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ten Oever, Niels

**DOI**
10.1016/j.telpol.2022.102442

**Publication date**
2023

**Document Version**
Final published version

**Published in**
Telecommunications Policy

**License**
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Link to publication

**Citation for published version (APA):**
ten Oever, N. (2023). 5G and the notion of network ideology, or: The limitations of sociotechnical imaginaries. *Telecommunications Policy*, *47*(5), Article 102442. https://doi.org/10.1016/j.telpol.2022.102442

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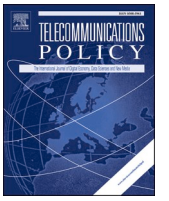
Download date:08 11月 2026

Telecommunications Policy 47 (2023) 102442

Contents lists available at ScienceDirect

Telecommunications Policy

journal homepage: www.elsevier.com/locate/telpol



# 5G and the notion of network ideology, or: The limitations of sociotechnical imaginaries

Niels ten Oever

*University of Amsterdam, the Netherlands*

A B S T R A C T

Transnational communication networks are produced in contestation between and among multinational corporations and nation-states. In the study of the governance of communication networks governance in science and technology studies, traditionally the emphasis has been on sociotechnical imaginaries (Jasanoff & Kim, 2015) which encapsulate joint futures that produce institutional configurations and the discursive roles in the power tussle between various stakeholders. I argue that next to the studying of power *over* infrastructures and their governance by sociotechnical imaginaries, there is an increasing need to study how power is distributed and control is exercised *through* the shaping of the technological materiality of infrastructures, as is happening for instance in the process of standardization. To describe the workings of the distribution of power and the exercising of control *through* networks, governance, and standardization, I expand the concept of network ideologies (Bory, 2020) to show how several network ideologies are at play in the shaping of 5G networks. I base my analysis on the qualitative analysis of standard-setting processes through document analysis of mailinglist conversations, standards, and policy documents, as well as through the parallel operation of experimental 5G networks. The analysis shows that sociotechnical imaginaries are insufficient to show the political process of the distribution of power and opportunities for control through the production of transnational communication infrastructures. The notion of network ideologies might provide a basis to study the merging of internet and telecommunication infrastructures, their standard-setting, and their governance as well as the excommunication of the user by relinquishing its ability to understand and configure infrastructures.

## 1. Introduction

To analyze the development, standardization, and deployment of 5G technologies I expand the concept of 'network ideology' (Bory, 2020). For the analysis of policies, infrastructures, and institutions, many scholars in science and technology studies have relied on the concept of sociotechnical imaginaries (Jasanoff & Kim, 2015). While sociotechnical imaginaries are very successful in explaining collaborations between diverse groups with distinct interests, expertises, and backgrounds through a joint vision of the future, the concept of network ideology can help analyze and explain the intentional ordering of infrastructures as means of power and control. Where sociotechnical imaginaries have allowed for the translation of political ideologies into material infrastructures (Steger, 2009), network ideologies allow for the translation of particular modes of infrastructural control into standards and implementations. The notion of network ideology helps explain how power is exerted *through* technological standards and *by* transnational communication networks, whereas political ideologies help explain how power is exerted *over* transnational communication networks. This contribution helps further the debate on the turn to infrastructure in Internet governance (Musiani et al., 2016; DeNardis, 2020).

5G standards make use of the availability of processors for routers with increased speeds and more memory for lower costs to leverage technical computing paradigms such as *Software Defined Networking*, *Network Function Virtualization*, and *Edge Computing* (Adamuz-Hinojosa et al., 2019; King et al., 2019). These paradigms relocate service provision from network endpoints to inside of computing networks and thus increasing the influence and control that can be exerted through these networks by their operators. In

*E-mail address:* mail@nielstenoever.net.

https://doi.org/10.1016/j.telpol.2022.102442
Received 1 February 2022; Received in revised form 7 September 2022; Accepted 8 September 2022
Available online 22 October 2022
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governance bodies and standards development organizations such as the 3rd Generation Project Partnership (3GPP) and the International Telecommunications Union (ITU), this has led to requests for networking requirements by a wide range of actors, ranging from law enforcement agencies to car manufacturers and Internet of Things equipment providers. Whereas in the Internet standards development this could lead to the development of a consensus through productive contestation (ten Oever, 2018), in the case of 5G nearly all requirements seem to be accommodated in a wide range of standards. I argue this can be attributed to an underlying network ideology that locates control over end-user devices inside the network, with network operators and aligned service providers.

I will first provide an overview of the methods I used to operationalize this research, after which I will provide a brief overview of the literature on sociotechnical imaginaries, the governance of communication networks, standardization, and power and the role of various stakeholders. After that, I will provide an analysis of the standardization and development of 5G and its projected functionality, its sociotechnical imaginary, and provide an overview of how the techno-material properties of 5G are being shaped through various network ideologies. Finally, I will provide some reflections on the impact this might have on the studies of transnational communication networks.

