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Innovation and Equality: an Approach to Constructing a Community Governed Network Commons

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Innovation and equality: an approach to constructing a community governed network commons

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ABSTRACT

Networked computing affords users distinct opportunities to communicate with each other, build relationships, transact business, and create. Yet, the digital divide perpetuates existing disparities between social groups. Interventions that rely on private ownership or philanthropy often fall short. Efforts to redress these disparities require collaboration across academic disciplines and with government and private sector organizations. This paper chronicles efforts in Harlem to address this through a collaborative approach to networked computing. We draw on two concepts--responsible innovation and co-governance--to sketch a community-based approach to networked computing. Second, the article identifies two potential systems, based in property law, through which a cross-section of community stakeholders could govern this networked computing infrastructure. In the end, this article seeks to integrate aspects of co-design and responsible innovation and reflects upon building bridges between researchers across academic disciplines, as well as the opportunities and difficulties of partnering with entrepreneurs and civic leaders.

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Introduction

The global adoption and broad integration of networked computing have afforded users around the world new opportunities to communicate, conduct commerce, gain employment, and socialize. The internet expanded from approximately 147 million users in 1998 to an estimated 4.2 billion users twenty years later and supported an estimated 25 trillion USD in global trade in 2017 (UNCTAD 2017). The internet, or networked computing, can be understood as a cyber-physical-legal-social system. The *cyber* component consists of software programs, data, and algorithms that are connected by *physical* components, including fiber-optic cables, servers, and processors, as well as the electricity to cool those components. The legal dimension includes formal institutional conditions dictated by laws and policies, such as regulations and subsidy programs offered by the Federal

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Communications Commission (FCC) in the United States (US), as well as local and state laws. Further, the terms-of-use set out by private providers are formal institutional conditions. Social components pertain to informal phenomena, including the lived contexts in which people design, build, and use networked devices and the group norms that dictate who (and why) certain persons are included (or excluded) from those uses.

In the mid-1990s, the US National Telecommunications and Information Administration (NTIA 1995) issued a series of groundbreaking reports on the disparate deployment of networked computing, coining the phrase *digital divide*. What the NTIA described over twenty years ago continues to plague Black and Hispanic communities in the US, as well as the elderly and rural residents (Vogel 2021). This is especially true in communities whose residents have less formal education and that earn less income. Recent research by Vogel (2021) shows the relationship between household earnings, race, education, and access to networked computing. This should not be surprising, since earlier work by Moss (1998), some twenty years ago, offered similar findings.

The relationship between Internet access and income is in part the result of actions by telecommunications companies, who committed billions of dollars to expand their networks by installing fiber-optic cables. Through these investments, private firms sought to recover their capital expenses in the shortest time possible, which meant targeting communities with higher incomes. This resulted in a specific market failure based upon *differential development* whereby communities are afforded service that reflects, instantiates and reproduces extant disparities based on wealth, race, education, and class. The expansion of networked computing resulted in what many call 'digital redlining,' which harkens back to US zoning policies that excluded non-White persons from buying homes in designated White neighborhoods. Those zoning policies that have reinforced racial segregation and similar patterns of segregation associated with technological design have been observed in transportation infrastructure (Winner 1980), and more recently with respect to the internet, e.g. Elkins et al v. AT&T, FCC, and FTC (2017).

The FCC (2015), the US federal agency with regulatory oversight of retail consumer broadband infrastructure, issued a statement that determined that the internet is a dominant, 'general purpose technology' that ought to be subject to common-carrier-like regulation and, as a 'general purpose technology,' every home *should* have physical and financial access to it. This means that this designation mattered because, as with electricity – another 'general public purpose technology' – the FCC asserted that the internet is so essential that any pricing increases or changes to the quality of service should be subject to regulatory oversight. Despite the FCC's declaration, there remains an inequitable opportunity for different individuals and organizations to access the Internet (Sylvain 2016). The lack of access to the internet has shown to be tied to a litany of negative consequences, including the lack of educational attainment and foregone employment opportunities (c.f. Anderson and Perrin 2016).

This paper is the product of a research project whose aim has been to overcome some of these challenges by testing 'a novel architecture for Secure, Energy-Efficient Community-edge-clouds with application in Harlem' (SEEC Harlem) in New York City. The project combines research into the functionality of state-of-the-art wireless computing and the governance of that resource by stakeholders in the largely underserved and historically marginalized community of Harlem. There are two goals for this research:

1. To develop technologies that enable a secure and energy-efficient 'community network' that affords robust and equitable opportunities to all of its constituent members; and
2. To lay the groundwork for a fundamentally new computing and network access environment that is affordable, secure, and energy-efficient.

In this paper, we explore the processes and governance structures necessary for meeting these goals through, among other things, the lens of *responsible innovation*. This paper revisits the theoretical foundations of *responsible innovation* and then utilizes that framework to analyze the formative phase of this research project. We then offer, based on insights from the SEEC Harlem project, two alternative governance schemes for the administration of a community network.

In presenting and analyzing the Harlem project through the lens of responsible innovation, we also integrate the concept of co-governance, the idea of joining together community actors and other stakeholders to collectively manage common pool resources. Co-governance is concerned with the ways that shared resources are utilized, designed, and maintained while also being attentive to which actors are empowered in the decision-making processes that manage those resources. The co-governance approach has been applied, for example, to user- created and collaboratively managed wireless 'mesh' networks – decentralized wireless access points connected to each other in a defined geographic area (Greig 2018). Mesh and community networking are often referred to as a form of 'digital stewardship' which includes equal access, participation by historically excluded populations, common ownership through cooperative business models or municipal ownership, healthy communities which promote economic development from within, and expanded educational opportunities (Detroit Digital Justice Coalition 2020).

The responsible innovation and co-governance frameworks are also an intervention that could address the tensions that others have identified regarding smart cities. These tensions manifest in a lack of trust between public authorities and the communities who are seen as the beneficiaries of 'smart' technologies. The recent collapse of a technologically sophisticated, state-of-the-art neighborhood project on Toronto's waterfront by Google subsidiary Sidewalk Labs is illustrative of these tensions. The failure of the project was attributable in no small part to the public's frustration with the lack of transparency about data privacy and data protection. Further, citizens lacked confidence in the project and questioned how (and if) public governance would support the ongoing project implementation in a way that was consistent with the public interest (Goodman and Powles 2019). As others have argued, it is possible to re-orient smart cities and smart projects in a way that harnesses smart technology to an agenda of sharing and solidarity, expanding and sharing physical and data infrastructure more widely with the most disadvantaged communities (McLaren and Agyeman 2015). Such re-orientation pushes against a technocratic and market-driven vision of a smart city that ignores questions of power and distribution in the accessibility of basic goods and services in contemporary urban environments.

