Lit up and left dark: Failures of imagination in urban broadband networks

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Abstract

The design and deployment of urban broadband infrastructures inscribe particular imaginations of Internet access onto city streets. The different manifestations and locations of these networks, their uses, and access points often expose material excesses of urban broadband networks, as well as failures of Internet service providers, urban planners, and public officials to imagine the diverse ways that people incorporate Internet connection into their everyday lives. We approach the study of urban broadband networks through the juxtaposition of invisible networks that are buried under the streets and have always been "turned off" (dark fiber) versus hypervisible that are "turned on" and prominently displayed on city streets (LinkNYC). In our analysis of these two case studies, we critique themes of visibility and invisibility as indexes of power and access. Our findings are meant to provide a critical analysis of urban technology policy as well as theories of infrastructure, visibility, and access.

Introduction

Broadband connectivity has become a hallmark of post-industrial society, with both corporate leadership and policy makers promoting social cohesion and economic development through online access. This ethos of connectivity typically manifests in policies and initiatives concerned with the supply-side of internet access. The physical infrastructures of supply-oriented initiatives such as computer labs, fiber optic networks, antennae, and digital kiosks have become emblems or symbols of public internet access, digital inclusion, and broader commitments to "smart city" development. Yet simply supplying internet access has proven inadequate in promoting full inclusion, largely because of a failure to imagine how the supply of internet access will be used in everyday lives of diverse publics (Koltay, 2011). Crucial to addressing this gap between intent and actuality, access and use, is an understanding of how available broadband projects are for critique, adjudication and accommodating multiple forms

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of use. While the physical visibility of broadband projects varies significantly from highly visible digital kiosks and signage for public WiFi access to buried fiber networks, an additional and perhaps more fundamental concept emerges from their legibility, or the degree to which a system's designers, controllers, and adopters are able to read and comprehend the system's structure, governing policies, and/or meaningful uses (Offenhuber, 2017). Legibility manifests in the physical structures of these technologies, the resources and methods available for reading networks, the policies that govern the implementation and access to these networks, as well as the kinds of uses and users imagined.

Beyond their technical functioning, the legibility of broadband infrastructures offer insights into conflicting government, corporate, and community desires for public internet use. Reading and recognizing the different materialities and geographies of networks, uses, and access points can expose material and ideological excesses of urban broadband networks and the failures of internet service providers, urban populations, and public officials to imagine all of the different ways that people incorporate internet connection in their everyday lives. Drawing from these overarching issues, three key questions guide this project: How do the geographies and materialities of broadband projects inscribe these imaginations in urban space? When broadband projects are planned for city space, what assumptions about users and uses are imagined within these projects? When gaps emerge between intended and actual use, what implications can be teased out for discussions of urban policy and socio-technical transparency?

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As a way of theorizing power relations around connectivity and legibility, we consider the politics of two internet infrastructure projects currently in place on urban sidewalks across the United States that promise urban broadband connection: invisible or inactive networks that are buried under streets and have always been "turned off" and hypervisible, activated networks that are "turned on" and prominently displayed on city sidewalks. In our consideration of invisible connection, we focus on "dark fiber" networks that are purposefully constructed as inactive and are effectively invisible. In contrast, we consider WiFi enabled digital kiosks that provide free internet access to pedestrians, drawing attention to the contested use of free WiFi among diverse populations. We've chosen these two case studies because they are emblematic of themes of (in)visibility and spectacle in critical infrastructure studies, allowing us to develop a critique of visibility and invisibility as indices of power and access. While we structure our comparison around hidden versus hypervisible projects, we are ultimately less interested in whether technologies are visible or accessible than in the negotiations of their use. Whether lit up or left dark, urban broadband projects operate at the convergence of how to use city streets and how to use the internet. These case studies help us articulate the power dynamics at work in public WiFi projects, as well as the limits of visibility in critical infrastructure theory and transparency in policy discourses of "smart cities" and techno-political ethics.

In our investigation of urban broadband projects, we build on critical infrastructure scholarship examining the policies of inclusion and exclusion, narratives of access, and forms of imagining the urban. Visibility has been a fundamental way of theorizing infrastructure, from Bowker and Star's (1999) influential analysis of infrastructure as only becoming visible in moments of

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disrepair to Larkin's (2013) analysis of infrastructure as spectacle. As other studies have shown (Farman, 2013; Hu, 2015; Parks, 2010), normative imaginings of digital use and access can limit or disguise internet infrastructures in ways that shroud their politics and obscure possibilities for transformation, radical intervention, or even direct input from end users. While transparency has been proposed as a means to address these issues and promote citizen engagement with urban infrastructures (Sassen, 2012), our research highlights the extent to which transparency can be a reductive rather than a radical means of relating to infrastructure.

In addition, our critique of visibility recognizes how city streets are socially, culturally and technologically encoded by layers of corporate as well as local government imaginings of internet access needs. We argue that these encodings configure how the internet and the city street are and are not public, who is and is not supposed to be using these utilities, and who gets to decide their use. These case studies highlight the shifting parameters of inclusion in both imagined urban communities and imagined internet publics, calling into question what it means to connect a public or to publicly connect. By analyzing LinkNYC as a public spectacle of connectivity and the buried potential of dark fiber networks, this paper re-envisions the street as a contentious space where the relationships at stake in our "digital rights to the city" (Shaw and Graham, 2017) are discerned and debated.

Related work: The (in)visibility of infrastructure

Ethnographic approaches to media infrastructure have understood cables, wires, and signal routes as artifacts and systems encoded with cultural and political ideologies that address and

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constitute us as subjects through ongoing interactions (e.g. Larkin 2013; Starosielski, 2012). People interface with these cables and wires as technological objects, but also as manifestations of social processes and imaginations from specific geographical and cultural contexts. Advocating for further work in this area, Parks (2015) has encouraged researchers to think about "infrastructural dispositions" and "infrastructural imaginaries" in order to ask questions about what media infrastructures are made of, how and why they came to be, where they are located (and where they are not), who controls them, and what they are intended to do. We take up these questions, focusing particularly on the latter three, in our analysis of urban broadband projects as a way of unraveling the layers of access and control in narratives of urban connectivity.

