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Time constructs: Design ideology and a future internet

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Abstract

This article engages the politics of technology as it examines how a discourse of time is framed by engineers and project principals in the course of the development of three future internet architecture projects: named data networking, eXpressive Internet Architecture, and Mobility First. This framing reveals categories of a discourse of time that include articulations of efficiency, speed, time as a technical resource, and notions of the future manifest in each project. The discursive categories fit into a time constructs model that exposes how these projects were built with regard to concepts of speed and how different notions of time are expressed as a design ideology intertwined with other ideologies. This time constructs framework represents a tool that can be used to expose the social and political values of technological development that are often hidden or are difficult to communicate in cross-disciplinary contexts.

Keywords

Future internet architectures, networking protocols, transmission control protocol/internet protocol, time, temporality, ethics, future, sociomateriality, feminist science and technology studies

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Introduction

The Internet has grown beyond the limitations of its original design. Mobile devices, content streaming, the Internet of Things (IoT), and social media have flooded the Internet's infrastructure with data that it was not built to handle (Crawford et al., 2014; Fisher, 2007; Gillespie, 2006; Yuan and Gong, 2011). Super high-speed Internet has been rolled out by Google in cities across the country, but users do not have access to the technologies, capacity, or desire to make use of it, all the while Internet service providers underserve large subsets of the population because they are averse to develop and deploy the infrastructure necessary to get these users "up to speed" (Burrell, 2018; Halegoua, 2015). IoT devices can be unreliable because they are enormously taxing on network bandwidth (Celic and Magjarevic, 2020; Nicolescu et al., 2018). Emergency and natural disaster notifications often come too late or miss entire swaths of mobile users (Cobb et al., 2014; Tan et al., 2020). Furthermore, numerous critical studies of communication technologies have focused on how applications like Google and Facebook monitor users' activity to capitalize on fleeting seconds of their attention to predict their future desires and consumption patterns (McChesney, 2001; Noble, 2018; Vaidhyanathan, 2018; Wu, 2016; Zuboff, 2019).

While it is common to focus on applications as the source and symptom of the problems that exist in our information and communication environment, this article describes *how* the Internet infrastructure undergirding these applications has developed over the years, and why our temporal experiences seem to be so affected. Many studies on contemporary time and acceleration contemporary information infrastructures gesture toward time as a design ideology (Hassan, 2009; Mazmanian, 2012; Mazmanian et al., 2014; Vostal, 2016; Wajcman, 2014). This article builds on the concept of time as a design ideology, or how time and temporality manifest as design concepts and practices to facilitate acceleration, frictionless use, surveillance, commodification, attention capture, and prediction that reifies and extends existing sociotechnical structures of power and inequity in the infrastructural projects at hand (Paris, 2018).

Because the Internet's infrastructure was quickly becoming incompatible with how people use it, in 2009 the National Science Foundation (NSF) funded the future internet architecture (FIA) projects that are analyzed in this article. These projects were developed to build new protocols to replace Internet Protocol (IP) that routes and transmits information based on addressing. During their 11 years of existence, these FIAs have already generated discussion regarding how protocols can foster the public good (Nissenbaum et al., 2013; Shilton, 2015, 2017; Shilton et al., 2014). However, during this time, the promise of the public good in these protocol projects has gone largely unmet. This failure shows how specific time-based values form the foundation of these research projects and

suggests the benefits of reimagining protocols that correct the forms of control and capture at the application level.

The methods for this investigation are shaped by infrastructural analysis as summarized by Star and Ruhleder (1994) in their qualitative study of technological infrastructure as a process of ongoing negotiation among individuals building technologies, the technological artifacts involved, and the broader social structures and institutions of which this work is a part. The analyses I present here result from a 2016–2018 grounded study that incorporated documents from the three FIA projects in question: named data networking (NDN), eXpressive Internet Architecture (XIA), and mobility first (MF) (Paris, 2018). The NDN protocol derived a naming and routing system for internet data transmission that would replace IP. The project has operatives across the world, but its main hub is at University of California, Los Angeles (UCLA), and included developing applications to run with the protocol at the Research in Engineering, Media and Performance Lab (REMAP) at UCLA. XIA is much smaller in scale than NDN and focused on developing an entire protocol stack to accommodate network objects, each with unique identifiers to replace IP. This project runs primarily from Carnegie Mellon University, with a handful of other US universities. MF operates at the smallest scale and looks to route data via a globally unique identifier for packets mapped to network objects using a global name resolution service. It is run from Rutgers University with affiliates from six other universities, primarily in the Northeast United States. For this study, I conducted, recorded, and transcribed over 30 hours of interviews with project principals, observed eight demos, and attended NDN community meetings to clarify how these projects worked at technical, social, and institutional levels.

While analyzing documents, interviews, and observational data, I composed memos about the various topics and time-based values that came to the fore and coded them for allocation into emergent categories. The analysis and development of the time constructs framework is derived from Latour's (1999) and Stiegler's (1994/1998, 1996/2009, 2001/2010) critiques of Heidegger's philosophical treatise on time, technology, and human agency found in the "Question Concerning Technology" (1955/1977). These concepts of sociomaterial agency in human relationships with technology are explored in feminist science and technology study (STS) works from Barad (2003) and Haraway (1980/1991). I combine feminist STS with contemporary works on acceleration and sociotechnical friction from feminist STS scholars Wajcman (2014) and Mazmanian (2012, 2014) and future imaginaries from Jasanoff and Kim (2015). The point of this work is, on one hand, to develop a set of considerations for understanding time as a design ideology, and on the other hand, to wrest the concepts of sociotechnical materiality, agency, and time from Heidegger's reactionary technological determinism by weaving in works in STS and philosophy to introduce the co-constitution of infrastructures of time in a way that encourages new possibilities.