## 2. Methods

For this paper, I engaged in code ethnography of open source 5G implementations through the parallel deployment of experimental telecommunications networks in an act of transgressive infrastructuring. Transgressive infrastructuring is defined as 'a way of engaging critically with infrastructure that, in the case of GSM hacking, relie [s] on three strategies—reverse engineering, re-implementation, and parallel operation, all of which aim at appropriating the targeted network intellectually, legally, functionally, and/or operationally' (Wagenknecht & Korn, 2016, p. 1104). Next to that, I engaged in semi-structured interviews with engineers that develop and deploy telecommunication standards. The combination of these methods allows me to gain insights into the workings of 5G infrastructure production and the motives, interests, and approaches of the engaged stakeholders in the standardization and implementation of 5G.

### *2.1. Literature review*

#### *2.1.1. Sociotechnical imaginaries*

The concept of sociotechnical imaginaries - the combination of visions, symbols, and futures that exist in groups and society that guide the co-creation of knowledge, technology, policies, and institutions - as developed by Jasanoff and Kim (2015), has become a central notion in science and technology studies. It helps to explain processes of co-production of technology among heterogeneous groups with distinct interests, knowledges, and practices (Jasanoff 2004). It sheds light on the processes of technology production, and the role of institutions in this, but particularly centering the role of communities, sense-making, and world-building in the production of technology. The notion of sociotechnical imaginaries furthered the work of infrastructure studies (Bowker et al., 2010; Lampland and Susan Leigh Star, 2008; Star, 1999; Star & Ruhleder, 1994), a field that theorizes and uncovers how power and control is an inherent part of the production, maintenance, and usage of infrastructures.

Jasanoff and Kim write that sociotechnical imaginaries are 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology' (2015, 6). But if one looks closely at the processes through which infrastructures are produced, these visions often turn out to be '[m]yths [that] are important for what they reveal (including a genuine desire for community and democracy) and for what they conceal.

(including the growing concentration of communication power in a handful of transnational media businesses)' (Mosco, 2005, p. 19).

Sociotechnical imaginaries are commonly found and used within the analysis of communication infrastructures, starting with the telegraph, but similarly with the radio, telephone, television, mobile telephony, and the Internet. Whereas the technological sublime is a feature of sociotechnical infrastructures that depict them as an inherent part of a solution to social problems (Marx, 1956; Nye, 1996), sociotechnical imaginaries help describe how the sublime is leveraged to produce and implement an infrastructure by building social, political, legal, and economic support. Examples of this are the electronic superhighway metaphor – which helped garner political, economic, and popular support for the Internet (Abbate, 1999). However, as Julie Cohen highlights, the electronic superhighway metaphor has been replaced with the imaginary of the cloud. While this might seem innocuous, the imaginary of the electronic superhighway implied that there are rules and regulations that the internet should be bound to in a way that the cloud does not (Cohen, 2019). A cloud is ephemeral and cannot really be caught, and therefore escapes regulation. Cohen describes this as 'deep capture strategies are concerned not only with results in particular cases but also with crafting and reinforcing master narratives that become deeply internalized, and they do not target only regulators but also cultural influencers, public intellectuals, and academic thought leaders.' (Cohen, 2019, p. 105).

Could it be that sociotechnical imaginaries play an extensive role in 'how technologies are marketed, used, made sense of, and integrated into people's lives' (Sturken, Thomas, and Ball-Rokeach 2004, p. 3), but a rather limited role in the *material production* of technologies, for instance through standardization? If true, the production of technologies and the gathering of support for their acceptance and integration would occur simultaneous but not in parallel, meaning that sociotechnical imaginaries serve to legitimize a particular infrastructure, technology, or governance regime (ten Oever, 2021c) whereas the material production of the infrastructure, technology or governance regime happens through other means (ten Oever, 2021b). I will argue that the material production of communication infrastructures is led by network ideologies (Bory, 2020) that get translated into infrastructural norms (ten Oever,

2021b).

### 2.2. Infrastructure, standards, and power

Standardization is a point of convergence in the process of contestation about the shaping of the material technologies that underpin infrastructures. If 'changes to the globalising world are being written, not in the language of law and diplomacy, but rather in the language of infrastructure' (Easterling, 2014, p. 11), then standards are the grammar of this language. Within science and technology studies, infrastructure studies, and connected fields, excellent scholars have studied standards and their relation to power (Lampland and Susan Leigh Star, 2008; Abbate, 1999; DeNardis, 2009; Rogers & Eden, 2017). They have shown how power and standards are entangled and interrelated but have not provided a theoretical explanation for how it is exercised.

Aside from science and technology studies, the studying of telecommunication standards and standard-setting largely takes place within the fields of history of technology, economics, and law. The debate within this literature foreground the workings of network externalities (Ankney & Hidding, 2005; Katz and Shapiro 1985), patents (Baron et al., 2011; Bekkers et al., 2012), standard essential patents, (Baron & Pohlmann, 2018; Pohlmann, Neuhäusler, and Blind 2016), and path dependencies (Barnes, Gartland, and Stack 2004; Shin et al., 2015) in standard setting. These studies focus on how actors in standard-setting behave (Teubner et al., 2021), what makes standards succeed, and what makes them fail (Cargill, 2011). These studies provide a tremendously useful insight into the motivations and behavior of actors in standard-setting but provide relatively little insight into the societal impact and participation outside of the industry. Some scholars argue that standards are not just a public good, but that standard-setting is essentially the work of a global social movement (Yates & Murphy, 2019). Other strains of research have investigated how users can be integrated into standard-setting processes (Jakobs, 2000; Jakobs et al., 1996), how user interests can be prioritized in standards-setting (Nottingham, 2020), and how end-user rights advocates sought to participate in standard-setting processes (Morris & Davidson, 2003; Castka & Balzarova, 2008; Balzarova & Pavel, 2012, 29,000; Cath, 2021). However, the conclusion of most of these researchers is that there is little to no place for users or civil society in modern standards-setting if is not in the direct interest of the industry stakeholders (ten Oever, 2021b). Whereas matters of the societal implication of standardization and infrastructures have been a core part of standardization literature (Yates & Murphy, 2019), telecommunications, and internet standardization discussions (Braman, 2011, 2012), these matters of public interest are *intentionally* not structurally considered in standardization (Carr, 2015; Harcourt, Christou, and Simpson 2020).