Scholars from STS, media studies, and geography (Bowker and Star, 1999; Graham, 2010; Jackson et al. 2017*)* have discussed infrastructure visibility in terms of moments of maintenance, breakdown, or blackout that interrupt our imagination of media infrastructures as invisible. These moments become salient as exposures of the materiality and logic of networks. Conceptualizing media infrastructures in terms of visibility and functionality can be traced back to Heidegger's (1962) division of technology as "readiness-to-hand," or tools that are routinely visible, versus utilitarian apparatuses for connection that become visible at moments of change or crisis, when they become "present-at-hand." The planned invisibility of media infrastructure emerges when contractors develop more intricate ways to hide the physical layers of infrastructure from public view: bury telecommunication cables undersea and underground (Starosielski, 2015), disguise cell phone towers as natural objects meant to blend

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into the landscape (Parks, 2010), or construct data centers as bunkered or non-descript warehouse structures (Hu, 2015; Farman, 2013). Even while displaying media infrastructures through photo galleries and virtual tours as a spectacle of transparency, these images "blackbox" technical and social details about how infrastructures work or what they mean (Holt and Vonderau, 2015). In all of these cases, infrastructural materiality and politics are also rendered invisible (Parks, 2010, Mackenzie 2005) or at best, distant or removed from public access.

Supply-oriented infrastructure initiatives have been critiqued for the determinist implication that simply providing online access can overcome a complex array of structural inequalities (Donner, 2015; Gonzalez, 2011; Warschauer and Ames, 2010). In addition, as the supply of internet infrastructures and opportunities for public connection continue to expand, spatial disparities, lack of competition, and the marginalization of minority and rural populations persist (Grubesic and Murray, 2004). As shared space becomes increasingly privatized, libraries remain an important outpost of public internet access, and library and information science (LIS) offers another body of scholarship critiquing a reductive emphasis on access, pointing to a more granular understanding of technological, media and information literacy (Behrens, 1994; Koltay, 2011; Tripp, 2011). Following this shift away from a determinist emphasis on access and towards a more holistic focus on demand and use, our analysis considers urban internet projects as convergences of spatial politics, technological discourses and public policy.

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Whether in the context of urban internet networks, software program interfaces or public library initiatives, the ways in which media infrastructures are made invisible or kept hidden are never neutral. Previous critical infrastructure studies have frequently addressed the politics of access, implementation, and use through a framework of visibility, and tend to advocate for further transparency in infrastructure design and deployment. This paper builds on literature that examines how infrastructures are embedded within cultural and physical contexts, interrogates the social and material decisions about where networks are, who they're for, and how they're accessed. At the same time, we challenge work that focuses on the supply side of infrastructure, looking instead at how imaginations of supply belie use - once broadband projects are imagined and installed, who gets to decide when and how they are used? We also push back on established conceptual binaries of present/absent, visible/invisible, and connection/disruption as dichotomies for understanding infrastructural politics. Our analysis of dark fiber and LinkNYC both examines (in)visibility and seeks to unpack the different layers of seeing and not seeing, using and not using urban broadband.

Methods

Influenced by anthropological theories of infrastructure and urban media archaeology, our project maps both the physical and discursive infrastructures of dark fiber and LinkNYC in order to identify changes in "infrastructural relations" (Bowker et al, 2010) that shape these networks and imaginations of public connectivity. We understand urban broadband networks as material artifacts of economic, political, and social theories of internet connection. Our analysis draws on multiple methods to theorize infrastructural entanglements or the ways that digital infrastructures become embedded and layered within physical and social environments,

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combining cartographic and textual analysis, participant observation and interviews to account for different socio-cultural conditions that shape meaning, affect, and experience of infrastructure.

Our analysis of Links in the New York metropolitan region draws on analysis of news coverage, as well as 10 on-the-street interviews with Link users, conducted during the summer of 2016, within the first two months that the kiosks were installed on New York City streets. To conduct interviews, the second author visited LinkNYC kiosks in all three boroughs where links were then operating: The Bronx, Manhattan and Queens. Walking along Link routes in three boroughs provided opportunities to observe the emergent uses of these technologies, as well as recruiting interviewees. After obtaining consent, interviews were conducted and recorded, with interviews lasting between 10 and 30 minutes; the on-the-street nature of interviews made longer conversations difficult. We encountered three main groups of Link users: tourists, housing insecure folks using Links to pass time, and local workers on breaks or waiting for rides after a shift. We draw mostly on the latter two groups in our analysis as a way of describing tensions around which users and uses were acceptable when it came to internet access on city streets. Interview questions focused on what purpose LinkNYC kiosks were meant to serve, where they had come from and what institutions were responsible for their arrival. Effectively, our questions were meant to elicit grounded, local imaginings of LinkNYC as a newly visible infrastructure project.

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We encountered a variety of challenges in our research of dark fiber networks that underscore our interests in access and legibility. There is a lack of publicly available geospatial information about the routes and locations of telecommunications networks, particularly networks that have been left dark. Public access to route information of urban broadband networks is only available at the discretion of network owners, typically for prices prohibitive to ordinary citizens or researchers, or is provided for personal use and protected under nondisclosure agreements. Although we contacted dark fiber owners and operators, there were only a couple of cases when owners and operators were willing to exchange information about the installation and location of dark fiber networks with the authors of this paper. We are not permitted to show these maps or incorporate this information into this publication. As a result, we rely on maps of Form 477 data about broadband provision available through the Federal Communications Commission (FCC), maps of dark fiber networks owned by municipalities and made publicly available in order advertise them for sale or lease, and maps made publicly available through individual dark fiber operators in NYC such as Zayo. Publicly available maps of telecommunication routes and FCC maps of broadband activity and service provision do not represent dark fiber networks in their classifications of broadband infrastructure. In fact, FCC maps and Form 477 data only account for an area where at least one internet subscriber is present rather than the location of broadband infrastructure routes. As such, publicly available broadband maps must be understood as offering a partial view of network presence and potential activity.