This analysis uncovered three broad categories of time in the technical infrastructure projects under investigation. First, there is the practice of working with time as a spatialized, technical object. Second, technology can both include and induce a plethora of conceptions and regimes of time and temporality (Paris, 2018). To honor this fact, I attended to engineers' articulations of how they imagine the users' temporal experiences and demands. Finally, I studied these projects as they came to the end of their NSF funding cycle, which was an interesting moment to watch how projects oriented themselves with regard to larger narratives, both past and present, and in the future. These observations clarified how such technical projects are embedded within institutions that engage with larger political projects.

Engineers and FIA project principals have many ways to instrumentalize time both as a resource and as a nebulous concept of user-facing affordances that structure the development of these new networking protocols. I describe and locate categories of the discourse of time, particularly articulations of efficiency, latency, speed, and time as a technical resource, as well as visions of the past, present, and future (Paris, 2018) in engineer's and project principal's descriptions of their work. These categories of the "discourse of time" comprise a *time constructs* framework that allows us not only to articulate how projects are built with regard to varying notions of time and temporality but also to clarify how time manifests as a design ideology that is intertwined with other ideologies.

Figure 1 depicts how concepts of time—manifesting as characteristics, values, and qualities—interact with the material processes of designing with time as a material and practical constraint. These concepts and material practices of time are bound into a mutually constitutive process in which they shape and are shaped by one another, forming a co-constitutive sociomaterial spiraling torus, powered by existing technologies, cultural concepts, and processes of time. Engineering projects are generated at the perimeter of the spiraling torus and pass through conceptual and practical phases. As projects spiral around multiple turns of the co-constitutive torus, they become fixed into technological products that then shape future projects (Paris, 2018: 184).

Internet infrastructure development, as outlined here, incorporates various concepts of time: that time is linear and causal—that the past necessarily determines the future. In tandem with this, designers of these technologies, prizing efficiency as an unproblematic social and technical value, promote a situation in which all life becomes subordinate to goals of a market-based economy , allowing profit motives to drive innovation because they have difficulty imagining anything else. While they cannot necessarily be blamed for their lack of imagination, this inability to see other possibilities forecloses on a future in which we might produce technologies, information infrastructures, and systems of governance that coalesce around notions of the care and mutual respect, the public interest, or pro-social engagement, as opposed to the pursuit of enriching the already powerful.

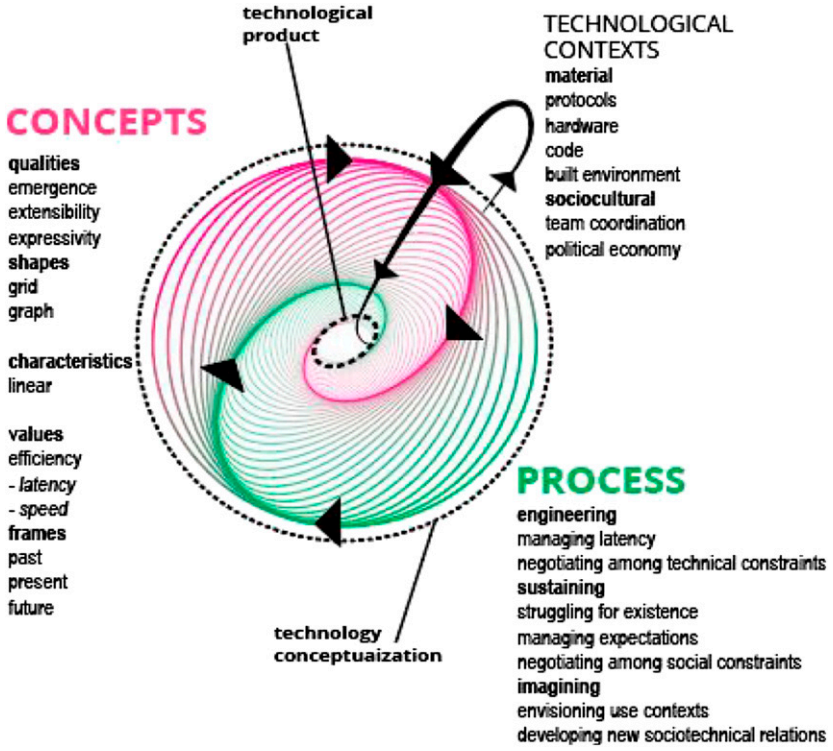

Figure 1. The time constructs model (Paris, 2018: 183).

The need for a future internet

The Internet we know today was originally envisioned nearly 60 years ago as a militarized system to facilitate transmitting documents, broken into bits of information called packets (Abbate, 2000; Clark, 2018; Kleinrock, 1976; Virilio, 2006/1986). The mid-2000s saw the advent of social media platforms like Facebook in which users generated and consumed content that proliferated. These networks ushered in a dramatic increase in Internet traffic. As social media facilitated many forms of content sharing, companies quickly capitalized on—and thus further encouraged—this wide-scale participatory content generation (Crawford et al., 2014; Gillespie, 2006). A part of what made this increase in traffic volume possible was the *end-to-end* principle, which dictates that the network treats all traffic the same and thus cannot make discriminatory or differential decisions about how to handle packets. Proponents of this principle argue that this feature has allowed the Internet to grow into the global

communication network it is today (Lemley and Lessig, 2000).The neutrality of the end-to-end principle is evoked as the Internet's primary social value by technologists and Internet policy experts alike, as an important principle that is fundamental to the way the Internet works, but it also tied to a conceptualization of an Internet predicated on data exchange, not real-time data or voice processing (Clark, 1988, 2018; Gillespie, 2006). In a sociotechnical context characterized by real-time data flows, maintaining the end-to-end principle is far from a foregone conclusion (Gillespie, 2006; Paris, 2018: 35).