The media scholar Alexander Galloway mainstreamed the idea that the founding principle of the Internet is not freedom but control. He argued that control was exercised in this distributed architecture was exercised through protocols (Galloway, 2006). Especially in a world where geopolitical tensions are rising and policymaking in global governance bodies is grinding to a halt, telecommunications infrastructure and its standardization form a welcome alternative. Especially since the standard-setting of transnational information networks has been cast as de-politicized through a veneer of open consensus-based standard-setting (Russell, 2014), but practically this translates into a limited role of the state and civil society (Carr, 2015), and a predominant role of transnational corporations. This practically makes internet governance and transnational communication standard-setting an exercise in bottom-up industry self-regulation (Sowell, 2012).

For the corporations involved in designing, standardizing, and maintaining transnational communication networks and the services that run over them, extracting data from end-users and exercising control over data streams is what the network is optimized for (Cohen, 2019; Easterling, 2014; Powell, 2021). The internet architecture is continuously shaped by the contention between parties that are interested in control over these data streams. An example of this is the deployment of encryption in the latest Internet transport protocol QUIC, which is used by content providers to ensure network operators have access to as little data and metadata as possible. This reinforces the position of consolidated content providers, such as that of the developer of this protocol, Google (ten Oever, 2021c).

### 2.3. The return of the state?

The Internet governance scholar Jeanette Hofmann (2005) differentiates three phases of internet governance. The first phase of technical coordination, the second phase of self-regulation, and a third phase in which the state reasserts itself in internet governance. I want to contend with this view because the state has never been structurally gone from the governance of transnational communication networks. It was the telegraph network that changed the British empire from a colonial power to an imperial power (Cowhey, 1990) by integrating an immense geographical space through the speed of near-instant communication. Equally, one of the most influential (and most-funded) predecessors of the internet, the ARPANET, was developed by the United State government in response to the launch of the Sputnik satellite by the Soviet Union (Abbate, 1999).

The influencing of standard-setting by the introduction of vulnerabilities in the Internet architecture by the United States National Security Agency, disclosed by Edward Snowden, is merely one example of continued engagement by states in Internet standardization (Rogers & Eden, 2017). The book edited by Haggart et al. (2021) highlights the return of the state in international policymaking, and the book edited by Musiani et al. (2016) shows the turn of the state to internet infrastructure for governance and policy goals. While there has been significant attention to the political economy of the production of transnational communication networks (Cohen, 2019; Hong, 2017; Powers and Jablonski 2015; Winseck, 2017, 2019; Zajácz, 2019), the production and reconfiguration of institutional arrangement for these networks (Cath, 2021; Drake, 2000; Mueller, 2002, 2010), and the economic drivers and interests in ICT standard-setting (Baron & Kanevskaia, 2021; Ermoshina & Musiani, 2019; Pohlmann, 2014; Shin et al., 2015) there is a gap in the literature where it comes to the inscription of particular network ideologies (Bory, 2020) in the architecture of communication infrastructures through standard-setting, or as Julie Cohen calls it: 'the exercise of network-and-standard-based governance authority'

(2019).

### 2.4. Network ideologies

To theorize how particular network ideologies are inscribed (Akrich, 1992) in communication infrastructures, I depart from the definition of ideology provided by James and Steger: 'Ideologies are patterned clusters of normatively imbued ideas and concepts, including particular representations of power relations.' (James & Steger, 2014, p. 423). To further the thinking about the role of ideologies in infrastructure, it is important to underline that ideology is not simply a linguistic phenomenon, but 'it also appears in material structures' (Humphrey, 2005, p. 39). This line of thought has also been furthered by Althusser who did not locate ideology in subjective convictions or 'false consciousness', but rather in discourses, institutions, and practices (Althusser, 2014). Institutions and practices are particularly important, especially in contrast with sociotechnical imaginaries. Where in sociotechnical imaginaries a shared discursive concept is leading in the development of technologies, in network ideologies it are the practices and materialities that are structuring reality. Media scholar Wendy Chun theorizes software as ideology when she describes that 'ideology persists in one's actions rather than in one's beliefs. The illusion of ideology exists not at the level of knowledge but rather at the level of doing.' In the analysis below of the contestation that takes place in the standardization and implementation of 5G, it will become apparent that there is a clear disconnect between the sociotechnical imaginary of 5G and the way the material technology is structured. Similar to the internet infrastructure imaginary, the sociotechnical imaginary does not describe the actual workings of the material infrastructure, but rather obscures the power relations and political economies of extraction, connection, and control (ten Oever, 2021c). Instead of the user being an active (configuring) part of the networking infrastructure. As Chun describes '[s]oftware produces 'users' (Chun & Hui Kyong, 2005, 43), in a similar way communications networks nowadays produce users. In communication infrastructure network ideologies determine the subject and objects of programmable infrastructures. Network ideologies are inscribed power relations in information infrastructures that shape how and by whom these infrastructures can be leveraged to accumulate influence and control, for instance through defining which actors can access, alter, and extract information and dataflows.

