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Protocol power: Matter, IoT interoperability, and a critique of industry self-regulation

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Abstract: This article puts forth the concept of protocol power as the disproportionate influence of dominant platform actors to shape and set industry-wide standards, and thus determine certain rules of inclusion at the technical, existential level of protocol. In this way, protocol power shapes and prefigures dynamics of platform power and intermediation as ever more objects are made “smart” and connected through such standards. To examine protocol power, I take up the case of Matter, an emerging Internet of Things connectivity standard led by Big American Tech promising to make all smart things interoperable across all platform ecosystems in the face of growing critiques from regulators, developers, and users. Increased levels of interoperability and connectivity are opening up new sites of data production and accumulation, and provide more opportunities for service and subscription provision by dominant platforms. This article argues that Matter and its promises exemplify processes of industry self-regulation, networked governance, and power-sharing among dominant actors in the tech industry in efforts to maintain and expand their market and platform power.

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Introduction

The three-arrowed logo of Matter was ubiquitous at the 2023 Consumer Electronics Show in Las Vegas, representing a new ‘universal’ connectivity protocol promising seamless integration and interoperability between smart devices regardless of the platform ecosystems in which they are housed. In recent years, virtually all new consumer electronics have been made connected or smart in some capacity. Seeking ever more sites of user data production and accumulation, as well as the provision of digital services and subscriptions facilitated by connectivity, the Internet of Things (IoT) and smart products for the home have emerged as key areas of focus for the technology industry. A rapidly multiplying number of household objects are now embedded with sensors to record, collect, and transmit various types of data and communicate with other devices and networks in the name of user control, convenience, efficiency, and automation (Crawford, in press-a; Sadowski, 2020a). Such visions of control and seamlessness have taken pride of place in contemporary technological imaginaries, shaping expectations that the future is inevitably ever smarter and more connected (Ferrari, 2020; Halpern & Mitchell, 2023).

Announced in late 2019, Matter is the joint initiative of the Connectivity Standards Alliance (CSA), an IoT consortium based in Northern California, comprising hundreds of companies such as Apple, Amazon, Google, Huawei, Samsung, Comcast, Schneider, and Ikea. Matter provides a unique example of platform ecosystem coordination and collaboration, with over 2,500 engineers from over 600 member companies coming together to design and build it (CSA, n.d.; Schneider, 2023). Based upon Internet Protocol (IP), Matter is proposed to be a ‘universal language’ that will allow IoT devices to communicate with one another at the application layer over local area networks of home devices, promising to reduce demands upon cloud communication and energy consumption and provide greater speed and privacy (Lamb, 2023). One of the CSA’s central goals is, somewhat ironically, to make all smart household objects and appliances as fast, simple, and easy to use as their unconnected predecessors, all while such connectivity produces and collects user data and allows for the insertion of more platform services in the home (CSA, 2022; Fung, 2022b).

The universal standard of Matter promises to make more objects not only smart and thus “platform ready” (Helmond, 2015), but also ostensibly interoperable and platform-agnostic (compatible across platform ecosystems). This standard is a prime example of cooperative or organisational interoperability, where numerous actors come together to make and promote the added functionality of newly interoperable products and services within various proprietary systems (Berg 2024; Doctorow, 2019). Business management theorists have described such dynamics as “coopetition” among firms in the greater service of market expansion (Adner, 2017). Coopetition is opposed to adversarial interoperability, wherein actors make new products compatible with existing systems without their knowledge or approval in an attempt to challenge or even replace them (Doctorow, 2019). Cory Doctorow has argued that the ways in which Big Tech – Apple, Amazon, Google, Meta, Microsoft – secures laws, regulations, and court decisions have dramatically restricted such pro-competitive forms of interoperability (2019). In the face of this critique, these industry leaders are now working together on the issue to expand the range of products in the IoT market and their ability to communicate and work with one another. This expansion is taking place in part through hardware Big Tech produces, and the rest through devices that most likely come into contact with and are mediated by their operating systems, as Apple’s HomeKit, Amazon’s Alexa, Google’s Assistant, and Samsung’s Smart Things make up the oligopoly of smart home operating systems currently dominating the market. In this way Matter exemplifies Big Tech’s vision of domestic space as a network of central and peripheral nodes, with their devices and operating systems as hubs and interfaces controlling a range of other smart hardware (Crawford, in press-a). While more interoperability may give users more choice and allow smart things to work more seamlessly, this shift must be critically examined nonetheless as an exercise of platform power sharing and self-regulation, through protocol.

That Matter is beginning with the burgeoning consumer smart home market is of particular interest, as it is a necessary step toward improving the clunky, fragmented, walled ecosystems of smart devices and apps. It is a kind of testbed to determine the balance (or bare minimum) of how porous, interoperable, and collaborative such ecosystems must be to maintain Big Tech’s dominant market positions, sustain product value propositions, and foster broader market growth. While primarily focused on removing barriers to the growth of the smart home and consumer IoT market at present, the CSA is also setting its sights on the smart building, factory, utilities, and urban infrastructure of the future in efforts to signal both Matter and the CSA’s potential importance in the coming years and decades (CSA, 2022). These protocols that facilitate the communication between a growing range

of smart things and *multiple* platform ecosystems represent a crucial infrastructural development for our broader understandings and analyses of platform power, tech policy, and the general expansion of smartness (Halpern & Mitchell, 2023). Matter is, therefore, an important case study for understanding the evolving and relational dynamics between platforms and IoT hardware as “data infrastructures that facilitate, aggregate, monetise and govern interactions between end-users and content and service providers” (Poell et al., 2021, p. 5).

Through this “smartness creep” (Crawford, in press-a) the home’s objects and occupants are emerging as critical sites of platformed mediation and extraction, and thus platform power (Langley & Leyshon, 2017; Sadowski, 2020b). The smart home’s promises of frictionless connectivity have, however, yet to materialise due to the notable lack of platform ecosystem interoperability, most basically defined as the ability for various technological systems and products to share and use legible information and resources with one another (Berg, 2024; Gasser, 2015). This strategic withholding of interoperability has resulted in a highly fragmented landscape of devices, apps, and platforms. Such fragmentation has sought to maximise product use and purchase and lock users into walled-garden ecosystems as much as possible to capture value from users through continued data production, product purchases, service subscriptions, and so on (Crawford, in press-b). In the context of growing criticisms of this walled-garden model from users and developers, as well as an increasing number of antitrust suits and policies aimed at Big Tech (e.g. the US vs Apple; EU’s Digital Markets and Services Acts), Matter is a promise from industry leaders to solve (self-regulate) the issue of interoperability on their own through this protocol (Department of Justice, 2024; Stoltz et al., 2022). I thus define *protocol power* as the disproportionate influence of dominant actors in platform ecosystems to produce and set industry-wide standards and thus determine certain “rules of inclusion” on the technical, existential level of protocol (Castells, 2009, p. 43). Protocol power exemplifies the relationality of platform power, as the setting of standards emerge from and shape unequal relations between actors (Emirbayer, 1997). In this way, Matter promises to rearrange the current constellation of protocol power from the closed ecosystems of the smart home operating system oligopoly toward more interoperability — if only *among* these already dominant systems.