Theories supporting a transdisciplinary research approach

Two central theories – responsible innovation and co-governance – inform this project and offer scaffolding for the research approach. First, the idea of co-governance builds

upon Ostrom's (2010) Nobel Award study of the ways in which communities can collectively manage common pool resources under certain conditions. We built upon Ostrom's work and applied her framework to the concept of *constructed urban commons*, focusing on the infrastructure of the city and highlighting the ways that shared urban resources are designed, built, and stewarded by humans. Here, various community constituents work together with other stakeholders to co-design and co-produce goods and services that are held in common.

Second, the theory of responsible innovation offers an approach to integrate knowledge from diverse expertise and to reflect upon the future outcomes of the design. The SEEC Harlem research project involves the application of both concepts in the context of multi-stakeholder efforts to community-based computer network development that supports low-cost devices and data management. It focuses on the ownership, data management, user privacy, and user responsibilities. The project is necessarily interdisciplinary, bringing together researchers from social science, law, computer science, computer engineering, and networked fiber-optics.

Co-governance

Elinor Ostrom's work influenced the study of a variety of user-governed, shared resources that extends far beyond the natural resources that were the subject of her work. Her work opened up new thinking about the process of developing and enforcing rules, social norms and other governance tools for sharing and sustainably utilizing 'common pool resources' or 'commons'. Scholars have conceptualized and articulated new kinds of 'commons' that involve 'communities working together in self-governing ways to protect resources from the enclosure or to build newly open-shared resources' (Hess 2008, 40). These include knowledge commons, cultural commons, infrastructure commons, neighborhood commons, digital commons, among others (Hess 2008). Collective governance or commons governance has become an important conceptual framework across many disciplines for examining questions of resource access, sharing, governance, and distribution of a range of both tangible and intangible resources (De Moor 2012). This growing body of literature encompasses both material and immaterial resources – ranging from housing, urban infrastructure, and public spaces to culture, labor, and public services (Dellenbaugh et al. 2015; Borch and Kornberger 2016). The boundaries separating public and private goods are redefined to open up those goods and services to public use. They do this in ways that do not depend on nor are they not controlled by a prevailing private or state authority. In other words, thinking of some resources as common goods opens the space between public and private or market and state, to reveal a set of rich conceptual and practical possibilities for governance.

Co-governance of shared resources

Based on the above literature, and their empirical study of hundreds of examples of collectively shared and collaboratively stewarded resources in cities around the world, Foster and Iaione (2019) found that it is possible to combine public, private, civic, and community actors to steward resources that can be more widely shared and available to many kinds of urban communities. They have found that resources such as built,

environmental, cultural, and digital goods are being co-created and co-managed through contractual or institutionalized public-community partnerships (PCPs) and public-community-private partnerships (PCPPs). These kinds of partnerships manifest through a multi-stakeholder governance scheme whereby the community emerges as an actor. Through sharing, collaboration, cooperation, and coordination, these stakeholders along (with potentially three others which we discuss below) are mobilized to co-manage these resources. Commons governance or co-governance is thus the product of a process of deep multi-stakeholder engagement and interaction involving deep collaboration and cooperation among actors of the 'quintuple helix,' a concept that expands the 'triple helix' idea from innovation studies (Leydesdorff and Deakin 2011). The helix involves five actors: (1) active citizens (social innovators; city makers; organized and informal local communities); (2) public authorities; (3) private economic actors (national or local businesses; small and medium enterprises; social businesses; neighborhood or district-level businesses) (4) civil society organizations and NGOs; (5) knowledge institutions include schools; Universities; research centers; cultural centers; public, private, civic libraries Foster and Iaione (2022) These partnerships for managing common resources consist of the community in which the resource is or will be located. These actors become deeply engaged over time in constructing and supporting institutional arrangements to support resource stewardship.

The co-creation cycle and process

The process of engaging in co-governance of shared, or common, resources is an iterative process which entails creating and adopting a methodological approach to bringing together collaborators and partners in the co-design process to deliberate, practice, and arrive at adaptable practices and policies. Foster and Iaione (2022), through their applied research arm *LabGov*, have experimented with what they call the 'co-city cycle' which includes six key phases: cheap talking, mapping, practicing, prototyping, testing and modeling.

1) *Cheap talking* – participants identify informal settings for face-to-face and pressure-free communication among key local actors to activate the community of stakeholders that will be involved in the collaborative project. These discussions or sessions are organized in a variety of settings with significant outreach done in the local community, often through anchor institutions like schools, libraries or non-profits.
2) *Mapping* – participants begin to understand the characteristics of the urban or neighborhood context through surveys and exploratory interviews, fieldwork activities, and ethnographic work. This lays the groundwork for the design and prototyping of governance tools and processes to be used later on in the cycle.
3) *Practicing* – participants identify and create possible synergies and alignment between project(s) and relevant actors. This includes co-working sessions with identified actors willing to participate in putting ideas into practice.
4) *Prototyping* – participants reflect on the mapping and practicing phases and begin to co-design specific policy, legal, or institutional mechanisms to address the issues and problems identified in the previous phases. One goal of this phase is to verify the conditions that promote the establishment of trust between the community and external actors.

5) *Testing* – project and policy prototypes are tested and evaluated through implementation, monitoring, and assessment using qualitative and quantitative metrics. This phase is often performed by working with one or more knowledge/academic partners to design appropriate indicators and metrics to capture the desired outcomes and impacts from the project.
6) *Modeling* – focuses on adapting and tailoring the prototype and nesting it within the legal and institutional framework of the city or local government through dialogue with civil servants and policy makers. This can involve the suspension of previous regulatory rules, the altering of bureaucratic processes, and the drafting of new policies which might also have a sunset clause and then a re-evaluation period.

This cycle represents a kind of urban experimentalism that is an essential part of the process of constructing common resources that result from the pooling of different actors, or sectors, but is rooted in the community being served. The urban experimentalism reflected by the co-city cycle is ultimately constitutive of three distinctive features: (1) an evaluative methodology that draws from knowledge created by the community and research partners, (2) an experimental process that is adaptable, and (3) iterative design and feedback among the stakeholders.