Network ideologies help explain how ideologies are located and perpetuated in and through communication networks through their (infra)structure, which includes its standards, governance bodies, and practices. Where in sociotechnical imaginaries the emphasis is laid on the discursive that leads the formation of materiality, network ideologies emphasize how material technology is the arena for power contestation that is hidden by professed sociotechnical imaginaries. Another example has been provided by Elinor Carmi when she describes the process of the standardization of web-cookies and how the digital advertising industry used the imaginary that web-cookies were 'anonymous' to legitimize the material technology (Carmi, 2020). One can recognize network ideologies by understanding the power dynamics that are perpetuated through standards and design, in other words, who has access to data streams, what is quantified, which data is shielded or encapsulated, and for whom. Telecommunication networks in particular are presented as universal standardized homogeneous objects that are constantly hovering in the background, ready to serve the subscribers' needs. However, telecommunications networks are also complex, outsourced, proprietary technical stacks that have always provided access to law enforcement and that reorganize the topography of public space and by providing new network topologies and cyber-physical infrastructures ().

It is important to note that the concept of network ideologies does rest on technological determinism. Rather the concept of network ideologies emphasizes the assemblage structure of networks and infrastructures while accentuating the role power plays in them. People play an equally important role in network ideologies as people do. However, network ideologies emphasize the importance of the structuring quality of materiality which often gets overlooked in the discussion on sociotechnical imaginaries, particularly in policy discussions. In this understanding, I seek to echo the thinking of Karen Barad who argues that matter and meaning are inherently entangled and not simply a matter of discursive activity (Barad, 2007).

In short, network ideologies describe the influence of power relations on the formation of information through communication networks, particularly through the design, standardization, and implementation of information technologies. This definition provides insight into the actors that enact network ideologies, these are the people and institutions that engage in these activities. When end-users are not able to engage in networking, they are not inscribing networking ideologies, but they are imbued on them. Network ideologies drive the architectural reconfiguration of network topologies.

## 3. Analysis

### 3.1. International mobile telephony standards in the International Telecommunications Union

The invention of the first two generations of mobile networks led to competing non-interoperable standards, namely GSM, produced by the European Groupe de Travail Spécial pour les Service Mobiles and the standard Code Division Multiple Access developed by the North-American Qualcomm. Both these standards gained popularity outside of the respective origin geography, and thus standardization in a body that covered more than Europe or the United States was needed. This role was taken up in part by the International Telecommunication Union (ITU), which developed the requirements needed for what would become the third generation of mobile networks, 3G for short. These requirements were summarized in the International Mobile Telecommunications 2000 standard, or IMT-2000.

Based on the requirements of the ITU, manufacturers engage in the production of technology and technology specifications that live up to these requirements. Once this is done, the ITU assesses whether these technologies deliver on their promises, and subsequently, these technologies and specifications become part of the standard. This is what happened with technologies for 3G (under the ITU IMT-

2000 standard), 4G (under the ITU IMT Advanced standard), and this is what is expected to happen for 5G (under the ITU IMT-2020 standard). However, this has not happened yet.

Preceding 3G there was strong competition between various families of standards, but the industry consortium that encapsulated telecommunications standards organizations from Japan, the United States, China, Europe, India, and Korea is now producing practically all standards for mobile telephony. This consortium is called the 3rd Generation Partnership Project (3 GPP). Qualcomm sought to establish the 3rd Generation Partnership Project 2 (3GPP2), but this has only been able to produce standards that have been recognized by the ITU for 3G (namely the CDMA2000 standard). There is one other body that produced specifications that live up to the ITU standards, and this is the Institute for Electrical and Electronic Engineers (IEEE), but their WiMAX standards mostly focus on long-distance WiFi connections that are not produced for mobile phones.

### *3.2. 5G's sociotechnical imaginary*

In the information, marketing, and communication material on 5G provided by the 3 GPP and those engaged in the standardization of 5G, three main points are consistently communicated: 5G will provide (1) higher bandwidths at (2) lower latency for (3) more devices. In other words, 5G networks will be faster, better, bigger, and more. But at the same time, 5G is positioned as the logical successor to 4G networks, which will be produced by the same (or similar) phone and equipment manufacturers and the networks will be operated by the same familiar telecommunications providers.

In the sociotechnical imaginary of 5G there is an inherent friction between the claims it makes: is it an evolution or a revolution? Will it simply be like 4G, but a tad bit better, or will it power smart cities, and create 'new immersive experiences'? The answer to this question might be simpler than one would expect: we do not know yet, because 5G has not yet been standardized or implemented. And the candidate standard for 5G, as it is currently being developed in the 3 GPP, is by no means uniform or monolithic. The 5G is a complex combination of standards (some of which have not been finalized yet) that can be implemented in modular manners, resulting in heterogeneous networks with varying functionalities.