This article argues that Matter must therefore be understood in two critical ways. First, as a form of networked governance (Caplan, 2023) and power-sharing: where dominant private actors are cooperating on this interoperability protocol in attempts to expand the range and functionality of all IoT products to maintain their

powerful market positions (Caplan, 2023). Second, as a case of industry self-regulation: a market-oriented ‘solution’ and response to the growing critiques and potential regulation of closed ecosystem business models and their corresponding technological designs. I begin by situating this analysis within critical theories of protocol, code, and the politics of standardisation and then provide an overview of existing debates about interoperability policy and the technology industry’s self-regulation. This is specifically in relation to the smart home and its Internet of Things. Following this, I trace the history of the organisation behind Matter, the Connectivity Standards Alliance, launched in 2002 under the name the ZigBee Alliance, and explain how it came to be in collaboration with many of the world’s largest and most powerful technology firms. Lastly, through the case study of Matter and its rollout, I examine how the CSA is shaping dominant discourses surrounding connectivity and interoperability to maintain and expand the hegemonic power of tech industry leaders.

Methodologically, this article brings together critical approaches from media, internet, and organisation studies, such as discourse, organisation, and web history analysis. This case study of Matter and the CSA aims to contextualise and historicise the range of industrial factors and dynamics that have brought the issue of interoperability and protocol power to the fore (Hartley, 2004; Heller, 2023). I made use of the Internet Archives’ Wayback Machine to gain access to old organisation webpages and trade literature (Ben-David & Huurdeman, 2014; Rogers, 2017). Through critical historical and discourse analysis of dozens of public statements and communications, industrial certifications and policy documents, trade literature and journalism, and promotional materials from the CSA and its partners, I chart the growing influence of this organisation and the uneven geographies of its development, application, and regulation over time.

Such an examination foregrounds the neglected, *prefigurative* role of protocol in connecting smart devices to one another as the foundation or infrastructure upon which so many dynamics of platform power are subsequently played out. This study of Matter offers a critical analysis of an important shift taking place in the configuration of protocol power from walled-garden smart home ecosystems (the Apple, Google, Amazon, and Samsung smart home operating system oligopoly) towards more openness and interoperability between operating systems and devices. I argue that the Matter initiative allows Big Tech to respond to the mounting critiques from users, developers, and regulators about the limits and harms of the closed ecosystem model, while maintaining as much of their platform and market power as possible through networked governance and self-regulation.

This article concludes its analysis of the shifting terrain of IoT interoperability by pointing to the larger stakes of the production of smartness and connectivity more globally in efforts to open up more radical, existential questions about which technologies should be smart or connected at all. Taking up the critiques of political ecologists and neo-Luddites, future analyses of protocol and platform power must challenge the interrelated social, economic, and ecological consequences of the smartness mandate from the scale of global networks and flows to the everyday Internet of Things (Crawford, in press-a; Garcia, et al., 2018; Halpern & Mitchell, 2023; Sadowski, et al., 2021).

Protocol, code, and the politics of standardisation

This article builds its analysis of Matter upon theorisations of computing protocols and standards (Beuster, et al., 2022; Cath & Floridi, 2017; Cohen, 2020; Cowen, 2014; Chun, 2006; DeNardis, 2009; Galloway, 2004; Lessig, 2000; Yates & Murphy, 2019) as management techniques “for achieving voluntary regulation within a contingent environment” (Galloway, 2004, p. 7; Lessig, 2000). Science and technology scholars such as Lawrence Lessig (2000), Laura DeNardis (2009), Deborah Cowen (2014), Alexander Galloway (2004), and JoAnne Yates and Craig Murphy (2019) have laid out that processes of technological standardisation are inherently political and have long histories: railroads, telegraph networks, shipping containers, internet protocols, and so on. Powerful stakeholders, such as states, corporations, and professional associations each exert their material influence in standard setting in attempts to lock in their preferred (or proprietary) methods and technologies, and thus further extend their power. Standards organisations such as the International Standards organisation (ISO) and Internet Engineering Task Force (IETF) foreground the vital role such bodies play in maintaining the “critical infrastructure of the global economy” (Yates & Murphy, 2019, p. 2). The Connectivity Standards Alliance and Matter, like other connectivity standards and their parent organisations (Bluetooth, Wi-Fi), thus embody the aspirations of dominant actors in the contemporary tech sector to create advantageous conditions of network and platform power at the technical level of IoT protocol through both standardisation and specific “rules of inclusion” (Castells, 2009, p. 43).

Galloway describes the power of the internet protocol as “a type of control based on openness, inclusion, universalism, and flexibility. It is control borne from high degrees of technical organisation (protocol)” (2004, p. 142). In Lessig’s formulation, TCP/IP (Transmission Control Protocol/Internet Protocol) operates as a strong regulatory force: “code is law” (2000). Wendy Hyui Kyong Chun further argues that code

is “better than law” as it isn’t bent or interpreted, but rather its “enforcement stems from itself” (2006, pp. 66-67). Code either abides by the rigid rules of a system standard or it simply cannot exist. The protocol power of TCP/IP lies in its high degrees of flexibility, adaptability, and interoperability upon which a vast range of activity is made to conform in order to transpire.

At a broader scale, Langdon Winner makes the case for conceptualising technology *itself* as a form of de facto legislation, as it creates specific sets of material conditions, rules, expectations, and requirements of use. Such conditions of use are most often undemocratically designed and implemented by dominant private interests and actors, and unevenly distributed and accessible to users and publics (2007, p. 205). In this vein Lessig writes that “when government steps aside, it’s not as if nothing takes its place. It’s not as if private interests have no interests; as if private interests don’t have ends that they will then pursue”, with the enforcement of such ends being employed through protocol (2000). At stake in the design and production of digital hardware, software, and often infrastructure, is the hegemonic power of private industry — in this case, Big Tech — to maintain and expand its infrastructural role in daily life (Gilbert & Williams, 2022). Relatedly, such quotidian ubiquity works to shape dominant understandings of interoperability and connectivity which limit our imaginaries of other more socially and ecologically oriented organisations of technology (Garcia, et al., 2018; Sadowski, et al., 2021). In this way, Matter represents a technological fix to the questions and challenges of tech design and regulation by proposing an industry-driven market solution in place of rigorous public policy which might direct tech production elsewhere.

Both through and beyond this discussion of interoperability and Matter, this article seeks to open up critical and existential debates about the current organisation, production, and direction of smartness and the Internet of Things as growing facets of platform power, through the idea of protocol power. While more interoperability between existing technologies is certainly positive and necessary, what Matter seeks to set up is the ‘smartification’ of ever more objects, to be produced and further mediated by dominant actors and their platform ecosystems (Dotorow, 2019; Sadowski, 2020a). These aspirations for greater connectivity seek to heighten the production and sale of hardware, services, and user data, shoring up the market positions and thus power of Big Tech *through* sharing it. Critical challenges and alternatives to industry-led ‘solutions’ like Matter are therefore imperative to our understanding, imagination, and potential regulation of platform power, not only at the level of software and services but also hardware and protocol.

Industry self-regulation & interoperability policy

Recent decades have seen an acceleration of the vertical integration of proprietary platform ecosystems which have brought about higher levels of digital enclosure and strategically restricted as much interoperability as possible for the purposes of market domination, user lock-in, and value generation (Crawford, in press-b). As major technology companies continue to grow larger and their power more concentrated, a range of critiques and debates about their business models, privacy standards, infrastructural power, and levels of interoperability have emerged, each reflecting the diversity and complexity of the regulatory contexts such dominant firms traverse (Cusumano, et al. 2021; Fei, 2023; Flew, 2021; Gillespie, 2018; Hovenkamp, 2023; Khan, 2017; Srnicek, 2017; van Dijck, et al., 2019). The American giants, for instance, are adapting to different regulatory pressures in several regional political contexts, such as content moderation and antitrust investigations at home, and the EU's implementation of its General Data Protection Regulation (GDPR) which expands user privacy and data portability rights, and Digital Markets and Digital Services Acts (DMA; DSA) which crack down on the gatekeeping roles these firms play in relation to issues such as App Stores and interoperability (Cyphers & Doctorow, 2021; Flew, 2021; Kerber & Schweitzer, 2017; Unver, 2022). Such regulatory efforts are relatively new, and dominant platforms have enjoyed minimal regulation over the past decades (Flew, 2021; Khan, 2017; Owen, 2019). The regulatory picture is rather different elsewhere, such as in China's technology sector, where the state continues to tightly restrict the operations of international firms. The Chinese tech giants are themselves facing heightened domestic regulatory crackdowns, with the state unilaterally enforcing greater interoperability between the ecosystems of Baidu, Alibaba, Tencent, and ByteDance, specifically for messaging and digital payment services (Fei, 2023; Flew, 2021).