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Regarding the difficulty of obtaining accurate maps of internet cables, we make two observations on cartographic visibility. First, as critical cartographers have noted, graphic representations of networks tend to reify the seamless operations of social, economic, political, and technical structures and encourage map readers to imagine network activity as unbroken, universal, and conflict free (Fidler and Currie, 2015). Second, the obstacles in locating maps of internet cable underscore our arguments about their invisibility and illegibility. Through our research into dark fiber networks we've run up against imposed limits of visibility in the documentation and representation of urban broadband networks. (On a related note, similar forms of obfuscation arose in our attempts to reach out to LinkNYC; repeated efforts to gain access to planning or promotional materials, or to allow interviews with employees, were unsuccessful.) The documentation and cartographic representations of urban broadband and telecommunication networks are made deliberately difficult to view by private ownership models and a lack of geospatial consolidation. Many networks are only mapped on request and/or are not represented on the same map as networks owned by different operators. Because resources on broadband routes are difficult and costly to acquire, it becomes challenging to critique and design for public connectivity when even the traces of connectivity aren't public.

With these complexities of infrastructure in mind, we turn to our case studies, the first an exemplar of invisibility, the second of hypervisibility. These cases are not the only exemplars of infrastructural (in)visibility, nor are they precise parallels to each other - with dark fiber we analyze a potential yet underused resource, and with LinkNYC we analyze a specific smart city

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initiative and its local fallout. Yet both demonstrate the complex relationships between industry players, local governments, infrastructure and socio-technical politics. Both cases help us to identify and analyze excessive imaginations of urban broadband initiatives as well as failures to imagine how, by whom, and in what contexts these networks will be used. The narrow visions of connectivity that emerge from analyzing these case studies can help us critique urban broadband initiatives, while also contributing to infrastructure theory around politics of legibility.

Dark fiber as invisible excess

In many metropolitan areas, only a fraction of the cable installed underground is actually activated or "lit" and used for internet service provision to urban residents and businesses. An estimate from 2001 indicated that there were approximately 35 million miles of fiber optic cable in the United States and 90% of these terrestrial cables were dark (Allen, 2001). Dark fiber networks are not networks that were once active and then extinguished; they are fiber optic networks that were conceived as "dark." Since there is no light pulsing through the cable, no data can be transmitted, therefore the cables are "off" or inactive.

Although members of the public are often ignorant of dark fiber until it is lit, these networks are not universally hidden or concealed. On the contrary, dark fiber networks are for sale or lease to Internet Service Providers (ISPs) who can light and extend them for residential, commercial, or government use. The companies that own and install these networks such as Zayo, Level 3, Unite Private Networks, and Lightower Fiber Networks may lease fiber to

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Comcast, Verizon, or Alphabet's Google Fiber. Cities such as Roanoke, VA and Centennial, CO have built their own "open access" dark fiber networks to connect institutions, provide public internet access, and to encourage local investment and competition among ISPs (Centennial City Council, 2016; Buckley, 2017). Several of these cities, including Huntsville, AL, Santa Cruz, CA and Westminster, MD own and maintain their dark fiber networks ("Our TVA Story," 2018).

Throughout the 1990s, several telecommunications companies were contracted to lay internet-ready cables across the United States. Bolstered by stories about the exponential growth of internet traffic, many companies over-invested in laying cables for internet service provision in anticipation of increased public demand and to avoid the high costs of paying for right-of-way and installation as demand increased (Allen, 2001; Odlyzko, 2010; Pletz, 2012). Cassidy (2002) estimates that between 1998 and 2000, the amount of buried fiber in the US increased fivefold yielding over a dozen national fiber networks with hundreds times more capacity than was needed to support Internet operations and traffic at the time. In the mid-2000s, there was another surge of dark fiber installation among fiber optic companies and municipal governments to generate revenue and to meet perceived demand for broadband services (Carino, 2016). Due to the prevalence of dark fiber networks constructed in the 1990s and 2000s, the potential for internet connection in certain areas may actually supersede public demand. However, because these networks are not evenly distributed or "turned on," competition among ISPs is further curtailed and certain geographic areas continue to have limited options for affordable or any internet access.

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While laying millions of miles of dark fiber was exuberant, it was not entirely irrational. Instead, the excess of dark fiber reveals particular imaginations of the network that might be (Bratton, 2014) and a blinkered imagination of the future of internet access. For example, Zayo's dark fiber maps of New York City reveal traces of the material exuberance of the 1990s and 2000s. A cluster of dark fiber networks are located in Midtown and lower Manhattan, but appear as single arteries in lower-income areas of Brooklyn, Queens, and the Bronx. In all boroughs, lit fiber and dark fiber networks rarely diverge from one another. As a 2017 map illustrates, there is nearly an exact overlap between dark fiber and lit fiber networks indicating that an overabundance of fiber was laid in neighborhoods where active fiber optic networks currently exist (Figure 1). Represented in these maps is the assumption that many people will be using the internet, but also that internet connection is a specialized service for specific populations -- supply and access is robust, but not ubiquitous or evenly distributed. This imagined use coincides with the practice of "cream-skimming" among telecommunications providers - where infrastructure is installed in areas with the largest return on investment (Alizadeh et al, 2017). Unfortunately, this practice leads to the formation of "urban islands of inequity" that disadvantage lower-income neighborhoods and communities of color (Grubesic 2006).