5G can be implemented to power smart cities, or 5G implementations could be run by private actors in 'Industrial Internet of Things'-settings to network production lines and factories with high timing precision and control systems (Schneir et al., 2018). But these things do not come without cost. To deliver on the high bandwidth and low latency promises of 5G, the use of higher frequencies than the ones that are currently allocated to private mobile communication networks are needed, namely in the mid-band (3.4–4.5 GHz) and high-band (24 GHz and up) frequencies. A consequence of the use of these frequencies is that signals will travel less far and have a limited penetration rate through for instance walls and trees, and will suffer more from interference from other signals. To establish coverage for this network new and more antennas will need to be deployed, leading to an increase in devices and energy consumption, as well as usage of spectrum by large telecommunication providers.

A cursory glance at the sociotechnical imaginary of 5G helps to show that sociotechnical imaginaries function to facilitate the introduction and absorption of this technology by society. It helps to build support and legitimacy - it however as we will see - does not describe the actual technological workings and material reconfigurations that come with the technology.

### *3.3. 5G network ideologies*

#### *3.3.1. The rise of a sensor network and the end of end-to-end*

The development of 5G networks heralds a significant change in the topology of communication infrastructures. The rise of the Internet model was characterized by the introduction of a dumb network with smart edges (Abbate, 1999; Clark, 2018; Zittrain, 2008) in which the sole role of the network was to route data, and for connections to be initiated by the end-nodes, where processes and innovation would take place (Internet Architecture Board, 1996). The introduction of this model was a direct response to the preceding telecommunications model in which the end-nodes were dumb (think of a phone with a rotary dial) and the network was (relatively) smart. Or at least smart enough to limit the smartness of the end-nodes (Russell, 2014).

The rise of 5G fits in a model in which the network can service more devices than ever, but these devices are not the room-filling computing devices from the 1970s, nor the size of smartphones, but rather take the shape of video cameras, smartwatches, vibration sensors, and traffic lights. For the longest time, it was expected that at least one end of a connection between two end-nodes was an end-user. But this is less and less the case. This is a process that Galloway, Thacker, and Wark theorize as the excommunication of the user (Galloway et al., 2013). Where the term 'user' was already a rather one-dimensional understanding of a human in relation to computing networks (Satchell & Paul, 2009), in the network ideology of the Internet of Things (IoT), as popularized by IBM (Powell, 2021) the user has less and less control over communication infrastructures. This results in humans being configured through their computational context through infrastructures in smart cities, instead of controlling these infrastructures themselves (Mosco, 2019). The infrastructures are thus, in short, producing the user. The sensory feedback loop between sensors, users, servers, screens, and urban devices produces an image of a fully programmable infrastructure that is programmable, adjustable, and optimizable, except for the subject that is being optimized (Gurses & Van Hoboken, 2017; Powell, 2021). The excommunication of the user in 5G enabled networks reveals the optimization of communication networks for data extraction and the creation of a data proletariat.

This is an example of a network ideology because it structurally changes power relations between different actors through communication infrastructure reconfiguration. In this particular example, power, and opportunity are taken from end-users, who become the subject of data extraction, whereas the network operators gain more control over end-points and data-streams.

### 3.3.2. *The 'telecomification' of the internet, or: back to the future*

Since 4G all traffic in mobile networks is using the Internet Protocol (IP). This removed the theoretical and practical difference between Internet Service Providers (ISPs) and Mobile Network Operators (MNOs). Next to that, all across the world, independent ISPs have been acquired through mergers and acquisitions by the telecommunication industry, leading to the overall oligopolization of MNOs (Genakos, Valletti, and Verboven 2018; Warf, 2007). This makes MNOs the main providers of wired internet connections to homes and businesses. In the near future this might mean that copper networks might not be replaced with fiber to the home (FTTH), devices in the home might directly be connected to 5G networks (Knieps & Stocker, 2019). Where a home router provides an opportunity for users to deploy firewalls, manage, and administer traffic, and provide a certain level of anonymity among family members, direct connections to networks provided by MNOs will provide the network operator with a lot of information about individual users. Especially since with new antenna technology and lower latency, the location and position of devices can be monitored in far greater detail with 5G networks. This means that MNOs will have a lot of data and control over end-user connectivity. Add to this is the introduction of so-called embedded SIM-cards, or e-SIMs. Meaning that devices can remotely be connected to telecommunication networks through software-based programmable identifiers. This is transforming the cloud into a fog that makes it impossible to see whether, how, and to whom devices are connected. This transformation makes communication infrastructures omnipresent and invisible at the same time, practically blackboxing the foundation of information societies.