Recent tech policy has sought to balance market competition with sociotechnical concerns for user welfare, choice, and security, each of which are made ever more complex given the various scales and layers of interaction necessary to the functioning of tech ecosystems and markets (Flew, 2021; Garcia, et al., 2018; Hovenkamp, 2023; Khan, 2017; Unver, 2022; van Dijck, et al., 2019). Here applications of network(ed) governance theory to Big Tech speak to both the governance of digital networks and the networking or distribution of governance responsibilities to various actors and organisations (Caplan, 2023; Cohen, 2020). This concept of networked governance is useful for thinking about the many actors involved in both producing and managing the issue of interoperability as a similar "problem of many hands" (Thompson, 1980, p. 905, as cited in Caplan, 2023, p. 3456). Though

meaningfully different from content moderation, transnational standards organisations like the IEEE (Institute of Electrical and Electronics Engineers) and the CSA can also be read critically as influential network governance entities in their own right, affording certain organisations, technologies, and standards their protoco-logical – and in the Winnerian sense, legislative – powers (Cohen, 2020; DeNardis, 2009; Galloway, 2004; Lessig, 2000; Winner, 2007). Here such organisations offer forms of networked governance where responsibility can be distributed, and highly brokered solutions can be reached on terms favourable to industry leaders (Cohen, 2020).

The setting of an international standard by dominant actors is a particularly productive form of power sharing and market control by determining the “rules of inclusion” and participation on a technical level (Castells, 2009, p. 43; Galloway, 2004). While interacting with focal firms in the tech ecosystem has been unavoidable for smaller companies and complementors across the value chain for some time, they must now adhere to the Matter standard set by dominant firms to partake in its promised benefits of universal interoperability and consumer choice (Adner, 2017; Fung, 2022a; Tiwana, 2014). Interoperability is thus a key issue which reveals not only the changing shape of tech markets, but also how dominant technological imaginaries influence our ability to understand, negotiate, and ultimately reorganise and govern platform power (Ferrari, 2020).

For the Internet of Things to function, interoperability and communication between various layers of devices, software, and networks are especially essential. These layers comprise the (i) perception layer of devices, sensors, and controllers communicating with one another; (ii) the access layer connecting such devices to local or larger networks; (iii) the cloud layer of databases and operating systems; and (iv) the application layer of software with which users interact (Unver, 2022, p. 233; Plantin, et al., 2018). Legal scholar Mehmet Bilal Unver writes that such layers “constitute the building blocks of the IP stack” and the levels of interoperability between system structures determine “interdependent value chains for the economic activities of the stakeholders” (Unver, 2022, p. 234). From this vantage, ecosystem lock-in, interoperability’s opposite, becomes all the more visible as the production of a false form of function scarcity or friction between product ecosystems for the sake of value generation (Crawford, in press-b).

Functionality and communication across these layers are what afford connected objects their so-called smartness, usefulness, and value. Focusing on protocol allows us to trace the contours of interoperability or the lack thereof among various ecosystems, adding perspective to critical analyses of platform power in relation to

key concepts such as gatekeeping, bottlenecks, lock-in, competition, and cooperation across hardware, software, and service layers. Matter's promises to break down the ecosystem lock-in effects of the giants' walled gardens are provocative as they present a sizable shift to the status quo – that is, if they ever really materialise. Outlining how industry leaders seek to guide and control such processes of transformation through the setting of protocol standards reveals some of the key ways in which platform power is negotiated between platforms, developers, regulators, and users through discourses of market potential, efficient production, and user value.

It is precisely in this light that Matter must be understood as a form of industry self-regulation amidst calls for policy intervention toward more open, interoperable, and holistic technology policy (Bourrea, et al., 2022; Cyphers & Doctorow, 2021; Edwards, 2016; Flew, 2021; Fung, 2022a; Morton, et al., 2021; Sweiss, 2019; Unver, 2022). Cyphers and Doctorow (2021) suggest that a more interoperable platform ecosystem requires a mix of more user- and public-centred interpretations of existing tech and media legislation as well as the implementation of new policies and standards. They suggest that allowing users, developers, and smaller companies the ability to build upon the existing frameworks of the giants in terms of greater data portability, back-end openness, and the ability to delegate tasks to non-proprietary code would also be necessary. Unver further suggests the following principles to guide a holistic, bottom-up regulatory approach to the issues of gatekeeping concerning interoperability: (i) accessibility and user choice; (ii) transparency in reporting to public regulators; (iii) fairness in guaranteeing unbiased components and services; and (iv) accountability for software and algorithmic management (2022, p. 240). He argues that such a framework of principles would work to solve some of the outdated challenges facing competition law and consumer welfare that trouble tech regulation.

While such analyses provide some ways to think about potential policy interventions, it remains clear that interoperability in and of itself is no silver bullet for tech regulation and is a complex issue given the growing range of markets and sectors in which the tech industry is entangled. We are also witnessing the industry capture some of these critiques through nominal concessions and forms of self-regulation, of which Matter is a prime case study. We must remain critical of analyses of interoperability – legal papers, policy reports, industry literature, and so on – if their stated goals are merely to foster more competition and innovation (Bourreau, et al. 2022; Cusumano, et al. 2021).

The promises of Matter to solve and self-regulate issues of interoperability, user

choice, and privacy speak to how industry leaders seek to capture dissent, curtail challenges to their hegemony, and frame such issues on their own terms. One of the key ways such private interests shape the production of technology and its imaginaries – the ways they network their governance – is through trade associations and private standards organisations (Cohen, 2020; Flew, 2021), such as Matter’s parent organisation, the ZigBee/Connectivity Standards Alliance.

“Control your world”: The development of the ZigBee Alliance

The ZigBee Alliance was conceived of in Northern California in 1999 by a group of tech entrepreneurs and engineers seeking to create a “complete, open, global standard for reliable, cost-effective, low-power, wirelessly networked products addressing monitoring and control” (Gislason, 2008). Officially founded in 2002, the ZigBee Alliance was composed of a growing number of international consumer electronics and tech companies such as Honeywell, Ericsson, Motorola, Philips, Intel, Samsung, and Somfy as leading partners. The founding mission of the working group was to:

Bring about the existence of a broad range of interoperable consumer devices by establishing open industry specifications for unlicensed, untethered peripheral, control and entertainment devices requiring the lowest cost and lowest power consumption communications between compliant devices anywhere in and around the home. (ZigBee, 2002)

The IEEE Working Group for Wireless Personal Area Networks (WPAN) ratified the 802.15.4-2003 standard in collaboration with ZigBee, which launched its first version in 2004 (Ergen, 2004). Parallels can be drawn between the ZigBee Alliance and 802.15.4 and other industry organisations and standards such as the Wi-Fi Alliance and IEEE 802.11 (Wireless Local Area Networks/WLAN) and the Bluetooth Special Interest Group and IEEE 802.15.1, with the IEEE granting such private organisations the commercial name brand for these connectivity standards (Kay, 2006). Aimed at battery-powered devices communicating simple messages at short range with lower data rates, the ZigBee standard promised to connect a larger number of wireless devices through mesh networking, allowing devices to communicate with one another without having to pass through a central node and thus self-heal if one node goes down, and accelerating rates and paths of data transfer to lower energy requirements (Ergen, 2004). Throughout the 2000s, dozens more companies partnered with ZigBee, such as Cisco, France Telecom, LG, Silicon Labo-

ratories, and Texas Instruments, signalling the desire of a range of actors across tech, consumer electronics, and communications industries to participate in the proliferation and standardisation of this wireless protocol.

