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IF NOT, ELSE: STANDARDS, PROTOCOLS, NETWORKS AND HOW THEY MAKE A DIFFERENCE

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The contemporary Internet's "network of networks" has become infrastructural to our lives. The Internet is a stack of physical, data link, network, transport, and application layers which all have unique rules and roles. While many see Internet infrastructure as a foregone conclusion, Paris, Cath and Myers West (2023) write "Internet infrastructure is built slowly, over time, protocol by protocol, in response to many different technical, social, political, environmental, and economic imperatives". Even as the particular model of the Internet we are all accustomed to has become the standard, other attempts proliferated and eventually failed, as did the Soviet Internet (Peters 2016), and as this panel highlights, the Internet is still ever-evolving.

The project of this panel is to trace alternative, parallel, and emergent network models, standards and protocols, theorize their impact as they appear in different places, spaces, and contexts, and gesture towards how the Internet might be different. As critical internet studies have since the early 2000s shown, computational standards, protocols, and network diagrams are more than technical details, they have the power to shape and structure the conditions for our socio-cultural lifeworlds (Galloway 2006; Chun 2008; Bratton 2016). As Gehl (2014) puts it: "interfaces, database structures,

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mechanisms of connection all shape social activities”. Change an element in the stack and a different connectivity, a different future becomes possible.

The papers of this panel introduce and discuss five different and potentially revolutionary network technologies that manage and organize our online lives.

Robert W. Gehl’s paper represents a media genealogy of ActivityPub – a protocol that enables the Fediverse, a collection of social media sites that can communicate with one another. The author argues that ActivityPub was not produced through an instrumental process, but was the result of accidents and coincidences. The accidental nature of the protocol, coupled with its being authored by self-identified queer and trans developers, has put it on a collision course with both the “standard” approach to standards production as well as mainstream, corporate social media.

Tero Karppi’s paper focuses on the design of the Interplanetary Internet and the idea of delay-tolerant networking fundamental to operating in outer space. The author maintains that when delays are central to a network model, we are forced to rethink how our connections are maintained and organized in the future. Delay-tolerant networking is thus not only a technical solution for a communications system but a control protocol through which interplanetary life can be managed.

Britt S. Paris’ paper is also focused on the temporality of networks. The third paper examines how time is enacted as a design ideology in the course of the development of a future internet architecture protocol project: named data networking (NDN). This work locates aspects of the sociomateriality of time in the processes of building Internet infrastructure and demonstrates how it binds together cultural, economic, and discursive power. The paper argues that thinking through time as a design ideology can be useful in projects imagining how the Internet might be built to engender and support different values than market ideology.

Sarah Myers West’s paper looks to the Crypto Wars of the 1990s as a moment where things could have been otherwise; comparing the examples of PGP and RSA encryption software and how they shaped the nature of our networked systems. It argues that a combination of regulatory and commercial interests influenced the development and use of cryptography in ways that facilitated the development of e-commerce, but left private messaging in dubious legal status.

Collectively the papers investigate alternative and emergent trends behind the Internet and its network models, standards, and protocols. The protocols and rules for network connection, standards bodies, and modes of governance are critical to maintaining and upkeeping a network. Their impact, however, is not merely technical but potentially world-changing. The papers direct their critical gaze towards the development of these technologies and what their introduction to our world potentially entails. By focusing on projects of past, present, and future and by exploring the Internet’s deepest sociotechnical layers, the panel critically dismantles the commonly-held idea that the Internet is a monolith and illustrates that the history of the Internet is still being written.

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THE ACCIDENTAL PROTOCOL: A CRITICAL GENEALOGY OF ACTIVITYPUB

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Amy Guy's role in Web history was the result of an accident. While procrastinating on writing their PhD thesis in the early 2010s, Guy was poking through the World Wide Web Consortium website and clicked on "standards groups." A bit more poking led Guy to the Social Web Working Group (SocialWG), a group seeking to create W3C standards for social media. Guy kept going, clicking on the SocialWG's "Join" button.

A few hours later, Guy was a member of the SocialWG. Despite never having participated in a standards-setting process before, Guy would go on to be one of the key members of the SocialWG, ultimately becoming a co-author of ActivityPub, the most important output of the group (C. Lemmer-Webber et al. 2018).