Constructed digital commons

Madison, Frischmann, and Strandburg (2014) define a constructed commons as the result of emergent social processes between users and institutionalized sharing of resources among communities and other stakeholders. Community created and user-managed 'mesh' networks are one kind of constructed commons. These networks have been established in many European and American cities, utilizing existing urban infrastructure and the combined efforts of many local actors – including public and private property owners who grant access to buildings and other structures to mount the access points – to create a solution to the 'last mile' connectivity gap. Many of these community internet infrastructures are constructed using the principles of *commoning* and co-governance (Cardullo 2018). The famed guifi.net, for example, is a community network of about 13,000 users based primarily in Catalonia, Spain and connected to the global internet, managed as a common pool resource or 'commons' (Baig et al. 2015; Baig, Freitag, and Navarro 2018). In this model, no one owns the entire infrastructure (open and free access), and participants share time, resources, and knowledge in order to contribute to the success of the network. This means that participants must accept the rules of the network to join and must contribute to the maintenance and administration of the required infrastructure. This model results in several benefits, including: a decline in multiplicity of infrastructures because all participants operate on the same infrastructure on a cooperative basis; increased efficiency; cost savings; more environmentally efficient since each device requires less energy; citizens are empowered to bring the network where it is needed; universal access.

Other community constructed and co-governed networks exist in places like Red Hook and Detroit (Greig 2018) that are grounded in the principles of 'digital stewardship' and 'digital justice' (Slager 2018). The principles include equal access, participation by historically excluded populations, common ownership through cooperative business models or municipal ownership, and healthy communities which promote economic

development from within and expand educational opportunities and environmental justice (Detroit Digital Justice Coalition 2020). For example, the Detroit Community Technology Project (DCTP) uses a process called 'vision-based organizing,' developed by the Allied Media Projects as an alternative to the strategic planning frameworks that philanthropic funders pressured them to adopt. In vision-based organizing, 'stakeholders come together in facilitated conversations to imagine future conditions that promote their community's liberation, empowerment, and flourishing, then together try to 'reverse engineer' that future to develop a strategy for achieving it' (Slager 2018).

Responsible innovation: aligning technological and societal research for equitable outcomes

Scholars trained in philosophy, history, sociology, and anthropology have intentionally partnered in the reflexive co-development of socio-technical systems in a limited number of instances (e.g. Fisher, Mahajan, and Mitcham 2006). We argue that scholars interested in responsible innovation as well as science and technology studies generally need to sully their hands and not just offer *ex post facto* critiques; they should endeavor to help define problems and collaborate in the development of solutions with stakeholders on the ground and in communities (Nature 2018; Novitzky et al. 2020). Since the inaugural issue of this journal, scholars have been calling for more interdisciplinary approaches to bring the public's values into innovation (Taebi et al. 2014). Yet, there remains a paucity of work to demonstrate those efforts, especially in regards to private firms with the few exceptions of recent work by Brand and Blok (2019), van de Poel et al. (2020), and Long et al. (2020), which are reviewed below.

Pre-conditions for multi-stakeholder collaboration

Inclusion of and collaboration with stakeholders is a key dimension of responsible innovation (Stilgoe, Owen, and Macnaghten 2013). Yet extant pre-conditions make even the best-intentioned efforts to collaborate across business sectors and academic disciplines challenging (van de Poel et al. 2020). Prior research by Foley et al. (2017) showed that multi-stakeholder collaboration demands attention to trust, power asymmetries, and inertia. Trust has long been discussed conceptually and attempts to measure it are often illusory. Yet, building relationships of trust is essential to collaborative projects and where it is lacking or abused, researchers will find it difficult if not impossible to settle on a shared understanding of the underlying problems or a common vision or strategic plan to achieve change (Waz and Weiser 2013; van de Poel et al. 2020). The ideal of deliberative engagement offered by Brand and Blok (2019) also acknowledges that trust-building activities are essential prior to iterative and recurrent deliberations between diverse stakeholders. Power asymmetries in access to knowledge and resources, while unavoidable in multi-stakeholder collaborations, need to be made transparent and addressed prior to and during the project. Another precondition to address is *inertia*, or commitment to the status quo. Mechanisms should also be put in place to explicitly acknowledge structural challenges which often remain unquestioned, including, for example, budgetary constraints, system maintenance, routinized local cultural norms and behaviors, and implicit biases.

Principles to guide multi-stakeholder collaborations

Stilgoe, Owen, and Macnaghten (2013) put forward four dimensions for responsible innovation as a way to distribute societal responsibility among and between corporate, government, civic, academic, and other stakeholders. Responsible Innovation aims to be proactive, and avoid the regulatory lag (Owen et al. 2009) and other reactive governance approaches (Valdivia and Guston 2015). Stilgoe, Owen, and Macnaghten (2013) listed the 'big four' dimensions of responsible innovation:

1) *Inclusion* – promoting deliberation among and between diverse stakeholders as a means to include alternative perspectives into the research or innovation process;
2) *Reflexivity* – systematic and iterative return to the motivations, operating conditions, and goals that are held by individual team members, the team, and by other key stakeholders;
3) *Anticipation* – exploring a range of desired (and undesired) futures as a means to uncover intended and potentially unintended consequences of technologies before they arise; and
4) *Responsiveness* – taking actions to change course based upon the acquisition of new knowledge, shifting goals, or to avoid undesirable futures.

These dimensions are intended to facilitate a deliberative democratic process that can both shape design and govern the research activities. This can only occur if effective coordination among decentralized organizations enables shared learning and experimentation, fosters local autonomy, provides redundancy and distributes power (Foley et al. 2017).

While such processes are important, goals and outcomes need to be equally considered. The digital divide can be problematized and reframed in many ways, yet there are three aspirational goals that motivate the research team. The first is born from economic development, such that Harlem residents are afforded equitable livelihood opportunities. Employment is limited by the educational experiences offered and many residents lack the skills to produce digital resumes, cover letters and communicate via electronic mail. The second goal draws from the philosophy of communicative expression that asserts that persons should be afforded an opportunity to flourish in digital environments. Third, the project aspires to achieve energy and material conservation and, thus, maintain viable socio-ecological systems that undergird human's existence on Earth. These goals bring conversations of social justice, creativity and privacy, and energy and material efficiency into the design in productive ways (Ziegler 2015).

Responsible innovation and deliberative stakeholder engagement

While relatively more responsible innovation scholarship has attended to publicly funded academic research in science and engineering (Gierup and Horst 2014), fewer scholars have focused on private firms. One example was the work offered by Brand and Blok (2019), which reviewed three theories of deliberative engagement. The first theory is *market failure* as an initiating force to drive deliberative engagement. Market failures occur when conditions of perfect competition are not met and costs external to the firm arise. Regulatory actions prompt the firms to internalize those costs (or externalities) and correct for the market failure. Yet, as Brand and Blok (2019, 12) point out, 'the 'limited' morality of the market with its focus on efficiency is therefore justified

against the background of a state that takes care for justice,' which means that state-based regulations are warranted, since the market is incapable of achieving just outcomes. The deliberative engagement is between agents of the state (who are indirectly influenced by broader publics) and agents of the firm to negotiate, enact, and mutually enforce the regulatory conditions. This model privileges the firm, its shareholders, and the government agents and excludes broader stakeholders and members of the public.