At the turn of the decade, ZigBee altered its self-description to read “ZigBee provides green and global wireless standards to connect the widest range of devices intelligently to help you control your world”, emphasising its energy efficiency, international reach, and functional application: to provide digital control (ZigBee, 2011). Around this time the organisation also launched its Zigbee Smart Energy standard for utility meters, aiming to establish itself in this market, as calls from governments the world over for expanded energy measurement and management became more popular (ZigBee, 2011). Throughout the 2010s, the Alliance’s membership grew to over 400 members, adding major players such as Huawei, AT&T, and Amazon’s Research and Development company Lab 126. The rhetoric promoting Alliance membership during this period speaks to the ways in which the Alliance was *networking* the governance of IoT standards. Their messaging emphasised how member organisations would have the opportunities to i) learn and shape IoT standards; ii) develop IoT products and services; iii) be a part of the ZigBee ecosystem; and iv) promote their products and services (ZigBee, 2017).

In 2019, Ikea, Apple, Amazon, and Google joined the ZigBee alliance as promoters and board members, announcing their collaboration on Project CHIP: Connected Home over Internet Protocol. This joint initiative came in response to years of wide-ranging complaints from users, developers, and regulators about the lack of interoperability between platform ecosystems. For the smart home, this lack was causing fragmented and frustrating user experiences, inefficient production processes, and barriers to overall market growth, all while concentrating the market power of Big Tech companies and their walled gardens (Amadeo, 2019; Edwards, 2016; Khan, 2017; Manyika et al., 2015; Sweiss, 2019). As an explicit promise to create a unifying smart home protocol standard, the giants — aided by the existing network of ZigBee — sought to soothe critics and display the potential for the industry to solve problems of its own creation, lest governments intervene.

With Apple’s HomeKit running over IP (both Wi-Fi and Bluetooth Low Energy), Amazon’s “Works with Alexa” using a combination of ZigBee and other IP protocols, and Google’s Nest/Home using various standards, including Thread, an open IP standard developed by its own Nest Labs, there was (and remains) a chaotic mix of heterogeneity and protocological fragmentation between these ecosystems. Earlier versions of Thread as an open 802.15.4 standard came closest to the promises of CHIP/Matter, but the project failed to garner any real momentum or

industry buy-in on its own (Alleven, 2016). For CHIP, the common denominator between these systems was Internet Protocol, the already ubiquitous network layer of protocols upon which a standardised application layer could translate such IP data into a universal language, allowing devices to identify and speak to one another and, in theory, usher in a new era of IoT interoperability as the tech sector was becoming increasingly focused on the home as a strategic site of growth (Amadeo, 2019).

The addition of these major players shored up the Alliance's position as an industry leader in IoT communications amongst several competing IP connectivity standards. The long-held vision for smart device communication and interoperability and the proximity to Big American Tech in Northern California set the ZigBee Alliance apart from other organisations as the site for the American giants' investment in such a project.

The first version of the CHIP website explained the project and its mission as follows:

The project is built around a shared belief that smart home devices should be secure, reliable, and seamless to use. By building upon Internet Protocol (IP), the project aims to enable communication across smart home devices, mobile apps, and cloud services and to define a specific set of IP-based networking technologies for device certification. The industry Working Group will take an open-source approach for the development and implementation of a new, unified connectivity protocol. [...] The project aims to make it easier for device manufacturers to build devices that are compatible with smart home and voice services such as Amazon's Alexa, Apple's Siri, Google's Assistant, and others. (Project CHIP, 2019)

Here we can observe the American giants' immediate influence, signalling a coming shift toward interoperability in the industry while also taking the opportunity to market their own smart home brands. During Project CHIP's (short) two-year life, relatively little information was produced or distributed about it other than a few meagre updates and info sessions hosted by ZigBee, Thread, and Silicon Labs, each citing the respective relevance and potential of their products within the coming interoperable IoT landscape (Higginbotham, 2020). Early visions for the CHIP stack included layered integration of various protocols for different processes: "Bluetooth LE for setup, Wi-Fi for high-bandwidth use cases, like streaming video from a security camera, and the still-nascent Thread for low-bandwidth devices such as motion sensors" (Seifert, 2021). Bringing these IP protocols together was champi-

oned as the promising innovation of the project: a resilient, low-power mesh network which could pass information between numerous devices and ecosystems over IP (regardless of network connectivity) and eliminate a single source of network failure, as is the case with Ethernet or Wi-Fi.

CHIP, however, faced many setbacks due to the pandemic as well as the complexity brought about by the number and scale of organisations working together (Higginbotham, 2021a). Originally hoping to have certified products to market by the end of 2020, the Alliance delayed this goal to the end of 2021 in April of that year and then rebranded both CHIP and the ZigBee Alliance entirely the following month (Seifert, 2021). While only existing briefly under this name, Project CHIP functioned to send the important message to users, developers, and regulators that major players in the tech industry, crucially the American giants, were invested in IoT and smart home interoperability. The following section investigates this process of rebranding and how the organisation and its partners have sought to continue to shape discourses surrounding interoperability and connectivity amidst the standard's protracted rollout.

Matter's protocol promises: "A rising tide lifts all boats"

In May 2021, ZigBee Alliance announced the rebranding of the organisation to the Connectivity Standards Alliance (CSA) and of Project CHIP to Matter. CSA CEO and president Tobin Richardson noted that the Alliance needed a new name and identity to reflect how it has grown and changed over its nearly twenty-year history to now host several communications standards beyond its original namesake. The Alliance's new website address, csa-iot.org, further consolidates the aims of all its certified products under the umbrella of expanding the IoT ecosystem through standardisation. The new name for its smart home standard, Matter, invokes the atom, framing the protocol as the "building blocks" of a more interoperable IoT with the new brand's entrepreneurial slogan "build with matter" (CSA, 2021). In the official Matter rebrand video, its logo of three curved inward-facing arrows appears next to the icons of Bluetooth and Wi-Fi, indicative of the CSA's hopes and aspirations for similar levels of connectivity brand ubiquity. Such messaging speaks to the promise of Matter to unify the industry and produce "a smart world greater than the sum of its parts" (CSA, 2021).

The launch event thematised how Matter as a single universal standard will do two key things (CSA, 2021). First, it will allow consumers to choose from a much wider range of interoperable smart products which are much simpler to set up and use with one another. Such simplicity and interoperability promises to heighten

value propositions for a larger range of less tech-savvy users and grow the IoT market through removing the friction and clunkiness currently impeding rates of adoption. Second, Matter aspires to liberate developers from wasting their time and labour developing and maintaining unique connectivity requirements for each proprietary ecosystem (Hill, 2023). This launch emphasised that with Matter, developers across the tech value chain will be able to focus on and compete at elevated levels of innovation, product design, and user experience since they will only have to develop products for one universal connectivity standard (CSA, 2021).