ActivityPub is the protocol that enables the Fediverse, a collection of social media sites that can communicate with one another. The ActivityPub-driven Fediverse is now one of the most viable social media alternatives (Lovink and Rasch 2013; Gehl 2015) to come along in the past decade. Currently, the Fediverse is getting public attention and traction because it offers a way out of corporate social media's mess of mercurial billionaires, shoddy moderation, and surveillance capitalism. For example, after Elon Musk's purchase of Twitter, millions of people left Twitter for Mastodon and other alternatives (Nicholas 2023; Hoover 2022). In fact, the Association of Internet Researchers itself will host its own Mastodon social media instance (Gehl 2022).

But neither Guy's participation in the SocialWG, nor Mastodon and the Fediverse itself, was guaranteed to happen. Guy's participation was entirely an accident, because if their university (University of Edinburgh) did not happen to be a World Wide Web Consortium member, Guy's clicking on "join" would have been ignored by the SocialWG. (As Guy told me in an interview, they did not know this at the time).

And, if Mastodon had not adopted ActivityPub at just the right moment in 2017, ActivityPub itself would have never been finished (Rochko 2017). Consider the "Mastodon extension": the Social Web Working Group's chartered period was reaching its end in 2017, well before Guy and their co-authors could complete the process of making ActivityPub. However, an outside party provided a lifeline. The Mastodon project – at the time gaining popularity as a "Nazi-free Twitter" (Jeong 2017) – adopted a pre-standardized version of ActivityPub. This was not the plan, but with Mastodon on board, the SocialWG now had a popular implementation of their nascent standard and were able to get a rare deadline extension from the W3C.

Critical Genealogy

This presentation offers a critical genealogy (Koopman 2013) of ActivityPub, the accidental protocol. As Chandra Mukerji argues, genealogies are catalogs of "utility, habit, forgetfulness, and error" (2007, 53). I would add "accident" to the mix. Critical genealogy requires us to attend to often overlooked or taken-for-granted habits, errors, and accidents in order to better understand the systems of power we encounter. Drawing on feminist and queer theory, Verena Erlenbusch-Anderson notes that critical genealogy is the use of contemporary philosophical concepts to "to interrogate the historically specific forces and relationships underpinning our political present" (Erlenbusch 2017).

In terms of data, the presentation draws on oral histories with the developers of the ActivityPub and Mastodon, close reading of archival materials (such as the meeting minutes of the SocialWG), as well as critical code analysis (Fuller 2017; Bucher 2018) of the ActivityPub protocol.

Queering Technology by Accident

In the case of technical standards production, standards such as ActivityPub might be naively seen as linear, commonsensical crystalizations of already existing practices. What ActivityPub teaches us, however, is that accidents can equally lead to standardization. And, perhaps, *non-standard* standardization.

In other words, at the center of the accidents that produced ActivityPub is queerness. Four of the five ActivityPub authors self-identify as queer or trans (M. Lemmer-Webber and Lemmer-Webber 2022), and the early Mastodon developers were queer and trans folks seeking to escape harassment on Twitter (Caelin 2022). However, queer and trans folks have been traditionally written out of technical progress (Dunbar-Hester 2019). Which begs the question: If ActivityPub was the accident, and if queer and trans developers caused the accident, what was the intended outcome that was planned? What outcome did the accident prevent?

As critical infrastructural scholar Susan Leigh Star argues of those marginalized in technological development, “we are the ones who have done the invisible work of creating a unity of action in the face of multiplicity of selves, as well as, and at the same time, the invisible work of lending unity to the face of the torturer and executive. We have usually been the delegated to, the disciplined” (Star 1991, 29). Rather than being delegated to, queer and trans accidental authors of a non-corporate social media system disrupt the normal conception of “standards.” In the case of ActivityPub, the resulting standard attended to issues such as safety, personal privacy, and content moderation which distinguishes the protocol from the worst problems of corporate social media.

As we seek to move past corporate social media, we have the accidental authors, such as Guy, to thank for new ways to socialize online.