The second theory arising out of business ethics focuses on stakeholder theory in relation to the firm (Freeman et al. 2010). Freeman's argument centers on the indirect influence that stakeholders exert on a firm's decision-making. This theory posits that these stakeholders have influence even if they have no formal standing or board representation. Phillips (2003) offers two types of stakeholders: normative and derivative. Normative stakeholders are those entities to which the firm has a moral obligation (e.g. employes or communities immediately adjacent to manufacturing operations that might be harmed by routine or accidental emissions). Derivative stakeholders are able to influence normative stakeholders, such as advocacy organizations or the media. Stakeholder theory suggests that firms must seek to negotiate trade-offs between the competing interests of the firm and its stakeholders. Firms can glean insights, elicit values and gain diverse perspectives from stakeholders to inform technological innovation. Yet, firms are not transparent in regards to innovation and privacy claims are used to protect their intellectual property to maintain competitive advantages. Stakeholder theory suggests that stakeholder engagement may create value for the firm.

The third theory of business ethics, which Brand and Blok (2019) argue is most aligned with responsible innovation, is *deliberative engagement* as a form of Corporate Social Responsibility (CSR). Palazzo and Scherer (2006) articulated that firms have a political role in society, and therefore require democratic legitimization to uphold the public interest. Firms gain political legitimacy through discourse with the public as a means of gathering information and building consensus about the firm's actions and activities. Firms pursuing innovative technologies through deliberative engagement need to identify, gather information, and seek consensus with civil society organizations, elected officials and users about the impacts and implications of novel technologies. The theory holds that if firms do not reach such a consensus then its license to operate will be revoked by the collective actions of consumers and civil society or regulated by the State. The strongest form of this governance structure would require that key stakeholders be appointed to an advisory or governing board to ensure accountability, transparency and formalize the relationship.

Research design

To investigate the construction of a community governed network commons through the lens of responsible innovation, and co-governance, this project takes a transdisciplinary approach. The community partner – Silicon Harlem a for-profit organization introduced in the Case Context below – shared in the task of formulating the grant proposal from the outset. By directly bringing the community partner into the formulation of the project, the research team immediately started to discuss the problem-definition and solutions for engaging with additional stakeholders, as theorized by Lang and colleagues (Lang et al. 2012).

This project is structured as a case study, following Yin (2011), and collects data from various sources that account for activities internal to the research team and with external parties. The research team's meetings, presentations, and communication offer evidence of the approaches, motivations, and reflections upon community engagement. Participant observations and video recordings that are available on Youtube.com and other online platforms serve as evidence of the public engagement activities, e.g. Silicon Harlem (2020). Further insights were gleaned from one-on-one interviews ($n = 16$) with stakeholders outside the research team. Additional evidence takes the form of photographs, written reflections, and work products developed by the research team in partnership with key stakeholders.

This research highlights key governance-related events from the first year of the project. Those moments are analyzed first by looking at the pre-conditions for the multi-stakeholder collaboration introduced above: trust, power asymmetry, and inertia and secondarily analyzed through the 'big four' dimensions of responsible innovation: inclusion, reflexivity, anticipation, and responsiveness. Further analysis points to events and activities that are theorized by the phases of co-governance previously described above: cheap talk, mapping, practicing, prototyping, testing and modeling. At the end of the first year, two alternative governance structures for a community-based networked computing solution were presented to the community partner. Here they are analyzed through the lens of co-design and responsible innovation.

Case context: a brief review of the social context and technological system

The SEEC Harlem project is designed to address the inequitable access to the internet of the residents of this historically significant neighborhood. Recent U.S. Census data shows that almost 40% of the population in Harlem does not have broadband access in their homes. Here, racial disparity significantly determines the nature and quality of access, see Figure 1. This is a shared characteristic for many communities facing the digital divide. A report from the NYC Mayor's office (Gamino 2018) shows that, for many people in NYC, the primary method for reaching the internet is through 'smart' phones. This is especially true for Harlem residents. Policymakers in New York City have sought to redress the digital divide by increasing access to broadband services.

Yet, prior attempts to address the inequities in internet access have failed for different reasons. The FioS broadband installation project, for example, bypassed so many households, particularly in low-income neighborhoods that the NY Attorney General filed suit against Verizon in 2017 (NYC Mayor 2017, 1). The LinkNYC project repurposed old telephone phone booths into a network of kiosks that function as Wi-Fi hotspots along the streets of NYC. This network is restricted to persons within 50' to 100' of these kiosks to access 9-1-1, device charging, and digital maps and is limited to outdoor uses. The Gates Foundation contributed $51M USD towards computer resources in 67 new schools (Gates Foundation 2003). Moreover, it invested in seven non-profits in NYC to execute the arrangement, thus counting on local intermediaries to ensure that the money was directed appropriately. While programmatic evaluations share little about the actual outcomes with the public, there is evidence that the computers were adequately distributed (Sawchuk 2018; Lewis-Krauss 2016). This highlights the need to work with civic leaders and professionals who are directly connected to the communities. The Gates Foundation's

Figure 1. Left: Broadband accessibility within the home in Upper Manhattan. Data source: American Community Survey 2011–2015 aggregated and visualized (Policy Map 2019). Right: Race-dot map of upper Manhattan. Data source: U.S. Census Block Data aggregated and visualized (Weldon Cooper Center for Public Service 2018).

intervention bodes well, but, even its approach contemplates the community members as beneficiaries of the charity. Under this approach, outsiders decide what is best for those living and working within the community, rather than engaging and leveraging the experience and distinctively local competence of community members (Hartley et al. 2021).

What differentiates this research effort is the extent to which stakeholders in the local community are involved in the project's design and management. The legal and property ownership landscape in Harlem makes it difficult for a single provider to gain the requisite permissions, as well as overcome legacy infrastructure challenges over and below the NYC streets. By placing the community at the center of the design, the goal is to leverage local circumstances, assets, and resources. In this manner networked computing is conceptualized as a *constructed commons* (Madison, Frischmann and Strandburg 2010).

Community partner: Silicon Harlem

To be sure, some in Harlem rely on fiber-optic or otherwise high-speed broadband connections from providers like Spectrum and Verizon for work. Many, if not most, residents and businesses in Harlem, however, do not have a reliable high-quality broadband connection. In 2013, Bruce Lincoln and Clayton Banks, people with decades of experience in networked computing and telecommunications, formed a MeetUp group to address the issue of internet connectivity in Harlem. After a year of hosting a series of these events, they decided that there was a convergence of people interested in and capable of tackling the digital divide in Harlem. They cultivated durable connections with civic leaders, including Manhattan Borough President Gale Brewer, as well as senior members of the Mayor's office, also including leaders in the Department of Information Technology and Telecommunications (DoITT). Since then, Silicon Harlem has routinely hosted 'co-envisioning' sessions that bring together key civic leaders to reimagine the community as it transitions into the twenty-first Century.

