If it Rains, Ask Grandma to Disconnect the Nano: Maintenance & Care in Havana's StreetNet

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In Cuba, where internet access is severely constrained, technology enthusiasts have built StreetNet (SNET), a community network (CN) that has grown organically, reaching tens of thousands of households across Havana. Through fieldwork conducted in 2016 and 2017, we investigate participants' strategies as they engage with a network where the material elements—cables, switches, nanos, and servers—are regularly breaking down. Drawing on maintenance and care (M&C) scholarship, we present an in-depth investigation of the management and anticipation of breakdowns in SNET, foregrounding the deeply relational nature of repair work, collective efforts required for SNET's M&C, and the values and motivations underpinning these practices. Our paper contributes a unique perspective on how CNs are run locally and organically, outlining considerations for how interventions along these lines might be more suitably designed. We also complicate perspectives of innovation through a discussion of cultural ideologies and tensions underpinning M&C practices.

Additional Key Words and Phrases: Cuba; ICTD; Community Networks; Maintenance; Care; Repair; Innovation

1 INTRODUCTION

> *"SNET is a mini-internet, it's just not as up-to-date as the internet. We can chat, there's new applications for PC, for phones, everything. We sell and buy things. This is perfect. Almost perfect. Imagine, we are on an island, and from the island, only a few have SNET. But hey, we are Cubans, it's what we invented."*—Diego[1] (M, 18)

In Cuba's capital city of Havana, access to the world wide web (WWW) is severely restricted by high costs, limited access points, and slow speeds [21, 23]. However, simply focusing on WWW access is not indicative of what engaging with the internet or digital technologies means to people in Havana. Walking the streets of the city, one need only look up to notice tangled cables running over roofs, balconies, and into windows. These cables are part of StreetNet (SNET), a community network (CN) that serves as an alternative to the WWW for thousands of people in Havana. As a distributed, grassroots network circumventing the need for outside intervention from the

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[1]All names have been changed to protect the anonymity of our participants.

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government or commercial entities, SNET relies on thousands of volunteers to maintain its physical and digital infrastructures.

Due to Havana's sociopolitical context, SNET's ad hoc nature, difficulty of finding new equipment, and scarcity of funds, the material elements of this system—cables, switches, nanos, and servers—are regularly breaking down. Building on Jackson's work, we consider SNET from a "broken-world" perspective, taking breakdowns, rather than growth or progress, as the starting point to think through "the nature, use, and effects of information technology" ([34]:222). We conducted fieldwork in 2016 and 2017 to investigate the management and anticipation of breakdowns in SNET, foregrounding the ongoing, collective efforts required for SNET's maintenance and care (M&C), and the values and motivations underpinning these practices.

Our work builds on M&C literature to emphasize the deeply relational nature of repair work, which we consider to be repair practices that are inherently collaborative and encompass both material and social elements that simultaneously facilitate and necessitate repair. "Relational" repair practices are so dependent on personal relationships that the relationships themselves need iterative repair as much as the material infrastructure people collaborate to maintain. Our findings reveal how participation through repair is informal, situated, and ambiguous, requiring collaboration and innovation in order for people to contend with daily, sociomaterial breakdowns in sociotechnical systems, particularly in constrained[2] contexts. The case of SNET orients us to the relational elements of M&C practices, underscoring how participation in this network does not and, in fact, cannot occur without the negotiation with and consideration of a variety of human and non-human actors.

This study extends CSCW scholarship on repair work, highlighting how the context of Havana drives repair practices that are both relational and innovative. However, we problematize the notion of technological innovation through repair by uncovering the tensions between arduous work, cultural and individual values, rewarding outcomes, and moments of exclusion or unfair treatment. We additionally contribute to CN literature by complicating prior assumptions regarding the design and affordances of CNs. SNET is a volunteer-led collaborative network that continues to evolve despite resource constraints and legal ambiguities. The elements that might normally threaten a network (repeated breakdowns, existing "illegally," no centralized or formal support) are part of the reality that SNET users live with on a regular basis, resulting in particular M&C practices. We highlight the role of leisure as a driving force shaping repair work in SNET, illuminating how repair practices draw on and shape community ties, while also fostering tensions and surfacing power entanglements. As a result, our work also contributes to the field of Information and Communication Technologies and Development (ICTD), which has long engaged with information infrastructures—both online and offline—in constrained contexts around the world (*e.g.,* [29, 38]).