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CONTROL PROTOCOL: INTERPLANETARY INTERNET AND DELAY-TOLERANT NETWORKING

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The interplanetary internet turns 25. In 1998, at NASA’s Jet Propulsion lab a group of scientists, including Vinton Cerf, were asking “what we might need for space exploration 25 years from now?” (D’Agostino 2020). One thing became soon obvious: the same internet technology that connects people on Earth, does not work well in outer space. The terrestrial internet cannot handle delays, disruptions, and disconnections caused by the long distances between nodes and planets and other objects that obstruct signals. As Cerf (D'Agostino 2020) notes, this is because the terrestrial internet has a very specific end-to-end architecture: “To transfer data on Earth’s internet, TCP/IP requires a complete end-to-end path of routers that forward packets of information through links such as copper or fiber optic cables, or cellular data networks” .

This paper seeks to render visible the differences between the two parallel internets, terrestrial and interplanetary. I begin my exploration by analyzing the OPSCOM-1 mission that took place on the International Space Station (Sarakanti et al. 2015). I follow Lisa Gitelman (Gitelman 2006, 1) who argues that to understand how media becomes what it is, we should direct the attention to “looking into the novelty years, transitional states, and identity crises of different media”, which “stands to tell us much, both about the course of media history and about the broad conditions by which media and communication are and have been shaped.” In practice, I will do a close reading of the public documentation of the OPSCOM-1 mission including NASA and ESA websites, scientific papers, and press releases. In the context of the interplanetary internet, this documentation gives an opening to a stage where new network protocols are being developed.

Opscom-1

November 8, 2012, NASA (Kraft 2012) releases a press release that declares that “NASA and the European Space Agency (ESA) successfully have used an experimental version of interplanetary Internet to control an educational rover from the International Space Station.” This is the OPSCOM-1 mission. Its main test subject was the idea of delay-tolerant networking and the use of a bundle protocol on which the former is based. Delay-tolerant networking was first designed for outer space and is “an end-to-end architecture providing communications in and/or through highly stressed environments” (Scott 2007). This network works in a situation where clear end-to-end pathways are anomalous and delays, disruptions, and disconnections are the norm. This model is premised on the capability to establish paths that relay information despite a fixed location of the endpoints or their constant availability.

RFC5050 gives the specification for the Bundle Protocol. Bundle Protocol “sits at the application layer of some number of constituent internets, forming a store-and-forward overlay network” (Scott 2007). “Since in interplanetary network environments continuous end-to-end connectivity cannot be assumed, the bundle layer must have the capability of storing data bundles as well as their address and route to their final destination until they can be forwarded to the next hop and so on” Jaiswal et al. (2013) explains.

The rover of the OPSCOM-1 mission is built from LEGO NXT 2.0 Mindstorms kit and equipped with a Beagleboard computer. Astronaut Sunita Williams on ISS controls the rover through a non-real time mode by setting waypoints on a map and giving the device sequences of movements (Martin et al. 2013) The rover then drives through a test course in Germany and takes and sends snapshots of the execution along its way

(Martin et al. 2013). The first two target runs are successful. The rover moves smoothly between the waypoints. But the third one fails. The failure of this experiment does not happen in real-time but after the fact. This mission is less about controlling the robot from outer space and more about developing a mode of control that deals with issues that prevent real-time communication. It is not the rover that fails but the network model. The things you can do in real-time are not the same as you can do with a non-real time model.

Control

I argue that the non-real time function of the interplanetary internet forces us to revise how we have come to understand control through the TCP/IP-based logic. It is different than both the Foucauldian panopticon in the form of enclosed spaces – a "gridlocked architecture of Euclidean positions and points" as Luciana Parisi (2013, 101) calls it and the network of real-time modulation that Deleuze (1995) first in the mid-1990s, Galloway (2006) in the 2000s and then many after so accurately described as a network of continuous modulation based on relational data of dividuals and their movements through different societal structures in time where the predicted potential of becoming is very literally based on points on the grid (Amoore 2011). The interplanetary internet due to its bundle protocol model resists the logic of such topological and networked forms of control. We do not know the points of the nodes in the matrix, not all the time. Delay-tolerant Networking and the Bundle protocol then become diagrams for a new logic.