Silicon Harlem hosts an annual meeting that features leaders from across the city to share their approaches to addressing the digital divide. Attendees learn about Silicon Harlem efforts to bring resources, expand networks and build more resilient infrastructure. Another organization that they partner extensively with is the Harlem Chamber of Commerce and during Harlem Week, Silicon Harlem facilitates a session called, 'Demystifying Technology' for senior citizens, as well as a Hackathon for youth and hosts a session for the Economic Development forum. The company is all the more unique for its demonstrable efforts to bring equity to the foreground of their business plan, as they seek to address the disparities in broadband service and access to networked computing.

Technological system: edge-cloud computing and KVM devices

Networked computing infrastructure is a highly complex socio-technical system. This section offers a brief review of the engineering and technical aspects of edge-cloud computing infrastructure, cf. Veeraraghavan et al. (2018) for a detailed description. In short, the proposed technological system is composed of two primary subsystems. The first is an edge-cloud cluster, which is composed of multiple servers located physically nearby the users. Generally, the term 'cloud' in computing today connotes a globally distributed set of servers that store and process data. An edge-cloud, on the other hand, is physically closer to the end-user, making the data transmission rate faster and decreasing latency (or delay) and packet loss. The edge-cloud hosts software applications, e.g. word processing or video editing, and stores and retrieves data.

The second subsystem consists of user-devices: keyboard-video-mouse (KVM) with no onboard processor or running-active-memory (RAM). All processing and data storage functions are performed by the edge-cloud servers, to which the KVM devices are tethered. This means that the delay between the edge-cloud servers and KVM should not be perceptible to users. By way of illustration, consider a keystroke: (1) the device sends a signal to the servers at the moment the user strikes their keyboard, (2), the server records the keystroke as data, (3) the server returns a signal to the user's screen, and generates the corresponding image pattern. This example illustrates how latency is critical to the user experience and was the first attribute tested with users (Alali et al. 2019).

This system does not exclude laptops, thin-clients, or desktops, all of which can access the edge-cloud without any changes to their functionality. Thus, an apartment building, visualized in Figure 2, could have a stack of servers in the basement, i.e. the edge-cloud, which support hundreds of KVM devices and other devices. This system offers four primary services:

- access to software applications hosted by the edge-cloud servers, e.g. web browsers, video conferencing, etc.
- virtual desktops linked to individual users or user-groups
- data storage for individuals or user-groups
- access to the internet

There are four advantages being pursued through this design (Veeraraghavan et al. 2018). First, the combination of edge-cloud servers and KVM devices may offer cost

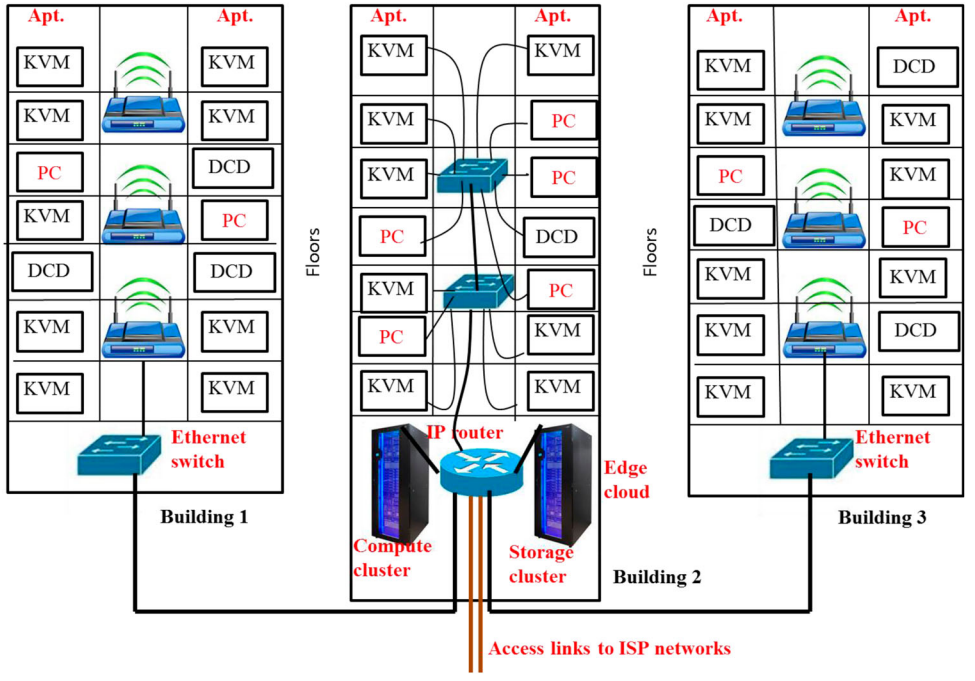

Figure 2. Visualization of an edge-cloud computing structure that connects KVM (keyboard-video-mouse) devices, PCs (Personal Computers), and DCD (desktop computers) to the servers within three hyper-localized buildings. Note: This image is reproduced from Veeraraghavan et al. (2018), which was published as an open source document.

savings and costs can be distributed among users. While the upfront costs are higher, the overall costs may be lower, as individuals would not need to purchase devices, software, and would share costs for maintenance. The second is security, since KVM devices cannot be 'hacked' because they do not have a processor. This reduces the 'attack surface' of the system and allows system administrators to deploy robust defenses to protect the servers from viruses, malware, and phishing attacks. Further, the servers can be programed to routinely back-up files on mirrored servers to prevent data losses. Third, the system can be managed to minimize power usage with the KVM devices using far less electricity than individual laptops as servers can be powered down when data processing requirements are low within the system. The final advantage is the potential to place decision-making power within the local system administrators about questions of data management, privacy, data sharing and terms and conditions. Thus, community members can be party to the deliberations on alternative data management approaches and (in-)directly influence those decisions.

Towards co-governance of networked computing

This section highlights insights from some key co-governance moments in the project and then sketches two proposals for the governance of the SEEC Harlem edge-cloud community computing network.

Trust, power asymmetries and inertia

In December 2016, Silicon Harlem hosted a meeting to explore and articulate shared research priorities in service of 'Equity enabled by narrowing the digital divide.' The team consisted of a loose network of persons that had forged trusted relationships prior to the launch of this project. The research team was born from relationships that its members had forged in prior years. However, power imbalances were ever-present, particularly between Silicon Harlem, the community partner, on the one hand, and the academic research institutions on the other. Pointedly, the proposed budget for Silicon Harlem was substantially smaller than that for the research institutions, at approximately five percent of the total award. While providing direct financial support to a for-profit firm to serve as a community partner is rare, the compensation received by Silicon Harlem was not commensurate with its proposed contribution and effort. The academic organizations would receive ten times the financial rewards compared to Silicon Harlem.