As Internet traffic expanded to facilitate mobile devices, Internet researchers and public and private funding agencies became concerned that demand for application-based communication would surpass the capacities of the Transmission Control Protocol/Internet Protocol (TCP/IP) that currently routes information packets according to location-based IP addresses, resulting in the demise of end-to-end communication (Clark et al., 2005; Gillespie, 2006; Paris, 2018). To preempt this unwanted outcome, the NSF's Computer, Information Science and Engineering task force in 2007 started the future internet design (FIND) program. FIND marked the first generation of new NSF-funded Internet projects (Fisher, 2007; National Science Foundation, 2010). Two years later, in 2009, the NSF formulated a call for a second round of future Internet projects, this time under the name FIAs (Paris, 2018).

The NSF "anticipated that the teams would explore new directions and a diverse range of research thrusts within their research agenda, but would also work together to enhance and possibly integrate architectural thinking, concepts, and components, paving the way to a comprehensive and trustworthy network architecture of the future" (National Science Foundation, 2011). The FIA project was intended to contribute to new Internet protocols and policy.

In addition to funding these technical projects to undertake this gargantuan task of developing a future Internet, the NSF-funded specialists in technology ethics, science and technology studies, policy, sociology, and philosophy called the Values in Design Council (VID) to perform anticipatory ethics workshops with the FIAs in the process of their development to more comprehensively build social values into the new Internet networking protocols (Shilton, 2015, 2017). These workshops took place from 2010 to 2015 and focused on discussions of privacy and security, which seemed to be the primary takeaways for the FIA project respondents, as well as issues of accessibility, transparency, and accountability, although they seemed to be less clear or meaningfully engaged by the FIA participants (Nissenbaum et al., 2013; Values in Design Council, 2014). Problems of disciplinary linguistic conventions and perspectives on technological development made the path difficult (Nissenbaum et al., 2013). As NSF funding drew to an end in 2017, each of the FIA projects sought new research partners, some of which seemed to directly negate the types of social values that the VID Council attempted to highlight as fundamental, such as attention to power

dynamics (Paris, 2018). The data for this study were collected in 2016–2017, at a juncture when each project faced an uncertain future.

Even as the NSF and the VID encouraged FIA engineers to build a range of social values into the protocols, the engineers continued to value efficiency over all other possible values (Shilton, 2015). The FIA project documents for each project all argue in different ways that their networking architectures will facilitate quick and efficient content distribution among stakeholders. These documents provide copious descriptions of how the technical aspects of these protocols will allow efficient content distribution, but the level of technical specificity and abstruseness suggests that this information is only for internal stakeholders (Jacobson et al., 2009; Mobility First, 2018a, 2018b; XIA, 2018). It is more common in the popular press to refer to the user-facing benefits of efficient content distribution as Internet *speed* that is "faster" or "swifter" and "allows smoother content streaming" than the Internet we have at present (Bauman, 2017; Rutgers University, 2016; Talbot, 2013). As each FIA project's documents claim efficient content distribution is articulated as the clear advantage of their systems, and as they promise users "speedier" communication, these projects are good sites to investigate to understand how these time-laden terms come to mean in practice and how these meanings and practices relate to the lay perception of a "faster" Internet (Paris, 2018).

Making time in the future internet

This is not the first rumination on speed and temporality at the protocol layer. Galloway (2004) provided many examples to support his theory of how common Internet protocols like TCP/IP and Hypertext Transfer Protocol shape not only the technical function of networks but also how humans relate to these networks. He suggested that TCP/IP plays a part in the user-facing speed of networks allowing access to information as a "natural extension of the user's own body" (p. 67). Moreover, he stated that there are profound implications of this design for speed in shaping how we make sense of the world around us.

Expounding on the epistemic and political implications of speed, philosopher of technology Stiegler (2001/2010) theorized that at present, individual human subjectivity is increasingly bound to technologies designed to engender a temporal orientation that focuses human attention on the elusive present, rendering us indifferent to learning from the past as we are thrown into the future without intention (Paris, 2018). Stiegler's theorization on technology's temporality and human subjectivity in the context of the real-time processing of the 1990s echoes the teleology of Heidegger's concept of "enframing"—that technology drives understanding everything as a resource to be instrumentalized in the process of development (Heidegger, 1955/1977: 6). Stiegler's contemporary account of Heidegger's enframing can be seen as compatible with sociologist of science

Bruno Latour's notion that *time enmeshes*, that over time, relations between humans and technologies are flattened, as technological development and governance is driven by the (misguided) modernist assumption that technological progress is an undeniable good and that Weberian efficiency is the ultimate goal of all of these systems (Latour, 1999; Paris, 2018).

Taken together, these provocations suggest that technologically mediated temporal experiences have a powerful effect on humans and suggest that notions of time and temporality are design ideologies that exist. Both Heidegger and Latour assert in different ways that while time exerts agency in technological development, this agency is often imperceptible. Galloway, like Stiegler (2001/2010), as well Wajcman (2014), Mazmanian (2012), and Sharma (2014), connects this directly to capitalist structures that undergird technologies. As Wajcman (2014) notes in her work on the social shaping of technology leading to the prevalence of concepts of acceleration in contemporary technologies, this capitalist conception of time is considered very narrowly and is naturalized in the design and engineering process. It is this narrow conception of time that constrains what types of user interaction and feedback into the system are possible within these projects. It, therefore, makes sense to uncover how the discourse of time manifests in protocol projects—that is, how it is articulated and regarded in practice as a *concept* and a *process* that shapes aspects of design (Paris, 2018).