After reviewing related work on CNs and M&C, we describe the context within which this work occurs and the methods we used. We then present findings that detail how SNET came into being, followed by a day-to-day perspective on cases of M&C, and individuals' motivations underlying the establishment and maintenance of SNET. We conclude with a discussion of how attention to M&C practices in SNET attune us to the relational elements of repair in constrained contexts, thereby extending work in the areas of repair, CNs, and technical innovation.

2 RELATED WORK

2.1 Community Networks

The communities of CSCW and HCI have long been interested in CNs, crowdsourced infrastructures collaboratively built by individuals and groups who pool resources and coordinate efforts to provide digital services to members [2, 9, 13, 20]. CNs may take on different technical structures, including

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[2]By "constrained," we mean resource, political, and legal constraints.

grassroots networks, wireless community networks, and alternative mesh networks [13]. Early work on CNs focused on community-oriented electronic bulletin boards, such as Community Memory, which began in the mid-1970s in Berkeley, CA, and is often considered to be the first CN [66]. In the early 2000s, the number of CNs increased, along with beliefs that they may serve as models for free, wireless, and ubiquitous internet [49, 65]. Current examples of CNs include guifi.net in Spain [2], Italy's ninux.org [46], the Athens wireless metropolitan network of Greece [26], and FreiFunk in Germany [50]. Research among rural and under-connected communities, particularly in the field of ICTD, has explored CNs as a way to provide last-mile connectivity, including the San Andres community cellular network in the Philippines [38], WiLDNet in India [73], and Digital Tribal Village (DTV) in the U.S. [64]. CNs in remote regions often face additional hurdles including repeated breakdowns, lack of technical knowledge by end users, equipment theft, and weather exposure [38, 73].

While CNs have a DIY ("do it yourself") ethos, many CNs need technical experts to deploy and manage equipment; a common problem is encouraging participation among non-technical experts [38, 60]. However, in rural India, Surana et al. found that local repair efforts by non-experts lead to new problems like damaged equipment [73]. Noting the limitations maintenance poses to the growth of a network, Jang et al. attempted to facilitate repairs by end-users in their work with a community cellular network in the Philippines [38].

Work on CNs has celebrated the "liberating" attributes of CNs to varying degrees. Since the 1970s, "the euphoric hopes [CNs] inspired for more equity, participation, and civil society is typical of the technological optimism that has been identified as a characteristic of U.S. social thought, literature, and public debate" ([42]:291-2). Scholars have celebrated the decentralized structure and grassroots organizational style of CNs. De Filippi contrasts CNs to centralized network infrastructures owned by "powerful third parties" ([15]:3). Further, prior work has emphasized commitments to free speech and resistance to surveillance and repression as defining characteristics of CNs [13, 15, 50]. Although research celebrates the ad-hoc, decentralized, "by the users for the users," model, most CNs operate with the assistance of third parties, including governments, universities, research centers, and/or corporations. For example, in their research on guifi.net, Baig et al. maintain that collaboration from lawyers and public administrators is crucial for the sustenance of the network [2]. Our aim is not to downplay the contributions of other CNs; instead we contribute a case of a CN operating without formal assistance from any third party. In doing so, we tease apart both opportunities and tensions embedded in the local, community-led M&C practices operating within a CN located in a constrained context.

2.2 Repair, Care, and Innovation

Scholars from the fields of CSCW and beyond have contributed rich, ethnographic accounts centered on the repair of both material and social orders [28, 35, 37, 56, 62, 76]. Based on Star's foundational work [69], research traditionally considers infrastructures to be invisible until they break. Both Latour [45] and Star and Bowker [70] position moments of breakdown as opportunities to explore hidden elements of the relationship between people and technology.