On display at this launch were enthusiastic and optimistic expressions of what management theorists call “coopetition”, the dynamics of both cooperation and competition among various firms in business ecosystems necessary to expand value propositions and overall market health (Adner, 2017; Crawford, in press-b). During a roundtable discussion at the event, the Alliance and its partner representatives emphasised how, despite being “fierce competitors”, they had to come together and collaborate to grow the market to keep competing and innovating (CSA, 2021). Such themes work together to support the future-oriented narrative drive of smartness evoked in the event’s language of how ubiquitous, ambient computing will finally allow for better, more convenient, and more efficient life in the home through universally interoperable technology (CSA, 2021). The main takeaway from these rebrands was that such visions of interoperability could only be materialised through new degrees of industry collaboration and standardisation.

At the time of announcement, the Alliance stated that Matter was ready for testing, and would have products to market by the end of 2021 (Brown, 2021). After numerous delays, ostensibly due to high demand and engineering complexity, the CSA held its official Matter Launch Event eighteen months later in November 2022 in Amsterdam (Lovejoy, 2022; Tuohy, 2022). Here Richardson announced the first wave of 190 certified Matter products in key product categories such as lighting, phones, tablets, smart speakers, hubs, TV and media devices, security sensors, door locks, and software components and applications, with more categories awaiting certification: cameras, robot vacuums, appliances, energy management, environmental sensing and controls, and ambient motion and presence sensing (CSA, 2022).

On a technical level, Matter, like its predecessor CHIP, operates at the application layer, translating Wi-Fi, Ethernet, Bluetooth, Thread, and other IP protocols into a universal language to allow devices to transmit messages to one another and use whichever protocol necessary given their function. Building a Matter network, however, requires at least one device to act as an always on and in the home bor-

der router, such as a compatible smart speaker, hub, smart tv box, or smart light, to link devices together and extend the range and reliability of the smart home network (Hill, 2023). While some backwards compatibility is available for devices with the right semiconductor hardware to house these various IP radios and protocols, the necessity of hubs and border routers will also drive future hardware sales, particularly in the popular smart speaker segment dominated by Amazon, Google, Apple, Samsung, and Baidu's Xiaodu, and critically, their cloud-connected digital assistants and operating systems (Cohen, 2020; Hill, 2023).

Responses since the announcement and launch of Matter have been mixed, with tech writers simply reproducing the unbridled optimism of the CSA and its members (Alleven, 2021; Brown, 2021) and others waiting to see how well Matter will actually work and how long it takes to fully roll out (Fung, 2022a; Tuohy, 2021; 2022). Amazon began by only adding Matter support within its own ecosystem with seventeen Alexa products, plugs, switches, and lightbulbs over Wi-Fi and Android. More complex constellations of device compatibility over Thread and iOS arrived in May 2023, in theory opening up the Alexa ecosystem to a much wider range of interoperable products (Vonau, 2022). Apple, on the other hand, updated its smart home platform ecosystem to be Matter compatible several months earlier but is also still waiting on the wider rollout of certified products and software to observe what effects the new standard will have on its TV & Home product category (Apple, 2024). The many promises of Matter thus remain speculative at this juncture, though its existence has been productive and useful nonetheless in that it allows its members to point to it as a solution on the way – whenever that may be – for a range of audiences: users, developers, investors, and regulators.

The CSA's new self-description projects its lofty ambitions to such varied stakeholders:

The Alliance is the Foundation and Future of the IoT. Our wide-ranging global membership is on a mission. That mission is to ignite creativity and collaboration in the Internet of Things, by developing, evolving, and promoting universal open standards that enable all objects to securely connect and interact. We believe all objects can work together to enhance the way we live, work, and play. (CSA, n.d.)

The CSA further states that its role is to provide “the infrastructure and processes for consensus-driven standards with actionable outcomes” (CSA, 2021). Such promotional discourses and rhetoric from the Alliance and its members acknowledge

certain issues, critiques, and challenges in the industry – interoperability, privacy, security, energy consumption – and presents their own carefully crafted and self-interested solutions: collaborative efforts on open, universal, low-energy, or otherwise more efficient connectivity standards for the IoT. This messaging seeks to signal the ability of the industry to self-regulate and bring about new forms of networked governance through the growing industry organisation of the CSA.

The Alliance has also explicitly expanded the role of global lobbying in its mission, recently partnering with major non-governmental organisations such as the World Economic Forum and its Council on the Connected World, making good on Richardson’s promise that “the organisation will be taking on more active roles, including with policymakers and regulators” (Higginbotham, 2021b; Allevén, 2021). For example, in a LinkedIn post following a White House event for enhancing IoT security, Richardson wrote:

The fact that the White House, the Government of Singapore, the European Union and other government bodies are defining security and privacy protocols is great. What makes their work even more impactful is when they incorporate private companies from the ecosystem into that process. In my opinion, the only way we can stay ahead of the threat to consumers is through public/private collaboration. Taking that one step further is attacking the problem on a global and not regional scale. (Richardson, 2022)

Here we can see the championing of co-regulation by industry and government in part through groups such as the CSA. Amidst recent scrutiny from national and regional regulatory bodies, member companies stand to benefit politically from associating with the CSA due to its broad coalition of firms, open-source standards, and ostensible commitment to IoT security through co-regulation efforts (Haldane, 2023).

In terms of structure, firms on the CSA’s board of directors are Alliance “promoter members”, the highest level of membership with the most influence in shaping the strategic decisions and directions of the organisation, and Matter specifically as its new flagship product. While Matter is an open standard which can be accessed and implemented by all developers, the use of the Matter logo as a marketing tool and guarantee of interoperability, as well as access to Alliance networks and resources, requires paying for product certification and/or membership fees, creating a clear hierarchy of influence, power, visibility, and functionality. While the organisation rhetorically emphasises its “global” reach and membership, the composition of the

Alliance's board of thirty-four members reflects its priority markets, with firms balanced between North America (12), Western Europe (12), and East Asia (10) (CSA, n.d.). Unsurprisingly, market analyses project smart home growth in these highly networked, overdeveloped economies to be much higher than in South America, Africa, and Central and South Asia, and such priorities shine through (Statista, 2023).

The aspirations of Matter as a universal standard, however, speak to the transnational market capture sought by its creators. At the level of protocol, the Matter standard seeks to dictate the future of the Internet of Things and smart home on the terms of dominant transnational tech firms from North America, Europe, and East Asia by unifying already ubiquitous IP standards. Such a power-sharing arrangement speaks to the vital role of protocol and private standards organisations working closely with industry leaders as ever more objects are made smart, connected, and “ready” not only for one platform but ostensibly for all (Helmond, 2015).

While Matter proposes some benefits for consumers through heightened choice and smoother functionality, we must remain critical of how and why the issue of interoperability is being negotiated and to what ends. For regulators, the temptation is to take industry solutions such as Matter as substitutes for rigorous public policy, eliding the ways in which such shifts shore up the platform power of already dominant actors through sharing it. Like antitrust tech regulation, if decisions are guided merely by consumer choice and welfare, much of the issue remains untreated (Khan, 2017; van Dijck, et al., 2019).

Conclusion

The story of the CSA and the development of this standard speak to important shifts taking place across technology industries, value chains, and platform ecosystems. These developments showcase how dominant actors have come together to cooperate and network the governance of IoT connectivity standards with the dual hope of both avoiding potential regulation and expanding tech markets and smart products through new levels of interoperability. This vision of interoperability represents some concessions of the industry to various levels of critique and a degree of acceptance of the growth limits of the walled-garden model of proprietary platform ecosystems. In doing so, it dresses up this shift toward more interoperability as the newest iteration of Big Tech's fantastical projections of the perfectly smooth, smart, frictionless, indeed *enchanted* user experience of technology. This article has shown how Big Tech is exercising its protocol power as the industry

seeks to dramatically expand and universalise the Internet of Things as one of its next extractive frontiers. Through attempting to establish a global, “universal” IoT connectivity standard backed by major transnational firms across the tech value and production chain, Matter’s initiative represents important forms of industry self-regulation and power-sharing among dominant firms.