The proposed technical solution, detailed above, also ran into an early hurdle. A concept paper, based upon the proposed research, was rejected and the reviewer comments suggested that the research was an affront to the direction of the field towards 'smart' devices or IoT. Computer science research is working to enable and expand 'smart' devices and networks involving 'smart cities,' as well as 'smart' home devices. Yet this project was seen to be heading in the opposite direction by removing processing power from the user-devices. This news was combined with the NSF's initial discouragement of the proposal suggests inertia within the computer science research community that privileges advances in 'smart' devices.

Cheap talk and initial community engagements

The first opportunity for many members of the research team to engage with community members and civic leaders occurred at Silicon Harlem's 4th Annual Conference on 27 October 2017 hosted at the Silberman School of Social Work at Hunter College. The event brought together political and business leaders, city officials, entrepreneurs, nonprofit organizations, and educators. Silicon Harlem featured the SEEC project in one session that redressed the challenges of bringing high-quality internet service to underserved neighborhoods across the city (Silicon Harlem 2017). Subsequently, in the first year of the project, the research team engaged in five public events during 'Harlem Week 2018.' During one event, fourteen local teachers joined the team to discuss classroom technology and the challenges and opportunities facing teachers and students. The teachers noted the difference in performance between students with computers at home and students that relied solely upon mobile phones. The conversation made many disparities clear and offered important information about the software and hardware typically used in NYC classrooms. That forum was insightful for many on the research team, as the lack of equipment, limited software packages, and disparities between NYC schools were made abundantly clear.

During another Harlem Week workshop in August 2018 with twenty people from government, technical industries, advocacy organizations, as well as local residents, the audience raised important questions. A young man concisely restated the design

principles to the research team and then asked, 'What are the latency concerns, if the device has no processor or memory? Who will control, administer the server in response to users' needs?' The audience at times challenged the research team about how questions of data management, privacy, and security could be handled. The research team also participated in the Harlem Economic Development Day and recruited 40 volunteers for the technology trials and a community-based survey on internet usage.

These events offered an opportunity to practice the co-creation cycle, theorized by Foster and Iaione (2022) through community-engaged research activities and process, see Figure 3 below. These events demonstrated Silicon Harlem's pivotal role as a *trusted convener* between local stakeholders and the research team. Community members gained insights into the technological system proposed, and subsequently raised important governance questions. The research team gained an understanding about the community's knowledge of computer systems and insights about the uses and applications within educational and business settings from the school teachers and business leaders. Those initial community engagements allowed the research team to listen and engage in 'cheap talk' to start to identify additional partners and identify different forms of expertise in the community.

Knowledge integration and practicing reflexivity

From nearly the outset of the project, in late 2017 into early 2018, the research team relied on an integration plan that involved iterative discussions on the technical design team, legal scholars, social scientists, and community partners – see Figure 4. However, in the weeks leading up to the public engagements, tension had emerged between Silicon Harlem and the technologists, on the one hand, and the legal scholars, on the other.

Figure 3. Activities performed by the research team in Harlem that followed the co-creation cycle in 2018. Note: Testing was not conducted during this phase of the research and thus is illustrated and was not photographed.

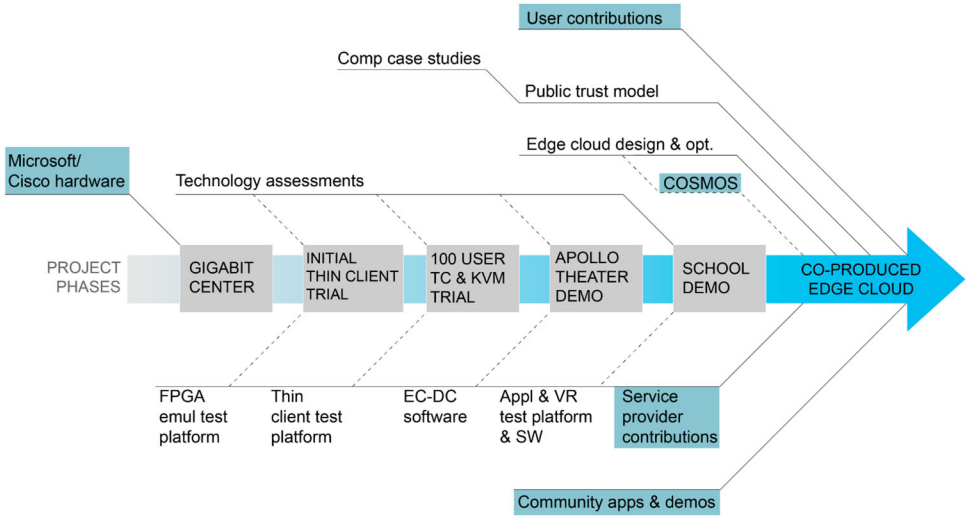

Figure 4. Research integration slide presented to full research team. Image credit: Farrah Dang.

The latter had two sets of memos prepared by graduate student assistants on the privacy implications of a community-owned network. Recognizing that the SEEC Harlem network could be used by the Harlem Hospital, these memos (1) identified legal protections for consumers in health markets that would have implications for the technological design of the project, (2) compared existing agreements for large commercial cloud-based service providers, (3) outlined consumer data protection in cloud administration generally, and (4) proposed potential governance schemes for community-operated computing networks. The memos identified limitations and challenges with such systems, which is typical of legal research. The memo's findings alarmed the technologists, and which seemed critical of certain design-decisions.

These tensions roughly map onto, or lightly mimic, what Kitchin et al. (2018) have identified as conflicts that can arise between technocrats, epistemic communities, and advocates working in the smart city space. On one hand 'smart city enthusiasts' – scientists, technologists, technocrats, companies, and government – who want to develop and implement the technologies and initiatives to improve cities and community life. On the other are social scientists, civic organizations, and those in the knowledge and policy sector who raise a host of concerns focused on issues of power, equality, participation, labor, surveillance, among others.

As a way to facilitate cross-disciplinary dialogue, one of the computer scientists presented the legal scholarship to the full group. That team member discussed the advantages of market-based mechanisms for efficiently distributing computing resources and questioned the need to manage networked computing as a 'common pool resource.' This prompted a dialogue about how the 'commons' approach did not exclude market-based efforts, yet collective approaches sought to achieve greater equity, rather than efficiency. The conversation was robust and positive, although the market-based and commons-based approaches were positioned as competing, rather than as complementary. The cross-disciplinary talks generated robust discussion about market failures and presented challenges for common pool resource management. One of the legal

scholars subsequently described the technological approach set out by the project, attending in particular to design priorities and limitations, irrespective of legal requirements. This presentation did not engender anything close to the same intensity of discussion presumably because these aspects of the research project were well known and settled. The meeting served as a forum for both knowledge integration and reflection among members of the research team. One person offered that, 'the technical and social, legal, and humanities projects can all stand on their own, but the project aims to be truly collaborative and integrate the various research strands.'