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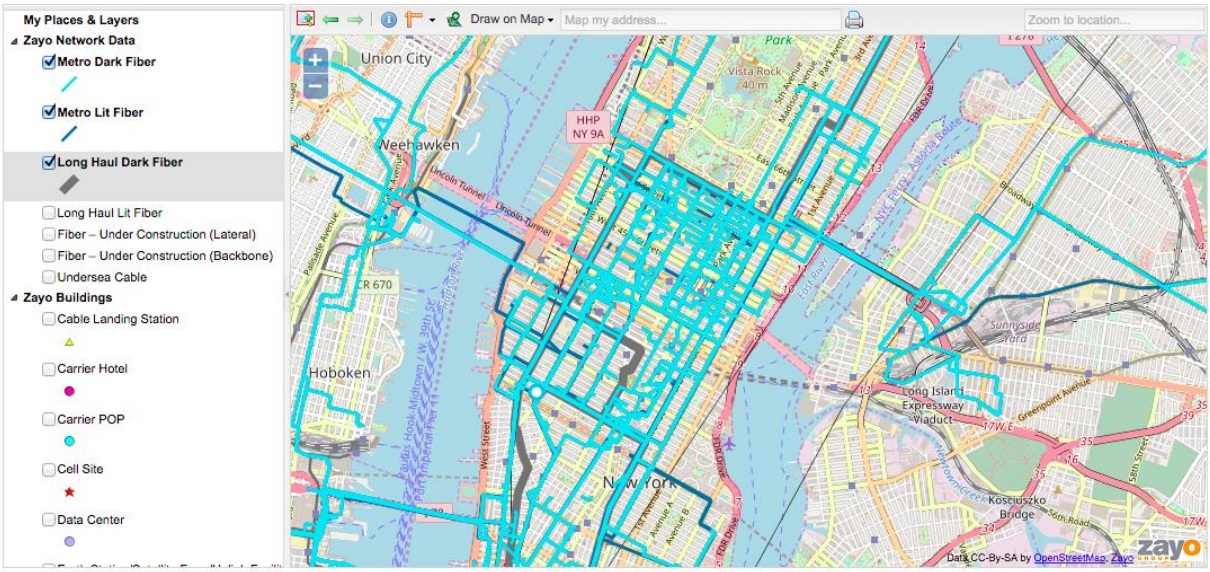

Figure 1: Zayo owned dark and lit fiber networks in NYC. Image: Zayo Group

In Long Island City and Sunnyside, Queens just north of the First Calvary Cemetery and south of the Sunnyside Railroad Yards are expanses of industrial buildings currently in use by shipping and delivery companies, elevator repair shops and motor parts companies, as well as warehouses and office spaces for Manhattan based vitamin retailers and bakeries. These industrial spaces have been in Long Island City for decades, as have the adjacent tree-lined streets of apartment buildings, single family homes, and bustling boulevards and highways that connect the neighborhood to Manhattan and Brooklyn. Zayo dark and lit fiber networks form an eight-block ring around Van Dam St between Hunters Point and 47th Avenues. The geography of the dark and lit fiber networks coincide exactly, indicating that the industrial and residential spaces in between these blocks were always imagined as spaces of connection, and excessively so, as Zayo laid extra cable along a single route.

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Although layers of lit and dark fiber circle the western section of Long Island City (closer to Manhattan), the networks do not extend east, beyond 34th Street to Woodside, Elmhurst or south to Blissville (Figure 2). In fact, dark fiber networks appear to be absent in the majority of Queens except for the areas in close proximity to midtown and lower Manhattan or near the railroad and highway routes that lead there. Unlike trends in rural environments where dark fiber will extend down dirt roads in sparsely populated areas (Burrington 2015), Zayo (as well as American Fiber Systems acquired by Zayo in 2010) did not eschew lighting the dark fiber networks they laid -- they just didn't lay any. FCC maps of fixed broadband deployment in 2018 confirm that on streets that surround Zayo's dark fiber network as well as adjacent residential neighborhoods, only two broadband providers offer satellite or fixed wireless access, but no fiber optic connection (Figure 3). While this dearth of fiber service provision could indicate a perceived lack of demand by fiber providers, it also implies that there may be a need and lack of competition for affordable fiber network service in the area.

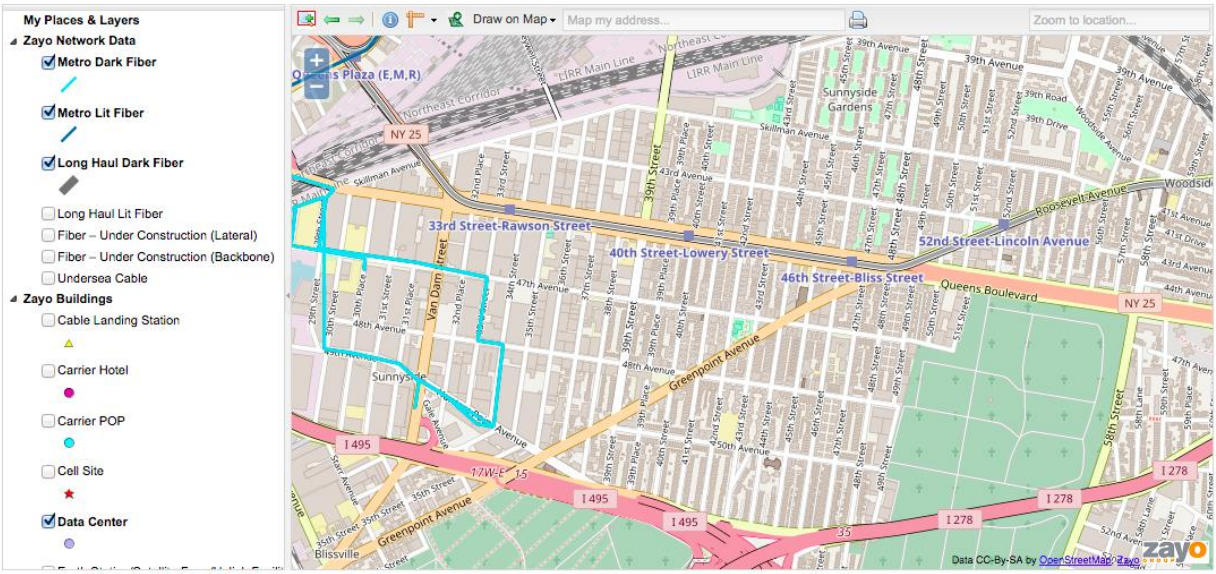

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Figure 2: Dark fiber networks in Eastern Queens. Image: Zayo Group