There were examples of articulations from each FIA project highlighting how time is a design ideology, or a powerful rationale that undergirds the processes development, so ubiquitous that it becomes invisible and accepted as a matter of fact. Across projects, principals framed latency as a particular type of inefficiency that slows down the network and should be avoided and mitigated at all costs. The participants articulated that they manage latency as they design how hardware, software, code, and other protocols interact and how this affects the design's overall efficiency and application user interface (UI) speed. Designers employ diagrams to communicate the way information transmission is ordered and organized in time, both within their respective teams and with the broader technical community. Concepts of project duration, the future contexts of protocol deployment, and the use also determine how these FIA projects are managed and oriented internally and relative to other FIA projects, government agencies, industry, and the public. These decisions are guided primarily by the material concerns of the existing technical world and less by the sociocultural concerns of that same world.

Interview and document data from each of the three examined projects (NDN, XIA, and MF) pointed to themes that coalesced around these broad categories—the projects' trajectories through time, modes of communicating temporality, technical time, and conceptions of a sociotechnical future (Paris, 2018). Technological time manifests in this study of FIA projects as several dimensions: (1) *time enmeshes*, embeds, and reifies constructs of efficiency and the sociotechnical

future in technologies as they are developed; (2) *the technics of time and power* describes how demands of contemporary capitalism drive design for technical efficiency; and (3) *spatializing time* details of how time is considered a material resource and made into a representational object in the technical work of protocol and application construction; and how principals relate this to the interface speed that users experience.

Enmeshed time

Sociologists, anthropologists, philosophers, and social theorists attend to the production of time in historically and socially situated contexts, from the practices of rendering time as a scientific endeavor (Fraser, 1983; Mazmanian et al., 2014) to cultural and political temporalities (Gell, 2001; Giddens, 1991; Hassan, 2009; Innis, 1951/1999; Sharma, 2014; Virilio, 2006/1986; Wajcman, 2014), and multiple instances of sensing, measuring, and controlling time from personal, informal interpersonal, and structured organizational perspectives (Adam, 1990; Brooks, 1975; Hassan, 2017; Vostal, 2016). Each of these contexts is useful to the study at hand. Sociologist of science Bruno Latour argued that there is great epistemological value in the way scientists measure and spatialize time to learn new things about the world. However, he argued in *Pandora's Hope* (Latour, 1999) that there is equal value in understanding time outside of its instrumentalized value, such as how technological development projects prize efficiency or productivity.

In "The Question Concerning Technology" (1955/1977), a well-known treatise on how time has been instrumentalized to negative ends, Heidegger problematizes the co-constitution of time, technology, and instrumentality. He proposes that technology's "essence",[1] or its contextual existence and influence beyond its technical function, lies in shaping the way we understand, engage with, and imagine the world. Through modernity, technology's essence seeks to justify technology's own necessity, thereby fostering complete human reliance on these technical systems. The scientific measurement of time leads to considering concepts of time and space as technological resources. The modernist drive toward technological efficiency is evidence that technology's essence comes to rationalize increasingly more aspects of human life as resources to be negotiated within the technological system.

In this text lies Heidegger's well-known example of a hydroelectric plant on the Rhine that he uses to show how the sociotechnical process of "enframing"[2] incrementally mobilizes ever-broader swathes of the natural world, including but not limited to natural resources, such as rivers, forests, and human labor, until this process collapses or erases the boundaries between the natural world and technology. Both entities are instrumentalized. The erasure of ontological distinction between human actors and nonhuman technologies renders them equally

susceptible to exploitation. Similar to Heidegger's enframing is Latour's notion of the "collective" detailed in *Pandora's Hope* (1999: 174–216) accompanied by his own metaphor of a computer chip factory. Latour's collective is a condition in which humans and nonhumans are ontologically indistinct, and this flattening is reified over time: "Instead of clarifying even further the relations between objectivity and subjectivity, *time enmeshes*, at an even greater level of intimacy and on an even greater scale, humans and nonhumans with each other" (Latour, 1999: 200, emphasis added).

Instrumentalized, technological time, for Latour (1999) is a modernist concept that justifies its existence by promising a better future. He noted that the modernist myth of progress holds that "the future" promises to restore "proper" human relations with technologies, to improve upon the current confused and instrumentalized relationship between humans and machines as ontologically equal, but one in which humans will eventually someday be the masters of technologies (p. 200; Paris, 2018: 9).

These myths are those we have become familiar with in the last half century of technological discourse: As echoed in the techno-utopian predictions from the 1960s by Touraine (1971), Bell (1976), and others, the hope for the sociotechnical future was that eventually, technocratic solutions under a burgeoning neoliberal capitalism will appropriately facilitate life, so that governance can be evenly distributed and so that people are left to live out their desires, to participate in unalienated labor or whatever utopia is promised by the teleological ends applied to technology. Latour frames this myth as one we labor under at present. One can see how this myth has been seeded into popular discourse to allow the unfettered expansion of social media platforms as these technologies are defended by their creators as "fostering social connection," even as these companies operationalize this social connection between users to generate profit (Vaidhyanathan, 2018). This myth obfuscates power relations that constrain the futures that are possible.