### 3.3.3. *The 'internetification' of telecoms, or: the collapsing of the stack*

The integration of the internet with telecommunication networks is working both ways. In 5G networks, the most commonly used transport protocol in telecommunications networks changes from the native telecom Stream Control Transmission Protocol (SCTP) to the internet native Transmission Control Protocol (TCP). Whereas previous telecommunication networks generally were provided through an integrated stack that was offered by one provider, in 5G the network consists of many interoperable microservices. This microservice architecture makes it possible to operate more heterogeneous networks, but also for parts of the network to be offered by different providers. This fits within the trend of financialization where MNOs are practically being hollowed out, and the running of the network is being outsourced to equipment providers through Service Level Agreements (Hubert, 2020). The presence of these microservices makes it also possible to place more content caching services in the network, a move that has been popularized by Content Distribution Networks (CDNs) (ten Oever, 2021a). CDNs, such as Akamai, NetApp, and Cloudflare, provide services that make content available closer to users by using content caches in edge networks. This decreases the amount of transit traffic because content gets distributed to regional or local caches, and from there gets requested by users near the cache. With the rise of 5G networks and the emergence of oligopolies at the edge of the network that has been described in the previous section, there is no cache that can be brought closer to users than through 5G networks. This means that not just the latency of the network is low but also the length of the path that the data needs to travel is very short, which leads to shorter response times. This is a popular approach to bringing traffic faster to users than competitors and thus moving around net neutrality legislation. But of course this cannot happen by itself, but needs to be designed and facilitated by standards to allow for such functionality to interoperate.

Facebook, the company that is known for its social media network, has funded the development of Magma, which describes itself as 'an open source platform for building carrier-grade networks'[1] by developing and providing both hardware[2] and software[3] for running 3 GPP compliant 5G networks. Facebook subsequently also provides a hosted environment to manage mobile these mobile networks.[4] The vertical cross-stack integration here seems clear, Facebook is seeking to stimulate a telecommunication market in areas where there is no connection yet. By providing this connectivity, and backhaul through submarine cables that they are investing in as well, it will be very easy to provide locally pre-cached services within networks that have been optimized to deliver Facebook content. Amazon has launched a similar service to manage private 5G networks.[5]

5G standards allow for increasingly modular functionality in communication networks, which enables lower latencies. The possibility of these services at the same time increases the importance of edge networks (since they become richer in services), but also increases the complexity of these networks. This drives telecommunications engineers of edge networks further into the hands of equipment manufacturers that operate Infrastructure as a Service (IAAS). This material reconfiguration matches the neoliberal practice also called 'financialization', or endless partitioning and reselling of companies. Most recently this can be observed in the trend of the selling off of physical telecom masts by network operators, such as T-Mobile and Deutsche Telekom. This is another example of how material reconfigurations through network ideologies have very concrete consequences, but not only on users, but also on the companies operating the networks.

### 3.3.4. *The United States vs China – an ironic geopolitical tussle for control*

In December 2018 Meng Wanzhou, the Chief Financial Officer (CFO) and daughter of the founder of Huawei was arrested in Vancouver, Canada, based on an extradition request by the United States. This heralded the intensification of a trade war between the United States and China, which culminated in the addition of Huawei equipment to a blacklist, designating the equipment a national

[1] https://www.magmacore.org/accessed on October 30, 2021.
[2] https://freedomfi.com/accessed on October 30, 2021.
[3] https://github.com/magma/magma accessed on October 30, 2021.
[4] https://freedomfi.com/accessed on October 30, 2021.
[5] https://aws.amazon.com/private5g/accessed on January 22nd, 2022.

security threat, making it impossible for critical infrastructure providers to use Huawei hardware in their network.[6] The United States subsequently went ahead and tried to convince other countries to follow suit (Rühlig & Björk, 2020). NATO added fuel to the fire and published a paper titled 'Huawei, 5G, and China as a Security Threat' (Kaska et al., 2019).

That concluded that Huawei equipment *could* pose a security threat because of its ties with the Chinese Communist Party and its intelligence apparatus. Interestingly, the United States Department of Defense, NATO reports, nor any of the other countries that followed suit in the implementation of restrictive policies towards Huawei equipment, produced a *technical* reason for the exclusion of Huawei from their networks. The reasons provided for this are that the dominance of Huawei could pose a risk for the market, produce vendor lock-in, and then make it easier for the Chinese government to potentially introduce *backdoors*, and thus the exclusion of Huawei equipment could be theorized as a kind of risk management (Radu & Amon, 2021). This argumentation has been echoed by many international media, whereas there has been no clear indication that this might concretely happen, and if it would, it would probably be the instantaneous end of Huawei usage outside of China. However, as recent research shows (Becker, ten Oever, & Nanni, 2022), this position is not reflected in the standardization of 5G networks. The standardization of surveillance techniques in the 3 GPP is driven by North American and European companies and implemented by network equipment manufacturers around the world.

The allegations of the United States vis à vis Huawei and China, which have become a sociotechnical imaginary by itself, are deeply ironic for several reasons. First, as elegantly shown by Yun Wen in 'The Huawei Model' (Wen, 2020), the emergence of a Chinese telecommunications market is the product of high technology transfer and export tariffs for European and North-American telecommunications equipment. Years of excessive costs hampered the expansion of Chinese telecommunication networks, leading to an interest by the Chinese state to develop an alternative. When China opened its telecommunications market to foreign investors, relatively low-tech parts were produced or the Chinese locations were used to assemble devices made out of more high-tech parts produced in other south Asian nations, for a while this was even called 'the Chinese disease' (Hong, 2017). To simulate a local market and expertise, China adopted its own 3G standard, TD-SCDMA. To reassert itself as a stronger global player, China chose to de-link itself from the global telecommunication standard, to reconnect with stronger expertise at a later stage. At the same time, China became part of the WTO and was stimulated to stop violating intellectual property and develop its own patent portfolios and engage in international standard-setting. And this is exactly what China and Chinese companies did, causing the second ironic twist in this story.