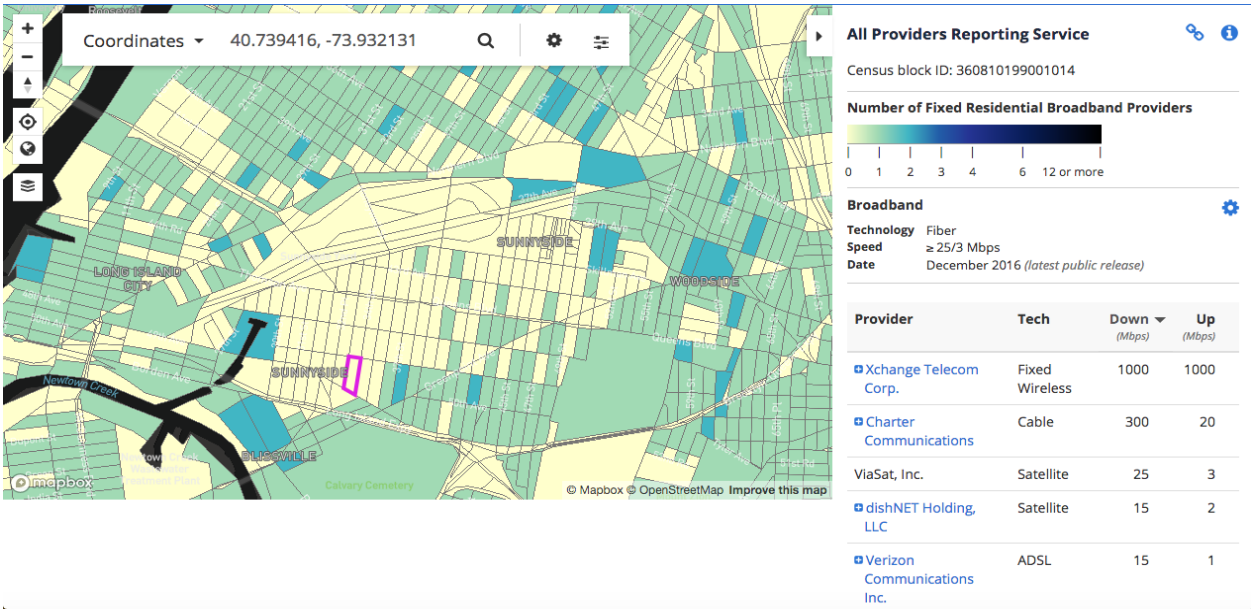

Figure 3: Fiber providers reporting service. Source data: FCC Form 477

By envisioning the supply of internet infrastructure as integral to access but not providing a way to meaningfully connect to this infrastructure, fiber networks exist under the sidewalks of urban neighborhoods but bypass certain populations. The circumscribed exuberance and excess of dark fiber presents a selective imagination of internet use and users as privatized and fragmented. Maps and other documentation indicate that dark fiber providers may have layered cables in urban areas that already required or requested connection, imagined internet access in a fixed location with fixed access points, and assumed that private entities would pay to provide “last mile” connections to private households and office spaces that demanded access.

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Many broadband activists and researchers are enthusiastic about the potential of dark fiber for more equitable, affordable, and geographically dispersed Internet provision (Crawford, 2016). Yet due to barriers such as high costs to the lessee in terms of equipment, last-mile installation and labor, and/or lack of skills and resources needed to light the fibers, the purchase and use of dark fiber networks for public and residential use is still relatively rare or limited to a few large corporations who can afford to lease and operate the network at scale (Whelan, 2017). In addition, dark fiber from the 1990s might already be owned by large telecommunications companies who are reluctant to lease it to competitors and may be reluctant to turn it on themselves because of limited capacity due to location of access points, cable quality, or type of fiber laid (Carino 2016). Corporate and legal barriers of obfuscation emerge here to produce a kind of bureaucratic legibility, limiting awareness, let alone more radical arrangements, of access.

Recent federal policies such as “dig once” and high-profile smart city initiatives and grant competitions have generated attention to city streets and sidewalks as spaces where digital connection happens. These endeavors construct an image of the city street as a space where technologies for internet access need to be installed anew, rather than a space that has already been outfitted with digital infrastructure that needs to be turned on. The persistent illegibility of dark fiber networks alongside policy initiatives that frame city streets as sites for digital access complicate institutional investments and understandings of public connectivity.

LinkNYC and the spectacle of infrastructure

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During the summer of 2016, New York City (in partnership with companies including Qualcomm and Google) transformed 7500 of the city's payphones into a Swiss Army knife of digital technology support, all free of charge. LinkNYC kiosks (called Links) originally provided four key functions: a USB charger, a WiFi hotspot, phone calls (provided by Vonage) and a web browser. All of these features were open to passersby and free to use. Links themselves are sleek and trim, bearing little structural resemblance to the payphones they replaced. Instead of rarely used, easily ignored payphones, Links epitomized contemporary visions of smart cities as seamlessly integrating internet access and digital connectivity (e.g. Graham, 2014; Kitchin and Dodge, 2011; Mattern, 2017).