The "future" is explicitly signaled in the name of the funding program that made these new protocol projects possible. At the same time, these projects barely reached the prototype stage and have fallen short of their original internal goals and timelines. As such, it is understandable that discussions with the FIA teams regarding project and subproject goals, structures, problem solving tactics, and practical workflows all pointed to the theme of the future, and most of the time directly invoked the future. Their responses pointed to how they understand the sociotechnical future and how these perspectives are built into their work (Paris, 2018, 2020). Interestingly, their articulations of the future were dependent on past protocol development work. The future imaginaries presented by NDN Principal Investigator (PI) for Network Development and Professor of Computer Science at University of California, Los Angeles, emphasized that as with the switch from telephony to packet-switching over 50 years ago, technology is fundamentally driven by a concept of efficiency (Baran, 1964; Clark, 1988, 2018). The PI

acknowledged that user demand is involved in technology advancements; but conversely, granted agency to the technology itself, and characterized technology as "pulling or enabling design" (personal communication, 22 September 2016; Paris, 2018: 130, Paris, 2020). All FIA project respondents' articulated expectation of future use contexts rested on explicitly technical advancements, like protocological efficiency. These comments reveal how they think their designs will be applied in future use contexts and imply that respondents believe—as Internet pioneers did over 50 years ago—that technologies developed for military use that value market-driven ideals above all others can be unproblematically wielded to promote prosocial ideals (Paris, 2018, 2020).

In addition to efficiency, mobility and the ability to store content forward, or caching information within the network for future use, featured heavily in the discussions of what types of sociotechnical futures these protocols could allow. As with the beginning of the TCP/IP-based Internet started with the Advanced Research Projects Agency instead of focusing on benefits for everyday individuals or groups of users, PIs frame their protocols as a security solution, beneficial to a narrow range of military applications and to the portfolios of corporate entities. The XIA PI noted that this functionality was likely a key factor that led to securing a large grant from Defense Advanced Research Projects Agency's Secure Handhelds on Assured Resilient Networks at the tactical Edge program, with the goal of "demonstrating secure exchange of information at multiple levels of classification over unsecured military and commercial networks (e.g., Wi-Fi and cellular) using a heterogeneous mix of devices from tactical radios, to laptops, to handheld devices" (Defense Advanced Research Projects Agency (n.d.): n.p.; Paris, 2018: 160). He noted, that even though it was not their specific goal to partner with the military, "it turns out that in certain environments [in-network content storing] it is really very important, including the Web but also more in a military context and so on" (XIA PI, personal communication, 30 October 2017). XIA and participants from MF also referenced separate partnerships with the Chinese company Huawei (Paris, 2018: 154, 159). NDN-affiliated project Content Centric Networking was bought by the US networking giant Cisco (pp. 37, 151). These partnerships suggest the directions the FIA projects will take after the NSF funding dries up and what types of capacities they will be building out. Partnering with defense agencies and corporate entities is standard in the history of Internet infrastructure development (Abbate, 2000; Clark, 2018). We can see it continues into the FIAs.

These responses suggested the FIAs engage in technological development as a kind of translational work in which project narratives privilege technical considerations, like efficiency, over social and explicitly political ones like monetization, control, and rights (Paris, 2018). What remains unexpressed is that while privileging technical considerations, social issues like corporate and governmental control over information in the forms of surveillance and

exploitation fall between the cracks, un- or underdiscussed in the construction of these new technologies. The NDN and XIA PIs' remarks show and provide examples of the engineers' inability, or disinterest, in conceptualizing alternative use cases, social needs, or even aesthetic options that depart from how these have existed in the past and present, or in attending to social and ethical constellations of power and inequality in ways that were largely absent from Internet history. The FIA projects' primary focus on technical concepts of efficiency and managing latency, with little attention to novel future use cases, suggests a lack of imagination and interest in developing tools that subvert dominant engineering rationality (Paris, 2018). These unilateral, intransigent concepts of time as a resource, such as technical "efficiency" and "low latency" transmission scenarios for time-critical applications like video supersede all other possible values that could be equally, if not, more important in developing future-facing Internet infrastructure.

Those working daily on subproject design, however, do admit that the larger projects are far from developed enough both in social structure and technical capacity for them to fully achieve their goals at the subproject level. They suggest that even the modest project goals will require considerably more time and investment of resources to achieve than project PIs had expected or ever willingly concede.[3] Much as private sector tech firms are accused of obfuscating their goals, large technical research projects also manage expectations within subprojects, larger projects, and across the wider development community to attract funding by making vague assertions about their capacity to produce viable products (Paris, 2018).

We can understand these observations in context of Jasanoff's and Kim's (2015) concept of "future imaginaries," which suggests that notions of what technological futures might be possible are collectively held and performed at the level of governance. These futures are ensured through funding and other types of formal and informal governance—in the case of the FIAs, the NSF funding initiated and organized the work of protocol development, to some degree. As these projects leave the auspices of the NSF, the US Department of Defense, Huawei, Cisco, and other organizations will shape what is possible for these new networking protocols. With the time constructs framework, we can understand how the future imaginaries displayed in the FIA projects reify, and to some extent are constrained by widely held cultural notions of the possibility for the technological future from the past. We see that then, as now, militarized, market-based ideology undergirds the construction of these communication infrastructures, which carry serious consequences.