Sarah Sharma maintains that (2014, 138) "power coalesces temporally". In the case of the interplanetary internet power also coalesces temporarily. The temporal term for thinking about control is that of non-real time of the interplanetary internet in contrast to the continuity of the terrestrial internet. The difference between the old and the new network model culminates in how we understand nodes through connection. The terrestrial network's model focuses on points and topologies that become manageable through continuous connectivity. The interplanetary network model of non-real time control, in contrast, is not a point-line system, but a system of temporal relations that can overlap, be conjoined, and constitute new relations based on the randomness of connections that appear. If we are working with nodes that come together only temporarily and are not under continuous control, we can follow Ulises A. Mejias's (2013, 153) proposition to: "shift your attention away from the nodes, to the negative space between them". He (Mejias 2013, 153) argues that these spaces are not empty as the network diagrams of the terrestrial internet suggest "but inhabited by multitudes that do not conform to the organizing logic of the network". It is from these spaces and how these spaces organize our relations that the alternative social and political ways of being (de Vries 2019) and the revolutionary potential of the interplanetary internet can be found.

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FAKE NEW FUTURES: TIME AS A DESIGN IDEOLOGY IN INTERNET PROTOCOLS

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The neoliberal drive to privatize public infrastructure and public-serving institutions is intertwined with ongoing, overlapping social, political, and economic crises that continue to shape Internet infrastructure. This phenomenon compels calls from interested parties to reimagine and rebuild Internet infrastructure (Fisher 2007, Ali, 2021, Tarnoff 2022), resulting in a dazzling array of projects that, for the most part, present rehashed visions of the future from the past that subvert the political economic realities of Internet infrastructure and push for more intensely privatized options (Greene 2022, B. Paris, 2020), often under the auspices of increased speed and efficiency of communication as a benefit to users.

Many studies on contemporary time and acceleration in contemporary information and communication technology gesture toward time as a design ideology (Galloway 2004, Hassan 2007, Stiegler 2010, Mazmanian 2012, Wajcman 2014, Vostal, 2016). This paper 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 one Internet infrastructural project, a new protocol called Named Data Networking (NDN) to replace Transmission Control Protocol (TCP)/Internet Protocol (IP) to transmit and route data based not on addresses, but on naming specific pieces of data and tracking them as they travel between named entities

Beginning in 2007, NDN was funded by the National Science Foundation (NSF) as one of several future internet architecture (FIA) projects to replace TCP/IP. During their 11 years of existence, the FIA projects generated discussion regarding how protocols can foster the public good as they were mandated by the NSF to engage with the Values In Design (VID) Council (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 that form the foundation of these research projects are antithetical to the public good, and suggests the benefits of reimagining protocols that correct the forms of control and capture at the application level.

Interview and document data from NDN gathered and analyzed from 2016-2021 pointed to themes that coalesced around these broad categories—(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.

Time enmeshes

The "future" is explicitly signaled in the name of the funding program that made these new protocol projects possible. 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 (B. Paris 2018 2020 2021). Interestingly, their articulations of the future were dependent on past protocol development work. The future imaginaries presented by NDN project leaders, 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, 2020). This response and other project respondents' articulated expectation of future use contexts rested on explicitly technical advancements, like protocological efficiency, and denied any meaningful agency to others, users, the VID Council or others to change this "fact". 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 appropriate social ideals (Paris 2018, 2020).