At present, most existing policy analysis, scholarship, and discourse on interoperability is limited by merely focusing on fostering more competition, user choice, and innovation. Matter can be read, in part, as a strategic industry response to such analyses in efforts to pre-empt policy intervention and to further open up the home as a frontier for platform extraction through hardware, services and subscriptions, and data production and collection. Instead, critical scholarship and policy must foster more challenging and radical debates about which technologies need to be smart or interoperate at all, to chart alternative paths forward for thinking about different technological imaginaries and regulatory frameworks which prioritise public, social, and ecological goods over market growth and private extraction. While preliminary, the analysis laid out here offers a way to begin to understand and critique the growing roles of industry organisations and standard-setting as key forms of networked governance and industry self-regulation for IoT interoperability and the tech industry more broadly. Upon such an understanding, further critical inquiries might speculate about what alternative interoperability policy could look like in limiting the expansion and consumption of smartness and the IoT at (or before) the point of production (Hogan, 2018).

The conspicuous consumption of energy and natural resources, manufacturing demands, and labour involved in sustaining this outward spiralling of smartness must be debated at the level of whether or how such smart technologies should have any right to exist at all (Crawford & Joler, 2019; Garcia, et al., 2018; Hogan, 2018; Mueller, 2021; Pickren, 2014; Winner, 1978). While beyond the scope of this article, future critical scholarship and policy on interoperability must take up the more radical challenges informed by neo-Luddism (Coulthard & Keller, 2012; Garcia, et al., 2018; Mueller, 2022) and critical political ecology (Hogan, 2018; Pickren, 2014) to debate, existentially, not only how technological systems interact and communicate with one another, but also what degrees of smartness and connectivity are socially and ecologically necessary or useful in the first place. What if international standards organisations were made to involve more rigorous public debate about technological design rather than viewing such issues as engineering challenges and market solutions? Might interoperability policy be expanded as a tool to limit consumption, and therefore waste, “at the site of production” of smart

technologies which use vast quantities of natural resources, energy, and labour primarily for the purposes of data collection, platform enclosure, and profit generation? (Hogan, 2018, p. 648; Pickren, 2014; Sadowski, 2020a). We simply do not need and cannot afford to use such resources on frivolous consumer electronics such as connected toothbrushes and toasters but must instead wrest debates about smartness from private industry toward public policy and democratic design to prioritise socially and ecologically useful technology production and regulation.

Case studies of industry-wide projects such as Matter provide openings to discuss larger questions of what is at stake in the production of such smartness and connectivity. Publicly oriented applications of smart tech toward more efficient energy management, mass transportation, and accessible and equitable communications infrastructure are but a few worthy horizons for alternative technological imaginaries and politics. Deeper investigations into specificities of the tech industry's legal, discursive, and technical responses to growing questions about data security and privacy in relation to the IoT is one path for such future work. Political ecological analyses of the resource extraction, production chains, and consequent e-waste necessary for such ubiquitous connectivity, not to mention how smartness is greenwashed through discourses of consumer energy efficiency and automation (Dixon, 2020; Nyborg & Røpke, 2011), are also essential elements of the smartness question requiring further investigation and critique (Halpern & Mitchell, 2023). As the creep of smartness moves outward in all directions, real political issues such as interoperability, privacy, exploitation, resource consumption, and waste must be understood as interrelated problems of platform power to be met with more rigorous public challenge from users, scholars, and policymakers alike.

References

- Adner, R. (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of Management*, 43(1), 39–58. <https://doi.org/10.1177/0149206316678451>
- Alleven, M. (2016, May 11). Google's Nest announces open source implementation of Thread. *Fierce Network*. <https://www.fierce-network.com/tech/google-s-nest-announces-open-source-implementation-thread>
- Alleven, M. (2021, May 12). ZigBee Alliance morphs into CSA, introduces Matter. *Fierce Network*. <https://www.fiercewireless.com/tech/ZigBee-alliance-morphs-into-csa-introduces-matter>
- Amadeo, R. (2019, December 19). Apple, Google, and Amazon create "CHIP," a new smart home standard [Updated]. *Ars Technica*. <https://arstechnica.com/gadgets/2019/12/apple-google-and-amazon-team-up-for-joint-smart-home-standard/>

Apple Inc. (2024). *Set up your HomePod, HomePod mini, Apple TV, or iPad as a home hub*. Apple Support. <https://support.apple.com/en-ca/102557#:~:text=You%20must%20set%20up%20a,support%20third%2Dparty%20border%20router>.

Ben-David, A., & Huurdeman, H. (2014). Web archive search as research: Methodological and theoretical implications. *Alexandria: The Journal of National and International Library and Information Issues*, 25(1–2), 93–111. <https://doi.org/10.7227/ALX.0022>

Berg, C. (2024). Interoperability. *Internet Policy Review*, 13(2). <https://doi.org/10.14763/2024.2.1749>

Beuster, G., Leistert, O., & Röhle, T. (2022). Protocol. *Internet Policy Review*, 11(1). <https://doi.org/10.14763/2022.1.1651>

Bourreau, M., Kraemer, J., & Buiten, M. (2022). *Interoperability in digital markets* [Report]. Centre on Regulation in Europe. <https://cerre.eu/publications/interoperability-in-digital-markets/>

Brown, M. (2021, May 11). Zigbee Alliance announces a new smart home standard, Matter; renames itself the Connectivity Standards Alliance. *TechHive*. <https://www.techhive.com/article/579405/zigbee-alliance-announces-a-new-smart-home-standard-matter.html>

Caplan, R. (2023). Networked platform governance: The construction of the democratic platform. *International Journal of Communication*, 17, 3451–3472. <https://ijoc.org/index.php/ijoc/article/view/20035>

Castells, M. (2009). *The rise of the network society* (2nd ed., Vol. 1). Wiley-Blackwell. <https://doi.org/10.1002/9781444319514>

Cath, C., & Floridi, L. (2017). The design of the internet's architecture by the Internet Engineering Task Force (IETF) and human rights. *Science and Engineering Ethics*, 23, 449–468. <https://doi.org/10.1007/s11948-016-9793-y>

Chun, W. H. K. (2006). *Control and freedom: Power and paranoia in the age of fiber optics*. MIT Press. <https://doi.org/10.7551/mitpress/2150.001.0001>

Cohen, J. (2020). Networks, standards, and standards-based governance. In K. Werbach (Ed.), *After the digital tornado. Networks, algorithms, humanity* (pp. 58–80). Cambridge University Press.

Connectivity Standards Alliance. (2021, May 11). *Brand announcement—Connectivity Standards Alliance & Matter* [Video]. YouTube. <https://www.youtube.com/watch?v=5YckrbqULY>

Connectivity Standards Alliance. (2022, November 3). *Matter, the new global standard for the smart home, debuts at the Amsterdam launch event* [Video]. YouTube. <https://www.youtube.com/watch?v=eFgG8isgMUc>

Connectivity Standards Alliance. (n.d.). *About us*. <https://csa-iot.org/about/>

Coulthard, D., & Keller, S. (2012). Technophilia, neo-Luddism, eDependency and the judgement of Thamus. *Journal of Information, Communication and Ethics in Society*, 10(4), 262–272. <https://doi.org/10.1108/14779961211285881>

Cowen, D. (2014). *The deadly life of logistics: Mapping violence in global trade*. University of Minnesota Press. <http://www.jstor.org/stable/10.5749/j.ctt7zw6vg>

Crawford, C. (in press-a). Make room for smartness: Platforming the home. In P. D. Keidl & J. Zündel (Eds.), *Platforms and the moving image*. Meson Press.