Technics of time and power

Labor, commodities, and exchange are all instrumentalized with relation to metrics of time within the broader political economy. Marx (1867/1990) wrote extensively about how use value and wages in a capitalist system are a function of

labor time. Horkheimer and Adorno (1944) spoke on how the expanding interwar and postwar "culture industry" served the dual role of commodifying leisure time and pacifying workers. Noble's (1986/2013) study of the forces of production in metal working introduced a concept of "engineering rationality" that considers efficiency as the erasure and extraction of humans from the process of technical production. Stiegler's (2001/2010) philosophical analysis of time and technology and Wajcman's (2014) treatise on acceleration from the perspective of social shaping of technology draw from these to argue from different vantages the market-driven political economic structure of contemporary society is predicated on standardizing and ultimately flattening multiple conceptions of time. This can be seen in conjunction with Lyotard's declaration that, "Technology is therefore a game pertaining not to the true, the just, or the beautiful, etc. but to efficiency: a technical 'move' is 'good' when it does better and/or expends less energy than another" (p. 44; Paris, 2018: 13).

Wajcman, like Lyotard, Virilio, and Stiegler, points to how the introduction of computers in public and private administrative functions in the early 1980s was accompanied by cultural, political, and economic changes brought by deregulation and globalization that emphasized the commodification of information, as networked computation technologies have made information increasingly programmable, efficient, and economically valuable. In this sense, from the perspective of the social shaping of technology, technology's efficiency necessarily promotes capitalist political and economic concerns, and vice-versa. The way efficient measurement, distribution, and allocation of resources is privileged as the primary goal of technology explains why human life, interaction, and communication are increasingly understood as commodifiable resources. These problems of progress are justified or subordinated as unimportant or insurmountable because of what Lyotard called metanarratives around the modernist drive toward technological and scientific progress, which are powerful intertwined teleological myths that promise ultimate freedom, the erasure of social problems, and the achievement of a perfect understanding of the world (Paris, 2018: 13).

Such promises abound in the FIA projects that doubly betray a drive toward capitalist efficiency and rendering the duration of human life as an exploitable resource. In the FIAs, NDN made the most explicit promises. At a 2015 NDN community meeting, NDN project leader and visionary in the history of developing networking protocols, Van Jacobson, asserted, "name-based data could be a godsend for exploiting Big Data, including information served up by a sensor-based IoT, and for supporting emerging applications, such as video streaming like we have never seen before" (UCLA REMAP, 2015; see also Brown, 2015: n.p.; Paris, 2018: 76–77). Jacobson's declaration demonstrates an awareness of the market interest in then-hot topics like "Big Data" and "IoT" and positions NDN was able to frictionlessly exploit, manage, or capitalize on those trends.

The daily work of project development engages temporal concepts of reduced friction, or user-facing speed, insofar as it is built to afford "emerging applications like video streaming," ostensibly bringing the data closer to the user and removing technical overhead within the infrastructure to reduce friction between the users and the data they seemingly desire. However, within NDN, packet size and hardware constraints present difficult technical complications for the "reduced friction" of their theoretical designs. The NDN developer noted that because the packet header for the data alone is about 30% of its size, he and others are not as interested in optimization. Just getting the applications to work is tricky enough (personal communication, 2 August 2017; Paris, 2018: 76).

Brittle technical systems with their own time-based concerns impede user-facing efficiency, speed, and reduced friction of these new protocol projects. An application developer working with XIA articulated how many material and social infrastructures stood in the way of developing an efficient demo to run on XIA as he noted that hardware vendors do not want people tampering with the hardware, so they lock it. Bypassing those locks without vendor support is not easy. Then, he noted, physical buildings and policies surrounding their use present problems with the work they do, as he noted that even dealing with parking services when testing their vehicular video demo required extra permission and explication as they drove around for hours, slowly, with strange looking technical equipment. (XIA, 2018 Developer, personal communication, 28 February 2018; Paris, 2018: 119–120)

Sociotechnical systems arise from existing physical infrastructure, routers, institutions, and other protocols and standards. Each of these exerts a certain amount of friction into the networking protocols. In addition, considering the NDN application developer's understanding of users' affinity for linear time and even the perceptual capacities of the users, all have their own built-in ways of regarding time which render them resistant to effectively reducing friction within these systems. It is in this way that the world pushes back on what Heidegger would call the enframing of technology and that poses some difficulties to the mobilization of technology's essence and exposes technology's enframing. Wajcman (2014), Stiegler (2001/2010, 2010), Noble (1986/2013), and adherents of feminist STS (Mazmanian, 2012; Star and Bowker, 1999; Star and Ruhleder, 1994) would say this juncture allows us to see where ruptures can be opportunities to inject different values and practices into technical systems. Latour would note that these processes of reducing friction, promoting efficiency, and injecting new values in sites of rupture would remain invisible unless one investigated the laboratory to understand how modernist myths are operationalized and executed by people (Paris, 2018). The next section looks to "the laboratory" as it exists in the study sites at hand, in the granular work of designing time and temporality into the technologies themselves.

Spatializing time

The concept of "configuration" from feminist STS takes up the question of how such bounded categories of the social and the material are agencies that are figured together and co-constructed (Barad, 2003; Cetina, 1997; Haraway, 1980/1991; Suchman, 2000). The concept of configuration aligns closely with and is contemporary to Stiegler's (2001/2010) conception of how human agency shapes and is shaped by technical systems, which presents an opportunity to create new futures that might be more hospitable. Stiegler (1994/1998) dedicates an entire book of his *Technics and Time* series (Stiegler, 1994/1998, 1996/2009, 2001/2010) to engaging and critiquing Heidegger's technological determinism. This determinism was critiqued more indirectly by Latour in *Pandora's Hope* (1999) and elsewhere (Latour, 1993a, 1993b; Serres and Latour, 2004; Paris, 2018). Stiegler argues that technics of time are the constellation of the practices, skills, and externalized tools of apprehending and shaping temporal relationships, such as various modes of communication from spoken language to the Internet, which shape—and are shaped by—human subjectivity. But Stiegler and Latour differ on the ends of this process. Stiegler focused on how the subjective apprehension of technologically mediated time affects society (Paris, 2018). Latour is interested in describing social processes and practices around technologies as they unfurl, with less attention to human subjectivity (Paris, 2018). Feminist STS bridges the two as it roots the notion of the configuration in the co-construction or mutual shaping of humans' agency and technical systems; the social and material do not exist without one another.