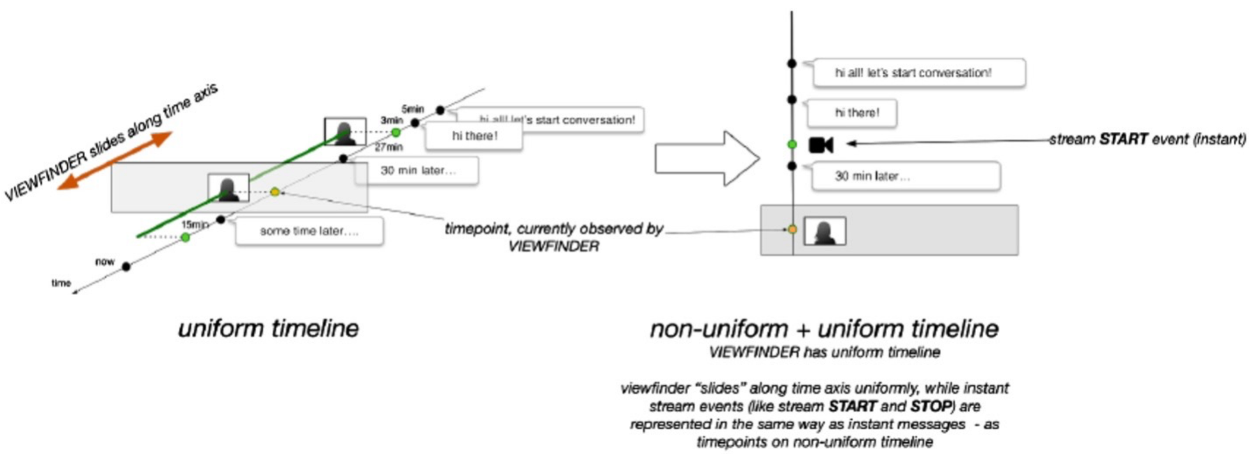
Technics of Time and Power

In the FIAs, NDN made the most explicit promises around speed and decreased network latency that doubly betray a drive toward capitalist efficiency and rendering the duration of human life as an exploitable resource. 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, 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. And this is attractive to military and corporate entities. At the same time as enabling efficiency and speed of communications among named objects, NDN has storage features and the ability to hold packets inside the network until they can be delivered, using a technique called Delay Tolerant Networking (DTN)(Paris, 2018), discussed above, and that allows packets to be stored in-network which might allow for circumvention of some of the “Landlords of the Internet” that exact rents from Internet carriers (Greene, 2022). Nonetheless, at the end of their NSF funding cycle, NDN began partnering with Cisco, Huawei, and the Department of Defense.

Spatializing Time

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 present time in predictable ways, and do not offer any affective relationality to it, like physical closeness, or say, human centered urgency, as say would happen in a natural disaster. NDN’s Flume application featured in Figure 1 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 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).

Figure 1. Merging continuous streams with instant events on a timeline. Reproduced with permission: Paris 2018, 86.



The Sociomateriality of Time and the Need for True People-centered Internet Protocol Projects

More than just pointing to ways to find time in its multiple manifestations in technical projects, this brief meditation hopefully helps us better understand the sociomateriality of time in the processes of building technical infrastructure and how it binds together cultural, economic, and discursive power. Revealing the discourses of time points to places to look to better expose these design ideologies as they relate to market ideology and think of ways to reinvent or reconceptualize them. This is 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.

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RENEGADE INFRASTRUCTURES: COMMERCE AND POLICY IN THE CRYPTO WARS 1.0

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In 1992, WIRED Executive Editor Kevin Kelly wrote that encryption was "the necessary counterforce to the net's runaway tendency to connect everything. It is a technology of disconnection. The net says 'Just connect.' The cipher says, 'Disconnect'…A cipher is the yin for the network's yang, a tiny hidden force that is able to tame the explosive interconnections born of decentralized, distributed systems" (Kelly, 1993).

Thirty years on from Kelly's writing, the harms of unbridled connectivity are abundantly clear, characterized by the dominance of surveillance-based business models and the unchecked spread of false and hateful information (Zuboff 2015, West, 2018, Donovan, Dreyfuss & Friedberg, 2022, Marwick & Lewis, 2017). The push to connect has been driven largely by corporate interests, serving largely to concentrate control in the hands of a small number of tech firms that have both the capacity to collect the massive amounts of personal data produced through such systems and the means to process this data (Whittaker 2021). And while encryption is squarely embedded throughout much of our Internet infrastructure – protecting the security of web browsing and digital transactions, securing data flows and e-commerce – law enforcement agencies seeking to expand their surveillance capacities continue to contest the legality of encryption *for communications* in several jurisdictions (Pfefferkorn 2020).

This presentation theorizes the radical potentials of encryption technology as a counterforce for connectivity. It seeks to answer the question: how did the internet become safe for companies, but not for the rest of us?

Answering this question took me to archives across the country and conferences in the US and Europe where technologists and advocates worked on building privacy-protecting tools, and particularly tools that rely on *encryption* - a process, technical artifact, and infrastructure that enables the transformation of a message or data into code inscrutable to anyone save those with the key to unscramble it. For these technologists and advocates, encryption plays an important social function under surveillance capitalism - it can grant individuals space to disconnect, or to regain autonomy around *how* and *to whom* we connect. As such, encryption is a form of communication, with mutual relationships and trust paths built into its very architecture.