Networks of power: reframing the internet as a constructed commons

After the first year of research activities, in the fall of 2018, the team recognized that it needed to set out how to structure governance of the edge-cloud computing network. To address this need, the team developed two approaches based on property law principles and 'constructed' common resources norms. This section outlines those two approaches for adapting and modeling the legal and property arrangement necessary to create this kind of digital constructed commons: a *Community Land Trust* and a *Common Interest Community*. These approaches were not envisioned to replace extant market-based solutions, i.e. incumbent broadband service. Rather, these models reflect alternative governance structures for residents to collectively opt-in as they wish, as a way to supplement conventional market-based service.

Researchers on this project set out to design the governance structures in ways that enable residents and other stakeholders to administer the personal data that would course through the proposed edge-cloud computing network. The stakes of these design choices increase as the networked computing infrastructure moves from design to implementation. Data protection concerns, moreover, may increase as the residents and users in Harlem become increasingly educated and wary about how application developers and broadband carriers manage their personal data. This article presumes that the SEEC Harlem project presents an opportunity to test network designs, network management models, and decision-making processes that attend to consumer data protection and other priorities of its constituent residents and stakeholders.

Community land trust (CLT) model

A community trust separates ownership and use of an asset (or assets), such as land. In a *community land trust* (CLT), the trust entity (typically a non-profit corporation) owns, holds, and manages land on behalf of the users or the community. The trust provides for the exclusive use of the land by the owners of any buildings (residential or commercial) or other land (e.g. community garden) located on the trust land through a long-term lease agreement. The CLT retains an option to repurchase any structures on the land if their owners ever choose to sell. The resale price is established by a formula contained in the ground lease. The lease, or contract, between the landowner (CLT) and the building's owner protects the owner's interests in security, privacy, and equity. It also enforces the CLT's interest in preserving the appropriate use of the land and the continuing affordability of the buildings on the land.

Typically, CLTs are run by a board of directors representing three groups of stakeholders: residents or leaseholders, people who reside within its targeted community but do not live on its land, and lastly the broader public interest. Any adult who resides on the CLT's land and any adult who resides within the area deemed by the CLT to be its community can become a voting member of the CLT. The third group is frequently represented by government officials, funders, housing agencies, and social service providers. Organization bylaws may designate each of these groups an equal number of seats, and they may be elected separately by their constituent groups.

The CLT concept could be applied to networked computing. The asset owned and held by the trust could be any physical aspect or component of the edge-cloud architecture. In this case, the asset could be any of the physical or tangible components of the edge-cloud network. These assets would 'belong' to the trust, which could then enter into legal arrangements with residents to use or even own them with a 'buy-back' provision. The purchase or lease agreement could build into the network guarantees or provisions addressed to ensure cost and affordability. It could also set the terms of service, like price, the ability to transfer, and other terms. The trust would be governed by a 'tripartite' board consisting of residents/leaseholders, other members of the community, and other stakeholders representing broader interests (the city, the provider, technical experts etc.). The CLT model leaves much of the decision-making about terms of use, including price and ability to transfer, to a governing CLT board of directors. The board directors can be chosen or elected by CLT's members, consisting of residents living in the subject area (in this case Harlem) The members can also develop enforcement mechanisms that ensure compliance.

Common interest community (CIC) model

Analogous to condominiums, planned unit developments, co-ops, vacation share rentals, and other housing developments, Common Interest Communities (CICs) are comprised of individually owned units with shared facilities and common areas. In a condominium, individuals purchase and exclusively own an individual unit or home, and also own a proportional 'share' of the common facilities and assets. Thus, they own 100% their own units or homes, and hold a percentage 'in common' of the community's shared property and assets. This shared property can include common areas like hallways and lounges, streets, garages, recreational facilities, etc. Cooperatives are another kind of CIC in which owners do not own an individual unit but rather shares in the cooperative corporation. The co-op instead technically owns the individual units and everything else – the building, the units, the common areas and facilities. Each owner becomes a shareholder and is given exclusive use of a unit along with shared access and use of the common areas and assets.

There are usually covenants, conditions, and restrictions (CC&Rs), as well as written bylaws by which members must abide. These set out the terms of membership in the community, including monthly assessments, special assessments, rules of the community, voting and election procedures, restrictions on use, and other matters on which all community members agree. Typically, a homeowner's association (HOA) or cooperative board governs the CIC through the enforcement of its CC&Rs, essentially

contractual terms, and can propose rule changes to which the community must agree, usually through a supermajority requirement, in order to become effective. Every individual property owner or shareholder is eligible to serve on the HOA or board through an election procedure set out in the CC&R.

If most of the components of the edge-cloud architecture will be individually owned, this might be the appropriate model. All owners would be part of the CIC edge-cloud network by virtue of their ownership. And a CC&R would govern its administration. Either the edge-cloud developers or some permutation of community members would have to set out these CC&Rs at the outset. Whatever elements or components are not owned can be 'shared' common assets that users have a proportional share in and are able to participate in the governance of those shared assets. This could include the hardware infrastructure (including the cloud server) as well as the software and applications. A governing board would have the responsibility of enforcing or revising the network's terms of use. The board would also be the entity that would enter into a contract or negotiation with a service provider, if applicable.

The CIC governance model presents a different set of legal concerns regarding the protection of user data. But, here, the legal obligations vary depending on (1) the form of CIC (condo, co-op, etc.), (2) who manages user data (technical administrator charged by the governing board itself) and (3) the CC&Rs. Thus, for example, pursuant to the condo approach, it could be presumed that each user 'owns' her data in the same way that she owns a KVM device or apartment? Alternatively, pursuant to the co-op approach, all constituents might own everyone else's personal data as a common asset. Or the CC&Rs might set out the terms by which any given member has exclusive use of a particular set of data related to herself in addition to shared access and use of the shared hardware and software. Aggregate data about residents or any information that could be distilled from the aggregate data about residents and their use could be an asset of the community. Ultimately, the difficult question here is: what ought to be the respective governing body's legal relationship to each member's personal user data? And, more pressingly, what does it mean for each individual member to have an exclusive ownership claim to their own personal data under a co-governance regime when that data is essential to the operation of the entire network? What is important is that the CIC model would set those terms, initially, and then those terms could be altered by the cooperative governing board in the future.