In Stiegler's account, Heidegger incorrectly emphasizes the artificialness of technologically mediated time and does not account for the fact that human subjectivity is present as these technologies are intentionally developed. Stiegler notes that this is a problem because under such a technologically deterministic perspective, there are few, if any, routes to a better future. This project seeks to understand the agency of those humans who develop technologies to show, as Stiegler suggests, that while there are material technological objects that enact agency of their own, humans—engineers and developers—despite being overwhelmingly bound to existing ideologies around time and infrastructural design, exert their agency as they negotiate with these ideologies, suggesting the possibility that given the right conditions, they might be persuaded to think altogether differently about the infrastructures they build and the process by which they build.

One instance of human agency in developing the temporal aspects of the FIA projects at hand can be seen in the spatialized representations of time in developers' diagrams and illustrations, which are intended to communicate how computational and network processes are engaged and ordered for applications. Although these applications were, as mentioned in the last section, intended to

demonstrate that the new protocols can change how users experience Internet-mediated environments, they express themselves using these user-facing applications and still regard time as linear and uniform. NDN's Flume application featured in Figure 2, depicts the UI to engage real-time audiovisual flows in a strictly linear way, much as those UIs of other video conferencing applications that already exist, rather than engaging other new and possibly exciting possibilities for organizing temporal audiovisual flows. Flume's developer working at the REMAP at UCLA explained that he organized the interface in this linear way because it is what people are used to (personal communication, 9 March 2017; Paris, 2018: 148).

In the case of MF, the content naming system (CNS) featured in Figure 3 considers how temporal duration carries different consequences and is thus felt differently by different people placed in certain scenarios (Paris, 2018: 98–103). The postdoctoral researcher who designed the MF CNS intended the messaging system to be used for first responders communicating in large-scale emergencies, in which individuals and first responders in different areas of proximity would require different time-sensitive information. Some who might be, for example, trapped in the immediate area of an emergency, such as an earthquake or a bombing, could be located through their mobile devices and interconnected sensors. For these individuals, mere moments may carry life or death consequences. There is also the need to order, for example, the dispatch of fire engines that are already in proximity to the scene of the emergency as opposed to others that are farther away. Here, the designer notes that in particular, sending messages to specific people based on their roles and proximity is a form of content-oriented messaging. Figure 3 illustrates the role- and location-specific structure by which messages can be sent through MF's architecture. The MF designer argues that IP is incapable of this type of targeted messaging. The MF CNS for natural disasters notes that MF can be more beneficial than IP because

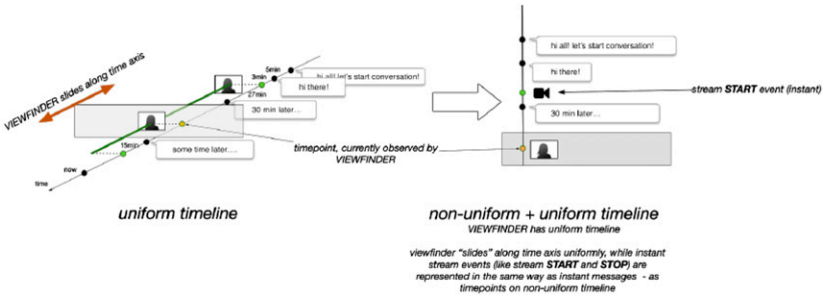

Figure 2. Merging continuous streams with instant events on a timeline. Reproduced with permission from Gusev (2017): 7; Paris (2018): 86.

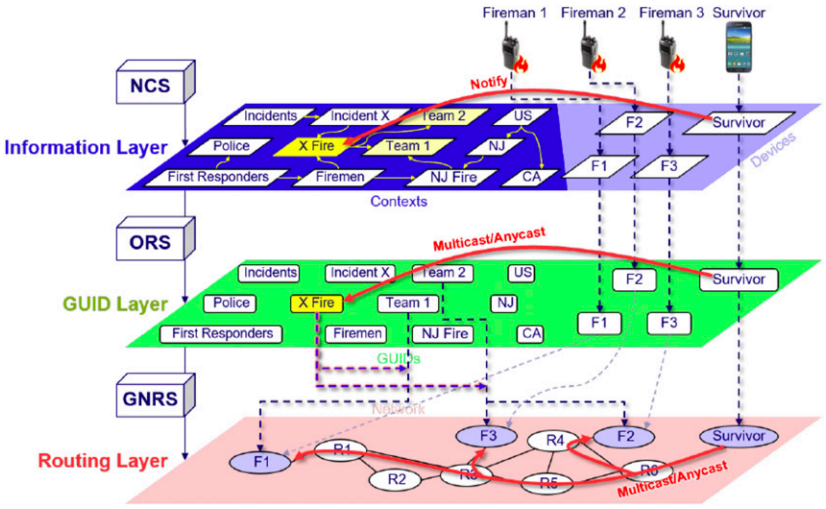

Figure 3. Content naming system in natural disasters (Mobility First, 2018b: n.p.; Paris, 2018: 103).

it allows for "more reliable and efficient" transmission of data, and it can store messages in the network and push those messages as any of their intended recipients become available (personal communication, 9 March 2018).