In standard-setting companies need to declare when they hold a patent over a technology that is being standardized. When a patent becomes part of the standard, the patent is called a Standard Essential Patent (SEP). This means that every time that standard is being implemented, the holder of the SEP should be paid a license fee (unless other arrangements are made, such as patent pools (Bekkers et al., 2006) or cross-licensing (Shapiro, 2000)). Because of the many new functionalities in 5G, there has been a sharp increase in patents in comparison to earlier generations of telecommunication networks (Baron et al., 2011; Baron & Pohlmann, 2018). The majority of these patents have been registered by Huawei, only to be followed by Samsung, ZTE, and LG. These four Chinese and Korean-owned companies make up the overwhelming majority of the totality of 5G patents (Pohlmann, Blind, and Heβ 2020). Nokia and Ericsson take up the fifth and sixth place, and only after that comes an American corporation, namely Qualcomm (ibidem). Meaning that in a relatively short period, Huawei has become at the forefront of telecommunication standardization, exactly as been told by leading countries in the WTO. But when they beat these countries at their own game, it is exactly these countries that cry foul.

The third twist of irony is that not China, but the intelligence services of Great Britain and the United States have been perpetrators of mass surveillance by weakening the security of global communications networks (Rogers & Eden, 2017). Furthermore, the United States has been accused time and again of seeking to de-state the governance of communications networks and use North American market parties to control the internet (Carr, 2015), now other countries are responding by either establishing rules and regulations to curb that influence, or engage in competition through standard-setting, but both are cast as acts against 'the open internet', or even 'acts of repression'.

The 3 GPP has a long history of appealing to the discontent of governments over the usage of communication networks that they do not approve of. Testament to this is the 'lawful intercept'-working group, which has been active in the 3 GPP nearly since its inception.[7] In this working group, technical requirements are determined for new technical standards and how they should facilitate state surveillance. In 5G this means that Law Enforcement Agencies (LEA) have access to nearly every layer of the 5G stack (Access and Mobility Management Function, Session Management Function, User Plane Function, Control Plane Function, Unified Data Management, and the SMS Function) through a standardized API.

The concern of the United States about Huawei's success in the 3 GPP and 5G industry in general, is that it seems to be losing its competitive edge. The protective measures initiated by the United States are not rooted in a concrete technical but in a potential and perceived threat (Radu & Amon, 2021) could be interpreted as attempts of a hegemon in decline to hold on to the position it once had. Europe used to have the competitive edge in telecommunications in times of the development of GSM (Hillebrand 2001), the United States had the competitive advantage with the development of the Internet (Abbate, 1999), and clearly, it is now China that has the competitive advantage in the development of 5G (Dunajcsik & Niels ten Oever, 2021).

The funding and original design of the internet as a distributed network was a response to the launch of the Sputnik satellite, after the fall of the Soviet Union the architecture of the internet was changed to decentralize the management of the internet's backbone (Abbate, 1999). The end-to-end architecture benefited America's cultural, commercial, and infrastructural power (Carr, 2015), and it championed the integration of China into the WTO and international standardization processes. However, now that China has shown to be effective in accommodating various network ideologies in 5G, and championing its development, the United States falls back on a

[6] https://docs.fcc.gov/public/attachments/DA-21-309A1.pdf accessed on November 1, 2021
[7] https://list.etsi.org/scripts/wa.exe?A0=3GPP_TSG_SA_WG3_LI accessed on October 31, 2021.

sociotechnical imaginary of insecurity of China-produced 5G that is not found in any concrete material technology.

## 4. Discussion - Making sense of 5G through network ideologies

While discussing the architecture of telecommunications networks with standards engineers, it can be complex to discover architectural principles or visions that underpin the development of new telecommunication networks. During a 3 GPP meeting, I asked a senior standards engineer for a large telecommunications provider: 'What is 5G optimized for?'. He looked at me and smiled when he said: '5G is not optimized for anything, it is optimized for everything.' He then continued: 'We will implement what we can to develop and explore new earning models.'. This characterizes the rapidly expanding size of the combined 5G standard. The total number of pages describing the 5G standards in the 3 GPP is already exceeding that of 4G and the standardization of 5G is expected to continue for several more years. The deployment of 5G will likely lead to the deployment of heterogeneous networks that become more configurable for network operators, and others that have access to the programming interfaces of these networks. This fits with an overall network ideology of network control that departs from the end-to-end architecture of the internet which places control at the edges of the network. Whereas on the internet it was initially expected that all end-hosts were equal, current dynamics play out between consolidated content providers such as Google, Amazon, and Facebook on the one hand, and consolidated network operators on the other, such as Vodafone, China Telecom, MTN, and AT&T, that vie for the access to user data and subscriptions.