Crawford, C. (in press-b). TV plus what? Data-capital, brand extension, and lock-in effects in the

Apple ecosystem. *New Review of Film & Television Studies*.

Crawford, K., & Joler, V. (2019). *Anatomy of an AI system* [Research project]. <http://anatomyof.ai>

Cusumano, M. A., Gawer, A., & Yoffie, D. B. (2021). Can self-regulation save digital platforms? *Industrial and Corporate Change*, 30(5), 1259–1285. <https://doi.org/10.1093/icc/dtab052>

Cyphers, B., & Doctorow, C. (2021). *Privacy without monopoly: Data protection and interoperability* [Report]. Electronic Frontier Foundation. <https://www.eff.org/wp/interoperability-and-privacy>

DeNardis, L. (2009). *Protocol politics: The globalization of internet governance*. MIT Press. <https://doi.org/10.7551/mitpress/9780262042574.001.0001>

Department of Justice. (2024). *Justice Department sues Apple for monopolizing smartphone markets* [Press release]. U.S. Department of Justice. <https://www.justice.gov/opa/pr/justice-department-sue-s-apple-monopolizing-smartphone-markets>

Dixon, L. (2020). Autowashing: The greenwashing of vehicle automation. *Transportation Research Interdisciplinary Perspectives*, 5. <https://doi.org/10.1016/j.trip.2020.100113>

Doctorow, C. (2019, July 11). Interoperability: Fix the internet, not the tech companies. *Deeplinks Blog – Electronic Frontier Foundation*. <https://www.eff.org/deeplinks/2019/07/interoperability-fix-internet-not-tech-companies>

Edwards, L. (2016). Privacy, security and data protection in smart cities: A critical EU law perspective. *European Data Protection Law Review*, 2(1), 28–58. <https://doi.org/10.21552/EDPL/2016/1/6>

Emirbayer, M. (1997). Manifesto for a relational sociology. *American Journal of Sociology*, 103(2), 281–317. <https://doi.org/10.1086/231209>

Ergen, S. C. (2004). *ZigBee/IEEE 802.15.4 summary* [Report]. <https://api.semanticscholar.org/CorpusID:62388391>

Fei, L. (2023). Regulation under administrative guidance: The case of China's forcing interoperability on digital platforms. *Computer Law & Security Review*, 48. <https://doi.org/10.1016/j.clsr.2022.105786>

Ferrari, E. (2020). Technocracy meets populism: The dominant technological imaginary of Silicon Valley. *Communication, Culture and Critique*, 13(1), 121–124. <https://doi.org/10.1093/ccc/tcz051>

Flew, T. (2021). *Regulating platforms*. Polity.

Fung, A. (2022a, August 11). Smart homes and policy: Interoperability. *Bipartisan Policy Center Blog*. <https://bipartisanpolicy.org/blog/smart-homes-policy/>

Fung, A. (2022b, August 25). Smart homes and policy: Privacy, data use, and the privacy paradox. *Bipartisan Policy Center Blog*. <https://bipartisanpolicy.org/blog/smart-homes-privacy-policy>

Galloway, A. R. (2004). *Protocol: How control exists after decentralization*. MIT Press. <https://doi.org/10.7551/mitpress/5658.001.0001>

Garcia, J. L., Jerónimo, H. M., & Carvalho, T. M. (2018). Methodological Luddism: A concept for tying degrowth to the assessment and regulation of technologies. *Journal of Cleaner Production*, 197(2), 1647–1653. <https://doi.org/10.1016/j.jclepro.2017.03.184>

Gasser, U. (2015). *Interoperability in the digital ecosystem* (Research Publication 2015–13). Berkman Klein Center for Internet and Society. <http://dx.doi.org/10.2139/ssrn.2639210>

- Gilbert, J., & Williams, A. (2022). *Hegemony now: How big tech and wall street won the world (and how we win it back*. Verso Books.
- Gillespie, T. (2018). *Custodians of the internet: Platforms, content moderation, and the hidden decisions that shape social media*. Yale University Press. <https://doi.org/10.12987/9780300235029>
- Gislason, D. (2008). *ZigBee wireless networking*. Newnes. <https://doi.org/10.1016/B978-0-7506-8597-9.X0001-8>
- Haldane, M. (2023, January 9). CES 2023: IoT security concerns? No matter. Chinese smart home firms among big adopters of new standard. *South China Morning Post*. <https://www.scmp.com/tech/big-tech/article/3206011/ces-2023-iot-security-concerns-no-matter-chinese-smart-home-firms-among-big-adopters-new-standard>
- Halpern, O., & Mitchell, R. (2023). *The smartness mandate*. MIT Press. <https://doi.org/10.7551/mitpress/14623.001.0001>
- Hartley, J. (2004). Case study research. In C. Cassell & G. Symon (Eds.), *Essential guide to qualitative methods in organisational research*. SAGE Publications. <https://doi.org/10.4135/9781446280119>
- Heller, M. (2023). Rethinking historical methods in organization studies: Organizational source criticism. *Organization Studies*, 44(6), 987–1002. <https://doi.org/10.1177/01708406231156978>
- Helmond, A. (2015). The platformization of the web: Making web data platform ready. *Social Media and Society*, 1(2). <https://doi.org/10.1177/2056305115603080>
- Higginbotham, S. (2020, April 27). Companies still believe CHIP products are coming in 2021. *Stacey on IoT*. <https://staceyoniot.com/companies-still-believe-chip-products-are-coming-in-2021/>
- Higginbotham, S. (April 13, 2021a). Project CHIP embraces a timeline and the blockchain. *Stacey on IoT*. <https://staceyoniot.com/project-chip-embraces-a-timeline-and-the-blockchain/>
- Higginbotham, S. (May 11, 2021b). Project CHIP gets a new name and so does the Zigbee Alliance. *Stacey on IoT*. <https://staceyoniot.com/project-chip-becomes-matter/>
- Hill, S. (2023, October 23). Here's what the 'Matter' smart home standard is all about. *Wired*. <https://web.archive.org/web/20231024020009/https://www.wired.com/story/what-is-matter/>
- Hogan, M. (2018). Big data ecologies. *Ephemera*, 18(3), 631–657. <https://ephemerajournal.org/sites/default/files/pdfs/contribution/18-3hogan.pdf>
- Hovenkamp, H. (2023). Antitrust interoperability remedies. *Columbia Law Review Forum*, 123(1), 1–36. <https://columbialawreview.org/content/antitrust-interoperability-remedies/>
- Kay, R. (2006, May 15). ZigBee. *ComputerWorld*. <https://www.computerworld.com/article/2554497/ZigBee.html>
- Kerber, W., & Schweitzer, H. (2017). Interoperability in the digital economy. *Journal of Intellectual Property, Information Technology and Electronic Commerce Law*, 8(1), 39–58. <http://nbn-resolving.de/urn:nbn:de:0009-29-45317>
- Khan, L. M. (2017). Amazon's antitrust paradox. *Yale Law Journal*, 126(3), 710–805. <https://www.yalelawjournal.org/note/amazons-antitrust-paradox>
- Lamb, H. (2023). Smart home matters. *Engineering & Technology*, 18(1), 58–61. <https://doi.org/10.1049/et.2023.0111>

Langley, P., & Leyshon, A. (2017). Platform capitalism: The intermediation and capitalisation of digital economic circulation. *Finance and Society*, 3(1), 11–31. <https://doi.org/10.2218/fin soc.v3i1.1936>