As an intervention in city streets, Links were always intended to be hypervisible. Link NYC was the winning entry for a design contest announced in 2012 by then-mayor Michael Bloomberg, who sought an innovative re-imagining of urban payphones. In addition to online fanfare, Bloomberg's tech czar, Rachel Haot announced the contest at the elite New York Tech MeetUp in December of 2012 by inviting the city's start-up community to submit their visions of the payphone redesigned (For a thorough review of the design values and selection process of Link NYC, see Shapiro, 2018). LinkNYC can thus be read as the winning entry in a contest of imagination, and while the public invitation to participate in a design exercise may be a positive form of transparency, more diverse forms of procedural inclusion could have produced different, and perhaps in the long run, more successful, visions for payphone infrastructure.

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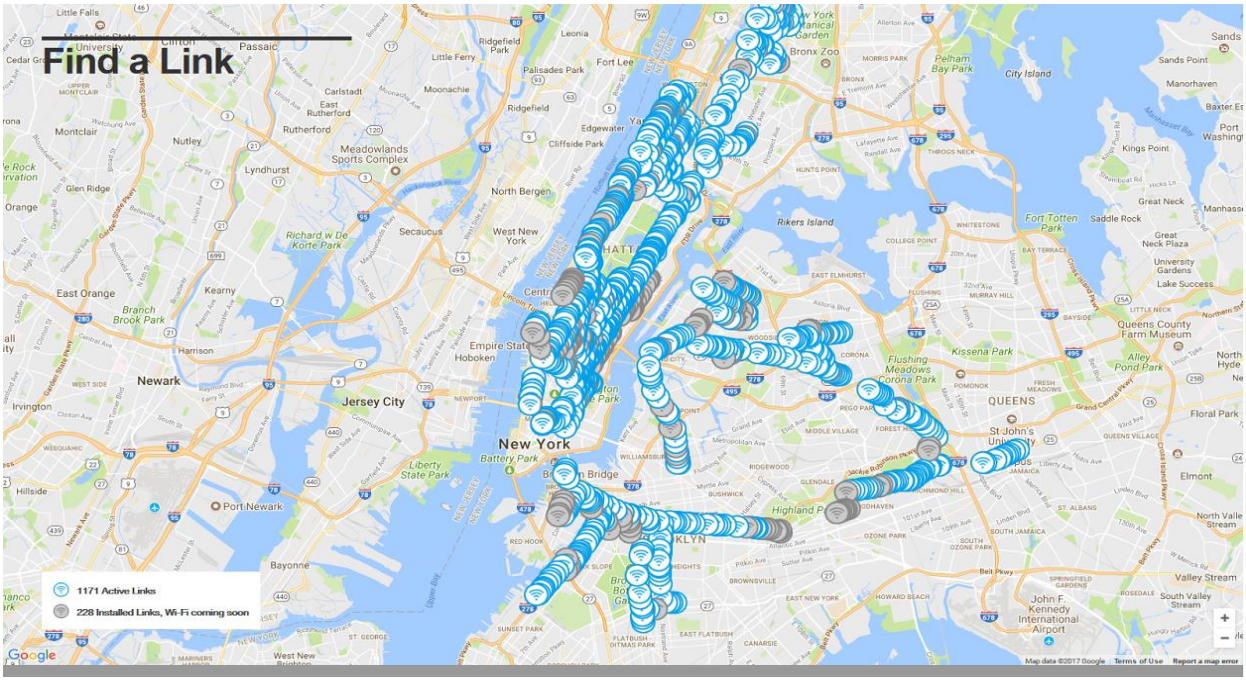

Figure 4: A screengrab of LinkNYC's coverage in New York City

Links were intended as a hypervisible intervention in the urban landscape, a signal of cosmopolitan, "smart city" sophistication. Among the people we interviewed, some of the strongest supporters were people who were poor and housing insecure. Two participants interviewed in Hell's Kitchen described themselves as residents of halfway houses, and for them Links were powerful tools of connectivity. One participant described its uses as particularly valuable for "indigent" people without a lot of resources: "I think it's meant for everybody, but for people like myself, indigents who ain't got much, it's a real asset. If you're low on funds or don't have much in your life, you don't got a laptop, this is a real asset." This participant went on to describe what he found most useful about Links:

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> [if] my phone is dying, I can charge [it]. And when my phone died, I paid a bill. [After getting out of jail] I was able to make a free phone call and let my daughter know I was still in the city. You can job search – there's a library, but sometimes you can't get in if you don't have a library card. Just look right here! I think it's a great invention for the city. It's a good thing, it keeps the city alive.

Another participant who described himself in similar life circumstances agreed, pointing to connectivity with family and daily internet access: "My phone came up missing, I had no way to get in touch with my family, I was like, you know what, I'm gonna try this Link thing, and it works." After describing how he had integrated use into his everyday life on the street, this participant went on to worry about the long-term survival of Links: "This is really, really important to the city. As long as they don't mess it up. Because we never know how long something that's good is gonna last. Honestly, in New York City, just about anything could happen to something good, and it always does. Like the saying goes, only the good die young." As it turns out, these participants were right to be concerned over the longevity of free internet access.

With the hypervisibility of Links came a battle over who should be using these devices and how. Fewer than 10 blocks away from the interviews described above, we found another participant with a very different view of Links and who should be using them:

> I thought it was a great idea, until you see homeless people parked all around it. It makes it so you almost don't want to touch it. Maybe [they should] make it so that you put in coins ... It's free to use, so these guys are exploiting it, you get

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> negative traffic and it's chasing away the positive traffic. These guys are just watching videos, playing songs, totally hogging it.

