the ongoing work to sustain, upgrade, and maintain the infrastructure as a whole. For example, notable studies in the field of Science and Technology Studies propose to observe how infrastructure is navigated and made sense of by practitioners during moments of breakdown (Star and Ruhleder, 1994).

As mentioned, infrastructure is a term that invokes images of pipes, structures, and roads that interconnect and enable activities (e. g., the flow of water, electricity, cars). The understanding proposed in this chapter relies on these images while at the same time incorporating an understanding of infrastructures as also related to the flow of information and data. In the case of digital criminology, this is relevant to understand the critical role of data flow for instance to feed predictive modeling of crime occurrences. This perspective foregrounds the role of humans as designers, users, builders, owners, and in general as actors affected by infrastructural effects. Infrastructure is thus a broad term that can be defined as "to pervasive enabling resources in network form" (Bowker et al., 2010).

Conclusion

In conclusion, though infrastructure is a mature concept with origins in the study of 'old' network technologies (electricity grids, the birth of internet), its conceptual bases are still relevant. Contemporary digital technologies and processes of digitalization do not take place in a vacuum but in contexts that are already populated by multiple technologies. Thus, understanding of digital technologies as interconnecting and interconnected sociotechnical assemblages is critical.

It is important to have an understanding of digital technologies as infrastructure that is sociotechnical, and takes into consideration the organizational forms, work practices, and institutions that shape them over time, as well as their knowledge generating effects and future implications. Understanding infrastructure has implications for how we design and contribute to shaping infrastructures in the future.

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