Content providers, network operators, networking equipment providers, content distribution networks, and nation-states all have their particular interests when it comes to the development and implementation of communication networks. These parties all aim to control data streams while seeking to benefit at the same time from the network effects of an interconnected network and thus seek to inscribe network ideologies that favor a world ordering in which they can increase their control. Continuously infrastructural norms are introduced that accommodate various networking ideologies. Within the standardization and governance of the internet, the accepted overlapping infrastructural norm was one of voluntary interconnection (ten Oever, 2018). But in the governance of telecommunication networks, asymmetrical end-to-end approaches have been common since the early 20th century (Zajácz, 2019). Therefore, to understand contemporary issues and trends in internet governance, it should no longer be discussed in separation from telecommunication governance. The studying of the rise and decline of the telecommunications regime provides ample examples of the role and impact of regulation on a sector controlled in some geographies by a monopoly whereas in other countries it is controlled and regulated by states (Cowhey, 1990; Drake, 2000; Frieden, 2002).

Another reason for no longer studying telecommunication governance and internet governance separately is the technical integration of both regimes through the IP layer, as well as the institutional ambitions of networking equipment providers and network operators to provide and standardize services outside of the lower layers of the traditional internet stack (see Fig. 1). Therefore a limited understanding of the internet governance regime, namely the idea that Internet governance consists of practices and institutions that produce the logical layer of the internet, is no longer sufficient. Because the networks underpinning the internet, as well as new devices that function as endpoints, and applications that are being run *inside* the network, are changing the nature of interconnectivity on the internet.

To better understand and conceptualize the governance and standardization of transnational communication networks, a new interdisciplinary understanding of them is needed. The tussle over control over data streams through the introduction of infrastructural norms by various actors should be understood as attempts to inscribe network ideologies into technological infrastructures. These network ideologies are more than mere reflections of the interests and values of stakeholder groups, they are the translations into material technology and technology policy of these values. Whereas sociotechnical imaginaries emphasize a joint vision of the future, network ideologies emphasize the technological translation of values, interests, and strategies. This contributes to the understanding of infrastructure as governance (DeNardis & Musiani, 2016).

## 5. Conclusion

The contestation over the distribution of power over data streams between network operators, networking equipment providers, nation-states, and content providers plays out at an ever deeper infrastructural level and is deeply seated in a network ideology of control over users, their data, and the services and content they have access to. The production of new transnational communication

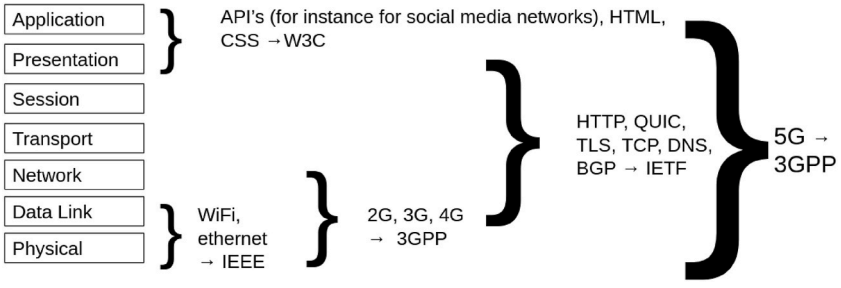


**Fig. 1.** Standards bodies and technological stack as per the OSI model. Adapted from A. Andersdotter and ARTICLE19.

infrastructures takes place outside of the confines of traditional internet governance bodies but has a potentially significant impact on them. Actors engaged in the standardization of 5G aim to reconfigure and transform the traditional end-to-end architecture of the Internet by excommunicating the user from control over data streams and providing network operators and content providers with an extensive programmable infrastructure. The programmable infrastructure, leveraged by concepts of network function virtualization, software-defined networking, network slicing, and beamforming antennas on small cells, provides a high density, low latency, high bandwidth, high capacity grid for data extraction and the shaping of urban spaces. The tussle *over* the shaping of this infrastructure has led to geopolitical tension between the United States and China based on a sociotechnical imaginary of insecurity. This is not rooted in technological materiality, but rather in the trauma of a hegemon in decline that is being beaten at its own game by a rising power.

The concept of network ideology helps to discern between the shiny produced visions of future technologies in sociotechnical imaginaries that build support and legitimizes the development and integration of infrastructures and the underlying tussle for power and control that take place in the material production of infrastructure in standardization and governance processes.

This article aims to contribute to the increasing attention to the material (re-)configurations that come with the introduction of technologies and their impacts on power and opportunity in society, particularly the rights and freedoms of end-users.

## Acknowledgments

The author gratefully acknowledges funding from the Dutch Research Council (NWO) through grant MVI.19.032 as part of the programme 'Maatschappelijk Verantwoord Innoveren (MVI)' and the Open Technology Fund. I am particularly thankful and indebted for the discussions with my colleague Peter 'Maxigas' Dunajcsik within the framework of 'the People's 5G Lab', the 'Cybertopologies' reading group hosted by Svitlana Matviyenko, and an excellent review by Julia Rone and the discussion with the Seminar on Technology and Democracy at the Minderoo Centre for Technology and Democracy at the University of Cambridge, and the anonymous reviewers of Telecommunications Policy.

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