Lessig, L. (2000, January 1). Code is law: On liberty in cyberspace. *Harvard Magazine*. <https://www.harvardmagazine.com/2000/01/code-is-law-html>

Lovejoy, B. (2022, March 17). Apple-backed smart home standard Matter has been delayed yet again. *9to5Mac*. <https://9to5mac.com/2022/03/17/matter-has-been-delayed-yet-again/>

Manyika, J., Chui, M., Bisson, P., Woetzel, J., Dobbs, R., Bughin, J., & Aharon, D. (2015). *The Internet of Things: Mapping the value beyond the hype* [Report]. McKinsey Global Institute. <https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world>

Moorhead, P. (2022). *CES 2022: Matter and Thread win the IoT connectivity wars* [Analysis]. Moor Insights & Strategy. <https://staging3.moorinsightsstrategy.com/ces-2022-matter-and-thread-win-the-iot-connectivity-wars/>

Morton, F. M. S., Crawford, G. S., Cr  mer, J., Dinielli, D., Fletcher, A., Heidhues, P., & Schnitzer, M. (2023). Equitable interoperability: The “supertool” of digital platform governance. *Yale Journal on Regulation*, 40(3), 1013–1055. <https://www.yalejreg.com/print/equitable-interoperability-the-supertool-of-digital-platform-governance/>

Nyborg, S., & R  pke, I. (2011). Energy impacts of the smart home: Conflicting visions. *ECEEE 2011 Summer Study: Conference Proceedings*, 4, 1849–1860. <https://findit.dtu.dk/en/catalog/537f0c8f7401dbcc120019ed>

Pickren, G. (2014). Geographies of e-waste: Towards a political ecology approach to e-waste and digital technologies. *Geography Compass*, 8(2), 111–124. <https://doi.org/10.1111/gec3.12115>

Plantin, J.-C., Lagoze, C., Edwards, P. N., & Sandvig, C. (2018). Infrastructure studies meet platform studies in the age of Google and Facebook. *New Media & Society*, 20(1), 293–310. <https://doi.org/10.1177/1461444816661553>

Poell, T., Nieborg, D. B., & Duffy, B. E. (2021). *Platforms and cultural production*. Polity Press.

Project CHIP. (2019). *Project Connected Home over Internet Protocol*. ZigBee Alliance. <https://web.archive.org/web/20191219121144/https://www.connectedhomeip.com/>

Richardson, T. (2022, October 19). *From the White House to every house—Security in IoT* [LinkedIn article]. <https://www.linkedin.com/pulse/from-white-house-every-security-iot-tobin-richardson>

Rogers, R. (2017). Doing Web history with the Internet Archive: Screencast documentaries. *Internet Histories*, 1(1–2), 160–172. <https://doi.org/10.1080/24701475.2017.1307542>

Sadowski, J. (2020b). The internet of landlords: Digital platforms and new mechanisms of rentier capitalism. *Antipode*, 52(2), 562–580. <https://doi.org/10.1111/anti.12595>

Sadowski, J. (2020a). *Too smart: How digital capitalism is extracting data, controlling our lives, and taking over the world*. MIT Press. <https://doi.org/10.7551/mitpress/12240.001.0001>

Sadowski, J., Viljoen, S., & Whittaker, M. (2021). Everyone should decide how their digital data are used—Not just tech companies. *Nature*, 595(7866), 169–171. <https://doi.org/10.1038/d41586-021-01812-3>

Schneider Electric. (2023, January 10). *Build with Matter: A promise to a home ecosystem* | Schneider Electric CES 2023 [Video]. YouTube. <https://www.youtube.com/watch?v=k5hYsS005Kc>

Seifert, D. (2021, April 16). Project CHIP will finally ship later this year—The long-awaited smart home partnership should show some fruits by the holiday season. *The Verge*. <https://www.theverge.com/2021/4/16/22387252/project-chip-will-finally-ship-later-this-year>

Srnicek, N. (2017). *Platform capitalism*. Polity.

Statista. (2023). *Smart home—Worldwide* [Report]. <https://www.statista.com/outlook/dmo/smart-home/worldwide>

Stoltz, M., Crocker, A., & Schmon, C. (2022, May 2). The EU Digital Markets Act's interoperability rule addresses an important need, but raises difficult security problems for encrypted messaging. *Deeplinks Blog – Electronic Frontier Foundation*. <https://www.eff.org/deeplinks/2022/04/eu-digital-markets-acts-interoperability-rule-addresses-important-need-raises>

Sweis, D. (2019, August 1). Solving the IoT's biggest paradox requires a collaborative approach. *Forbes*. <https://www.forbes.com/sites/forbestechcouncil/2019/08/01/solving-the-iots-biggest-paradox-requires-a-collaborative-approach/>

Thompson, D. F. (1980). Moral responsibility of public officials: The problem of many hands. *American Political Science Review*, 74(4), 905–916. <https://doi.org/10.2307/1954312>

Tiwana, A. (2014). *Platform ecosystems: Aligning architecture, governance, and strategy*. Morgan Kaufmann. <https://doi.org/10.1016/C2012-0-06625-2>

Tuohy, J. P. (2021, December 14). Matter's plan to save the smart home. *The Verge*. <https://web.archive.org/web/20211214232127/https://www.theverge.com/22787729/matter-smart-home-standard-apple-amazon-google>

Tuohy, J. P. (2022, March 17). Matter smart home standard delayed until fall 2022—The latest setback is due to 'unprecedented interest' says the CSA. *The Verge*. <https://www.theverge.com/2022/3/17/22982166/matter-smart-home-standard-postponedfall-2022>

Unver, M. B. (2022). Threading the needle from 'interoperability' to 'gatekeeping': Quest for a layered model. *International Review of Law, Computers & Technology*, 36(2), 223–250. <https://doi.org/10.1080/13600869.2021.1964916>

van Dijck, J., Nieborg, D., & Poell, T. (2019). Reframing platform power. *Internet Policy Review*, 8(2). <https://doi.org/10.14763/2019.2.1414>

Vonau, M. (2022, December 20). Amazon Alexa gets Matter support, joining Google Home and Android. *Android Police*. <https://www.androidpolice.com/matter-rollout-amazon-echo/>

Winner, L. (1978). *Autonomous technology: Technics-out-of-control as a theme in political thought*. MIT Press.

Winner, L. (2007). Is there a right to shape technology? *Argumentos de Razón Técnica*, 10, 199–213. https://institucional.us.es/revistas/argumentos/10/art_11_rea10.pdf

Yates, J., & Murphy, C. N. (2019). *Engineering rules: Global standard setting since 1880*. Johns Hopkins University Press.

ZigBee Alliance. (2004, November 13). *Join the ZigBee Alliance*. <https://web.archive.org/web/20041113083559/http://www.zigbee.org/en/join/>

ZigBee Alliance. (2005, February 3). *About us: Our mission*. <https://web.archive.org/web/20041205175334/http://www.zigbee.org/en/about/>

ZigBee Alliance. (2011, February 24). *About: Understanding ZigBee*. <https://web.archive.org/web/20110224210159/http://www.zigbee.org/About/UnderstandingZigBee.aspx>

ZigBee Alliance. (2017, July 12). *Join the Zigbee Alliance and shape the future of the Internet of Things*. <https://web.archive.org/web/20170712204253/http://www.zigbee.org/zigbeealliance/join/>

Zigbee Alliance. (2017, November 28). *ZigBee Alliance at CES 2018: Driving the IoT forward*. <https://web.archive.org/web/20180710233706/http://www.zigbee.org/zigbee-alliance-at-ces-2018-driving-the-iot-forward/>

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