The way in which messages and operations are ordered and issued in time-sensitive scenarios like large-scale emergencies highlights how FIA engineers think of time as a result of their training and the technical, economic, and social demands that shape and constrain their work practices. It also suggests that this understanding of time as an instrumental vector shapes what types of user-facing temporal experiences engineers conceive as desirable or possible. Perhaps, there is some notion of care being advanced by the developer in his CNS for emergencies. Flume and the CNS are more focused on real-time applications that unilaterally shape the experience of time that is predicated on technical efficiency, without much critical interest in the way the aesthetic benefits are engaged at the interface. It betrays a sort of "real-time" mindset that application developers, building on top of these new protocols, assume as a given and a necessary benefit of the new protocols to highlight in applications.

Through modernity, modalities of time have been created and instantiated in technology to control and co-opt nature and human activity (Latour, 1999; Lyotard 1979/1986; Wajcman, 2014; Innis, 1951/1999; Heidegger, 1955/1977; Stiegler, 1994/1998, 1996/2009, 2001/2010). These modalities of time and the practices they foster have enmeshed human time with machine time ever more

tightly, to the point that this human-technical assemblage decreases humans' capacity to interact with one another by making that interaction appear inefficient, impractical, or aesthetically undesirable. This is the technocratic mode by which people lose critical subjective abilities; in Stiegler's work, the most important of these subjective capacities lost is the ability to *care* for anyone or anything beyond the individual self at the present moment. Stiegler's notion of care aligns closely with the feminist STS concept of "configuration" focusing on the sociomateriality of the development, deployment, and use of technical systems and foregrounding human agency to change practices over time (Barad, 2003; Cetina, 1997; Haraway, 1980/1991; Suchman, 2000). Configuration in conjunction with the feminist ethic of care, is a productive site for reimagining sociotechnical relationships, as we envision technical systems that do not just reify the technocratic and often harmful structures of the past, but endeavor to reconfigure these relationships to bring about meaningful technological change that centers justice over efficiency. This type of reconfiguration requires conceptualizing a more just future to guide human decision-making around technology, information, and power relations brokered through governance structures.

Conclusion: Time constructs

I have provided a few junctures at which we can see *how* time has become built into the protocols set to become the backbone of the future Internet as these projects are on the precipice of unknown and perhaps unknowable futures. The discourse of time emerges as respondents describe how they build protocols and applications at the levels of code and hardware and how they grapple with funding, internal directives, and factors external to the project. Through this article, I have demonstrated that time can be investigated as a design ideology as it is an often unexamined factor that shapes how we think about technology, how technologies are built, and how these engage with sociotechnical imaginaries of what is possible.

This article shows how even projects that begin with value-centered goals may have trouble adhering to them if developers are not forced to confront power relations or build in solidarity with their users. Although the NSF FIA engagement with the VID Council and its "anticipatory ethical projects" was a good start, we need more sustained and robust reimagination of the training, funding, and/or goals of technological development projects of the type Costanza-Chock (2020) writes about in *Design Justice*. We must meaningfully attend to the harms of structural power as it manifests in technological development, deployment, and use, and reconfigure these technical systems to foster notions or relational justice and care, perhaps in protocol projects that were cooperatively developed and governed by a diverse base of users. Revealing the development process of these nascent protocol projects illuminates how these protocols have been built to solve a simple efficiency problem, while following the modernist impulse to build

things to remedy contemporary hopelessness, instead of building human relationships and ways to share visions for alternatives of many sorts.

There is discursive and explanatory power in breaking down time as a design ideology that manifests at the technical, social, and institutional levels. Here, we see how the components of the discourse of time within the "time constructs" is a framework that shows us how time is a design ideology that fits with other contemporary design ideologies or dominant assumptions about technology held by those producing them, including but not limited to, that widely held notion that the primary goal of technology should necessarily be to extract value. Revealing the discourses of time within the time constructs framework points to places to look to better expose these technical design ideologies and think of ways to reinvent or reconceptualize them. This last step is absolutely crucial if we are to keep technology from completely foreclosing on a future in which positive concepts of care proliferate, and in which people can be free from surveillance and market-driven subjugation, with the ability to determine their own modes of governance.

More than just pointing to ways to find time in its multiple manifestations in technical projects, the time constructs framework provides a way to understand the sociomateriality of time in the processes of building technical infrastructure and how it binds together cultural, economic, and discursive power. We might consider the time constructs framework a perspective or partial stance from which we can better critique contemporary technological projects so that we can start to imagine a future in which technology is not built to exploit and subordinate the masses to the benefit of the few.

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Notes

1. "The essence of technology is by no means technological. When we are seeking the essence of "tree," we have to become aware that what pervades every tree, as tree is not itself a tree that can be encountered among all the other trees" (Heidegger, 1955/1977: 4). "Translator William Lovitt noted that in English, *wesen* translates as the noun *essence* but does not mean what something is, but rather what it means and how it endures" (Paris, 2018: 8).
2. *Gestell* used in the original is translated into English as *enframing*, which means an active gathering of both humans and things, assembling, and ordering as it does so (Heidegger, 1955/1977; Paris, 2018).
3. Subproject designers and developers were grad students and contract workers. The ones I spoke to wished to remain on background for this information as they are among the most precarious workers within the entire project.

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