Privacy on Public Networks: Encryption and Imbrication

The Crypto Wars of the 1990s were a critical moment to question whether and in what ways encryption would be incorporated into the rapidly growing Internet. Drawing on archival research at the Computer History Museum, two critical points of evolution over the course of the 1990s surface: first, a company called RSA became the leading provider of cryptographic algorithms for software publishers as a result of the US government's reticence to license strong encryption and the company's aggressive policing of its patents. Second, an open source alternative, PGP, emerged during this time that offered a more privacy protective alternative, but a legal battle prevented widespread use. In combination, this meant that cryptography was built into internet infrastructure as a default in certain ways – such as the security protocols that would enable e-commerce to grow - but not in others, like privacy of online messaging.

This history illustrates the process of imbrication, or how social and material agencies become entangled in sociotechnical systems (Leonardi 2012). The case studies of RSA and PGP illustrate two distinct types of entanglement: first, they demonstrate how an author's intentions can be persistently embedded in the structure of software code: RSA was primarily designed for commercial use from the outset; though the company later sought to cultivate a reputation as an advocate for the rights of software publishers, it was always, first and foremost, designed for corporate adoption. By contrast, though PGP developer Phil Zimmermann hoped to make money from his software, it was always designed for the purpose of protecting users' privacy. In both instances, the intentions of the authors had a downstream effect on how the code was used, accelerated by influences and pressure from a variety of market and regulatory actors.

Second, these cases demonstrate the combined force of the market and law in advancing particular uses and understandings of cryptography. By the close of the 1990s, encryption was in widespread use among internet users, but was primarily designed around providing security for financial transactions necessary to make e-commerce possible. While developers like Zimmerman still actively built encryption designed to protect the privacy of users' online activities, this software was pushed to the margins by the active policing of patents by competitors and its unclear legal status.

Untwining the entangled dynamics of market, law, and authorship is particularly consequential for this period in the development of public key cryptography. During the 1980s and 1990s, encryption began to take on the functions of infrastructure – embedded, often invisible algorithms deeply imbricated in securing software code, made necessary for many software systems to 'work'. They are also important forces in structuring society (Edwards 2003). Here, I argue that the particular ways that encryption was built into infrastructure worked to encourage the development of the e-commerce industry, while relegating privacy protective uses to the margins. But infrastructures are also tools in practice, always in the process of becoming, and are mutually shaped by their social and technical dimensions (Star & Ruhleder, 1996). What factors, then, were at work in shaping cryptographic infrastructure in these particular ways?

One possible answer, I argue, is the constant possibility of regulation, a persistent threat that was never definitively resolved. Since the early 20th century, the US government has held an uneasy position with regard to use of cryptography in the public sector. In the 1970s, regulators acknowledged the importance of adopting a standardized method of encryption for the computerized communications of US government agencies and businesses. Recognizing the importance of public trust in whatever algorithm was adopted, the National Bureau of Standards and National Security Agency collaborated with an independent corporation, IBM, in the creation of the Data Encryption Standard.

By the 1980s, the government sought to strictly implement a regime to regulate the export of encrypted software. However, new actors and organizations involved in the development and distribution of cryptographic software made the enforcement of these controls more challenging. The examples of RSA and PGP illustrate the tensions within dual US government interests in promoting commercial enterprise and protecting national security. Ultimately, these resulted in creating a dominant player in the commercialized sale of cryptography in the 1990s: RSA. Zimmermann's PGP opened up a new realm of possibilities for hobbyist cryptographers, but its contested legal status – combined with its complex code and RSA's aggressive policing of its patents – prevented widespread industry adoption.

This resulted in a divide in the applications of cryptography: 'legitimated' commercial applications of cryptography were largely invisible to users, marketed as 'security' but with little transparency as to the inner workings of the cryptosystem. This meant that though the actual number of people using cryptographic tools grew considerably over the 1980s and 90s, for the most part cryptography was an invisible, embedded part of software programs and networked infrastructures. On the other hand, PGP took on great significance for a small community of cryptography advocates, in part because of its legal troubles: Zimmermann and his software developed a 'renegade' status that built cache among a nascent cryptographic community. Ultimately, this established the preconditions for the formulation of a new cryptographic social imaginary.

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