Discussion

The theories of responsible innovation and co-governance of shared resources offer alternatives to the firm-oriented decision-making model, as discussed by Brand and Blok (2019), and a shift towards a community-based approach. The two legal structures of CLT and CIC empower community members to establish rules-in-use and practices for sharing networked computing resources. This redefines what is typically understood as a private resource, into a *constructed commons* and affords the community standing and authority over the design and administration of the edge-cloud computing services. The knowledge, experience and expertise of local residents, businesspersons and non-profits can inform data management, software services, hardware updates and ownership and usership rights, while the existing Internet would remain unchanged. How that

process has unfolded through a multidisciplinary design process was the subject of this research.

The pre-conditions for collaboration, which include trust-building, identifying power asymmetries, and overcoming inertia, can be addressed in the first phases of co-governance process. During the initial meetings between the research team and Silicon Harlem, various ideas were shared and contested. This form of 'cheap talk' started to identify sources of inertia and contributed to trust-building. Later on, at public events, the research team and community members engaged in further 'cheap talk' during public events and workshops, which included a variety of residents and stakeholders, such as educators, tech professionals, and business and civic leaders. That contributed to the stakeholder mapping and indicated that Silicon Harlem was uniquely positioned to connect the research team to the remarkably heterogeneous community of Harlem. Further, the public meetings were only possible, due to the community members' trust in Silicon Harlem. The private and public meetings readily identified power asymmetries and sources of inertia, as well as identified potential change agents. Through those interactions, the researchers gained a deeper understanding of the nature of the broader societal challenges and cataloged assets and resources within the community that can be built upon. Thus, the pre-conditions identified were addressed, to an extent, by the co-design process.

The research team meetings and community events, detailed above, supported *inclusion* and *reflexivity*. Those meetings offered opportunities for an iterative and internal process of goal setting and discussion of research activities. The insightful questions asked among the team members forced many people to explicitly state the assumptions, research methods and how those research goals aligned with the project's broader goals. The public events hosted by this project can also be viewed as practicing the co-creation cycle through inclusion and exploring potential synergies among the project partners and relevant stakeholders in government agencies and private firms. The practice co-governance can be understood as a means to facilitate knowledge integration that is both exploratory and reflexive between stakeholders. In this manner, stakeholders considered new relationships, institutional conditions and decision-making approaches and, yet made no commitments, which them to reflect upon and reconsider those opportunities at a later time.

The two alternative governance proposals detailed in this article offer concrete examples for how networked computing can be reconceptualized as a constructed commons, rather than a private good. The CLT and CIC models both invite a diversity of stakeholder perspectives into the decisions that will direct the administration of networking computing resources and the data about its users. Currently, private firms issue terms and conditions (T&Cs) when software is downloaded or a laptop is purchased and there is no negotiation. It is a take-it or leave-it agreement between the buyer and seller. If the buyer wants to use the web browser, then they are subject to the terms and conditions offered by the firm. The power asymmetry between the individual user and the firm is gross and opting out and not using the internet is mostly a false choice. The proposed community-based governance models radically rethink the roles and responsibilities for decision-making. The market failures that led to the digital divide will not be solved by traditional market mechanisms. Unconventional approaches to governance are needed and proposals, such as this one, start with a vision for the equitable distribution and access to computing resources.

The two governance proposals (CLT and CIC) also stand in stark contrast to conventional 'top-down' franchise-agreement approaches for the regulation and delivery of broadband service in New York City and elsewhere. In the private-sector model, the principals that enter into such arrangements are local government officials and broadband providers. Under those conventional approaches, local residents and most other stakeholders minimally influence the terms of broadband infrastructure deployment and administration. The conventional approach has done demonstrably little to redress the core concerns that this project takes up. The CLT and CIC proposals seek to address many of the concerns raised by the residents in Toronto, whose concerns about long-term shared governance, data management and privacy lead to the opposition of the Sidewalk project (Goodman and Powles 2019). By empowering vested community members with the responsibility to govern the edge-cloud computing infrastructure, the CLT and CIC proposals seek to enact a form of 'digital stewardship' (Slager 2018). This positions local stakeholders and residents at the core of decision-making, rather than positioning them as recipients of services offered by private firms. Brand and Blok (2019) suggested that including stakeholders on the board would be the best practice to assure corporations addressed their stakeholders concerns and values, yet this research goes further. The board members constituting the CLT or CIC would be composed of the residents, entrepreneurs, and non-profits that share the benefits of the edge-cloud computing infrastructure, as well as maintain direct decision-making authority.

Yet, challenges for transdisciplinary research were in place well before the NSF issued the call for proposals via the Smart and Connected Communities program. The power asymmetries between the academic researchers and community partners were ever-present. Further, the franchise agreements that are described above are good examples of the overarching institutional conditions for business in this sector. This is to say that the premise underlying the SEEC Harlem project reflects a significant shift away from the incumbent conventions for regulating users' computing needs and networked connections. This research project challenges the dominant narrative that publicly funded science and technology can only achieve broader impacts through private markets. Consider by way of comparison the metrics on which researchers evaluate the impacts of patents, spin-off companies, and licensing agreements born from funded research. Publicly funded research into networked computing, which arises from the need to share data among government agencies and researchers, is now designed almost entirely for commercial markets. The seemingly complete reliance on private markets to distribute the 'goods' created by publicly funded research in the field of networked computing are yielding negative consequences for both the consumers of this technology, as well as for those excluded from the market.

Conclusion

Computer scientists and engineering researchers interested in redressing the digital divide ought to consider partnering with a diversity of scholars and community partners if they aspire to achieve equitable impacts. As for federal research agencies, there is a need to design policy interventions that cut across agency boundaries, particularly with regards to the digital divide. While, this paper does not offer an evaluation of our efforts to achieve the stated goals, it reflects on our efforts to put into practice the theories

of responsible innovation and co-creation cycle during the initial design of a community-based edge-cloud network in Harlem New York.

What this article suggests is that, while the theories of responsible innovation and constructed commons are born from disparate schools of thought, there are opportunities for synergy between these frameworks. The co-creation cycle and its process-oriented activities can be understood as a more refined expression of responsiveness. The iterative and didactic feedback between the activities draw upon the values of inclusion and put reflexivity into practice. Further, the co-creation cycle offers a set of activities, such as cheap talking, that aim to foster trust prior to initiating substantive engagement and deliberation. As van de Poel et al. (2020) and others have discussed, trust is a precursor to inclusive deliberations on alternative technical and governance arrangements. All the while, prototyping is, inherently, a future-oriented process that opens up deliberations on alternative governance arrangements and this appears to dovetail with anticipation from responsible innovation. In these ways, the theories are mutually supportive and together may offer guidance to practitioners and researchers designing complex socio-technical systems.

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