Within the first few weeks of installation, reports emerged about using the web browser to watch porn and play loud music, and photographs circulated of homeless people hanging out in front of Links for hours (McGeehan, 2016). Residents and store owners complained about the users as well as the uses of Links, suggesting a serious gap between how this technology was imagined and how it adapted to everyday urban life. Eventually, LinkNYC bowed to pressure to address the perceived misuse of its services, and shut off the web browsers, although the other functions continue to operate (Kirby, 2016). It is worth pointing out that these uses would have been predictable to public librarians, long familiar with disputes over appropriate uses of the publicly-accessible internet (e.g. Nieves, 2013).

We tend to think of "turning off the internet" as a political move of desperate dictators in autocratic regimes. In the case of unanticipated use of LinkNYC, it's a corporate attempt to deal with elitist discomfort about the urban poor. Underscoring the moral dimension to debates around legitimate versus illegitimate uses of Links, many local lawmakers framed their concerns in terms of crime and drug addiction. For example, Gale Brewer, then Manhattan borough president, likened turning off the browsers to "the decision during the crack cocaine epidemic of the 1980s to block pay phones from accepting calls. All along Amsterdam Avenue, she said, crack dealers were using pay phones as business offices" (quoted in McGeehan, 2016). Brewer connects Links to payphones not in terms of their shared infrastructure, but in terms of their alleged promotion of social problems. As a policy maker, Brewer failed to see Links as tools of

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social connectivity for resource-poor individuals, focusing instead of their potential misuse as public nuisances.

In the context of imagining urban infrastructure, LinkNYC marked a highly-visible intervention into city space that failed to anticipate what the street needed: a way for housing-insecure people to pass the time, communicate with loved ones and access local information. Similar to marginalized communities long ignored by ISPs, these uses and users were not originally imagined by Link's corporate sponsors. Although the controversy over LinkNYC briefly brought these bodies and practices into view, the ultimate decision to turn the browsers off emphasizes the priorities of LinkNYC planners, underscoring the very real gap between how infrastructure is imagined from above and below.

Discussion

Each of the case studies we've described opens up a critique of socio-technical imaginations and visibilities of broadband infrastructure. A comparison of these projects allows us to theorize a broader set of claims around the politics of legibility when it comes to the policies and designs of internet access. Based on our case studies, we suggest distinct perspectives on the politics of infrastructural visibility and policies regarding urban broadband networks that challenge previous paradigms and assumptions. Our critique highlights four main points: the need to complicate the invisibility/visibility framework for interrogating media infrastructures; failures of infrastructural imagination as failures of public connection; the problematic

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geopolitics of supply-side internet access; and the limits of calls for socio-technical transparency regarding infrastructure.

(In)visible infrastructure

Invisibility and hypervisibility are not inherent qualities of the infrastructure projects we've examined, but rather constructed ways of presenting public connection and situated ways of seeing and experiencing internet access on city streets. As Chun (2011) has noted, visibility and invisibility exist in gradation rather than as a black and white binary. For Chun, technologies can be obscured or made visible not only in their placement (e.g. above or below ground) but in terms of their user interface and the uses prescribed and prohibited. While dark fiber networks were built in order to cater to an imagined exponential growth of internet traffic and increasing populations of internet users, they remain virtually unseen, unknown, and generally off limits to the public. Dark fiber does not become visible when it is in need of repair, simply because these networks are always off; one does not repair what is not in use. Their potential and excess are only visible to entities able to turn them on, not the populations who might benefit from extended or more consistent connection.

Although LinkNYC kiosks are designed to be spectacles of public internet connection, they produced interventions far different than what had been imagined. What emerged as suddenly visible with the launch of LinkNYC were the many people and practices that some urban planners and residents would prefer to ignore: the homeless, the unemployed and the (allegedly) criminal. Echoing Larkin (2013), infrastructure doesn't only disrupt city life and

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infrastructure access when it breaks down or fails to work, but when the implementation of infrastructure fails to be inclusive in its imagination of who and how the network will be used by and in public.

Infrastructural visibility or invisibility isn't inherently salient of its own accord since what infrastructure looks and feels like, how infrastructure is seen, and by whom is always contextual and changes over time. We have emphasized legibility as a framework for thinking about how urban broadband infrastructures can shift in and out of visibility, not necessarily due to any material changes so much as surrounding discursive constructions. Narratives about what internet access in public urban spaces should be and how it should be used inform the placement and design of access points, as well as the behaviors that are seen as out of place. Research devoted to studies of urban broadband infrastructures (and communication infrastructure more broadly) might focus less on identifying moments of visibility and rupture (or even spectacle), and invest more effort in theorizing legibility, or unpacking the stories, processes, and ideologies that shape ways of seeing (and not seeing) urban broadband networks.

Imagining connectivity

Steeped in techno-determinist discourse that over-promises and under-delivers, urban broadband networks may fall short of their ambitions to provide connection to those who need it most. Urban broadband networks fail to imagine public internet access as a universal service and thus omit certain urban populations (low socioeconomic status or housing insecure

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populations, neighborhoods removed from metropolitan financial and business centers), their internet activities and desires for access from digital urban infrastructures (Bure, 2005; Gonzales, 2016). In both case studies, we see the privileging of users who are already connected to the internet. In the case of LinkNYC, the digital kiosks are conceptualized as charging and data stations for smartphone users or places for quick internet access while on the go. Dark fiber networks provide potential internet access and data speeds for businesses and residents in neighborhoods that already have fiber networks installed and activated.

Digital kiosks and dark fiber optic networks have been installed to create new opportunities for ubiquitous connection, but also claim to serve populations that have previously lacked internet connection at home or on the go. However, these underserved populations continually fail to connect, despite policy rhetoric promising inclusion. There is a paradox here in that the same urban broadband systems that promise public connection simultaneously end up impeding connectivity for certain publics.

By focusing on the "last mile" of internet access, researchers are under-theorizing the other 99 miles that are still not imagined ethically or accurately. The inequity of urban broadband networks is written into its supply, but not only in the locations where networks are absent or where there are not enough cables or signals. Inequity and exclusivity are also embedded in exuberant supplies of internet infrastructure for public use. Urban broadband projects that focus on providing excessive opportunities for internet connection -- in the form of hypervisible networks of digital kiosks or invisible layers of dark fiber, for example -- emphasize the stakes of

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miscalculating supply-side connectivity. The problem is not always that there needs to be *more* infrastructure provided for public use, but that these infrastructure projects need to adopt more inclusive imaginations of the public and imagine more varied uses of public connection.

The limits of supply side connectivity

Digital divide initiatives and municipal broadband efforts imagine the supply of internet infrastructure and infrastructure technologies as neutral to inequality, but artifacts have politics even before they are "present at hand" (Winner, 1980). Within digital divide discourse, nuance tends to be assigned to demand, where internet and media researchers have made crucial arguments about differences in terms of need and literacy (Hauge & Prieger, 2010). One outcome of our comparison is the need for nuance in terms of infrastructural supply of internet access. Our findings offer some insight in regard to recognizing and analyzing texture and complexity in the supply of internet infrastructure and addressing failures of imagination within the design and deployment of urban broadband networks.

Part of the failure of imagination in urban broadband networks might be the imagination of internet access points in fixed locations. Both dark fiber and LinkNYC imagine the internet as fixed to static locations -- homes, office buildings, and kiosks. Urban broadband initiatives can attend to evolving internet publics and internet uses by considering more mobile, flexible models of public connectivity for city street and mobile-only users. Instead of repurposing pre-existing infrastructures or supplying more of the same type of public connectivity, urban broadband initiatives need to include diverse experiences of internet connection. Further

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attention should be devoted to evaluating whether new infrastructures such as kiosks, cables, or computer labs are needed; or whether updating pre-existing infrastructures and internet service provision (at home, in shelters, at social service centers, on the street) would accommodate a wider variety of internet publics.

Transparency is not (always) the answer

Debates about technological access have an important counterpart in calls for greater transparency, whether in connected devices comprising the Internet-of-Things (Howard, 2015), search engine algorithms (Pariser, 2012) and social service databases (Eubanks, 2018). Understood as the ability of everyday users to access mechanisms of digital systems, transparency in the context of our analysis could take shape in open access to dark fiber ownership and the ability to contest or adjudicate attacks on browser content. Yet it's important to note that transparency alone does not guarantee meaningful legibility. As Ananny and Crawford (2016) have argued in the context of algorithms, visibility does not necessarily confer knowledge about the origins and inner workings of networks and computational systems. Similar to algorithms, transparency in urban broadband networks becomes problematic in terms of temporality. While our case studies recognize the "deep time" of urban broadband in the remediation, continuity, and layering of telecommunication infrastructures over time (Mattern, 2015), they also illustrate how ways of seeing and knowing infrastructures shift over the course of months or weeks as networks are lit up, left dark, or turned off. In the context of city streets, Sassen (2012) has called for wholesale infrastructural transparency as a

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way for members of the public to engage or dialogue with infrastructure, yet our case studies illustrate some of the limits of acting on or changing the networks we can see.

Transparency suggests visibility, making information and the logic of systems accessible to users. However, calls for radical transparency are faulty because access doesn't mean users can change or influence socio-technical systems. Our case studies illustrate a version of Offenhuber's (2017) argument that making systems (il)legible through representations of infrastructure, which are constructed by stakeholders' interests, is an exercise in authority. Because dark fiber competitors and LinkNYC operators obscure information about their operation and service provision (Silbey, 2015) or the location of their networks to serve industrial strategies, the cartographic and material transparency of dark fiber or LinkNYC at any given moment may be performative rather than actionable and does not offer discernable, coherent patterns of governance, ownership, and use. Even if the locations and ownership of dark fiber networks or the policies governing LinkNYC operations could be consolidated and made visible, there are still major economic and technical barriers to changing the placement or functioning of these systems.

Just as LIS researchers and others have cautioned against treating access rather than use as an endgame of public technology projects (Gonzalez, 2016; Koltay, 2011), our case studies illustrate the importance and difficulties of accounting for diverse uses and users of new infrastructure projects. More qualitative studies of internet use in public spaces such as libraries, makerspaces and city streets -- particularly among populations that lack home

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broadband connection -- are needed and should be incorporated into the design of urban broadband networks that promise public connectivity. In addition, new infrastructure initiatives need to assess past imaginations and failures of imagination embedded in existing media infrastructure systems.

Conclusion

Larkin (2013) suggests that infrastructure studies should "examine how (in)visibility is mobilized and why" (336) in order to begin to understand the cultural meanings and lived experiences of infrastructure. This paper has focused on the politics and shifting constructions of (in)visibility as a framework for analyzing power and access in urban broadband networks. At its root, these case studies highlight debates about two kinds of publics: who gets to use the internet and who gets to use the street, where the stakes involve thinking about what kinds of behaviors are viewed as appropriate, and whose uses will win as technologies stabilize. When LinkNYC caved to pressure for a more genteel set of internet uses, the stakes involve thinking about what kinds of technologies and behaviors are viewed as appropriate and which are objectionable, and whose uses will win as this technology stabilizes. As dark fiber networks lay in wait for institutions that can pay to turn them on, the space beneath urban streets are filled with "black stacks" (Bratton, 2014) of potential public connectivity that are controlled by powerful entities.

This project has brought attention to how inequities in internet access and control over internet activation and implementation restructure the meaning and experience of the city street. In

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both case studies, purveyors of urban broadband networks fail to imagine expanding populations of internet users, diverse internet publics and public uses of the internet (particularly among users who lack home internet service), and fail to account for concurrent systems and practices of public connection in their development and deployment. While we have implemented methods and identified methodological challenges for investigating and analyzing the public spectacles and buried potential of urban broadband networks, we hope that future research and researchers consider our recommendations when studying the supply-side of urban internet access.

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