We draw on these perspectives, but rather than considering breakdowns as atypical [45, 69], we join with scholars in advocating for a re-conceptualization of breakdowns as normal [28, 34, 36, 37, 62]. Focusing on repair worlds in rural Namibia, Jackson et al. propose broken-world thinking, "a gestalt shift in our ways of thinking about sociotechnical system development that moves moments of maintenance and repair, rather than just moments of design and adoption, to the heart of CSCW thinking and practice" ([37]:9). Broken-world thinking focuses on the ongoing labors, interests, and power underpinning the sociality of objects and their survival in the world [36]. This body of work situates repair as, "the subtle acts of care by which order and meaning in complex

sociotechnical systems are maintained and transformed, human value is preserved and extended, and the complicated work of fitting to the varied circumstances of organizations, systems, and lives is accomplished" ([34]:222).

Beyond keeping networks functional, repair practices constitute new sites of innovation [17, 34, 37, 74]. Drawing on feminist studies, scholars have adopted a commitment to decenter sites of innovation through explorations of often overlooked practices [17, 34, 72]. Using the term "artful integration," Suchman sought to shift the focus from the "heroic designer" to instead consider, "ongoing, collective practices of sociomaterial configuration, and reconfiguration in use" ([71] cited in [72]:12). A focus on these seemingly mundane practices, she argues, "represents our best hope for genuinely new reconfigurings of the technical" ([72]:12). A growing body of work examines repair in resource-constrained contexts through the resourceful and creative ways communities implement, maintain, and repair technological infrastructures and artifacts [35, 37, 56, 64, 82]. In rural Kenya, Wyche et al. considered mobile phone repairers as innovative designers, capable of informing designs for both local and global consumers [82]. Within the mobile phone repair shops of Bangladesh, Jackson et al.'s participants exhibited creative problem solving, collaboration, and technical mastery in repurposing sophisticated devices, which, the authors argue, constitute an innovative form of human-computer interaction [35].

While showing the creativity and resourcefulness of communities that must make-do, scholars have also noted the tensions present from the *need* to be inventive [32, 56, 64]. In Brazil, Nemer and Chirumamilla posit repair, "as a lens that highlights both the systemic instability and individual creativity that constitute the effort to create workable technological systems in the favelas" ([56]:222). These innovative, creative practices, therefore, also underscore underlying tensions. Likewise, Sandvig demonstrates how maintenance of DTV resulted in innovative practices that provided high-speed internet for residents of Native American lands, while also serving as a reminder for participants of their ongoing mistreatment and exclusion [64]. Lilly Irani argues that the move to decenter innovation still renders the definition of innovation as unproblematic. Instead, Irani says that, "we should examine innovation as a process of the recognition of value rather than granting it concreteness it does not have in practice" ([32]:191). Through this work, we question the underlying positivist assumptions of innovation through an empirical analysis of the tensions and opportunities present in the ways that people feel that they must be innovative through repair practices in order to participate in digital networks.

We focus on the care practices embedded in SNET's sociomaterial maintenance, demonstrating the social reliance underpinning these practices. Building on Mol [52] and de la Bellacasa [16], scholars have explored how sociomaterial practices are embedded within an ethics of care [17, 18, 34]. Tronto defines care as, "everything that we do to maintain, continue, and repair 'our world' so that we can live in it as well as possible. That world includes our bodies, our selves, and our environment, all of which we seek to interweave in a complex, life sustaining web" ([78]: 103). Jack and Jackson demonstrate how UNICEF logisticians simultaneously exercise care and control, traversing messy infrastructures in an effort to provide humanitarian aid [33]. Among makerspaces, Toombs et al. highlight how caring for others was central to the sustenance of the space, contrary to the dominant neoliberal values of autonomy in makerspaces [76]. In contrast to universalist approaches, Mol et al. position care as a style of work that is locally situated in world of shifting tensions [53]. Rosner and Ames demonstrate how repair depends on context, arguing that community values, socioeconomic status, and gender impact both the ability and desire to engage in repair practices, challenging assumptions that repair leads to empowerment [62]. Focusing on disaster-relief efforts in Ecuador, Wong-Villacres et al. reveal how the particularities of place impact underlying values and the way care is enacted [81].

Care is an action that involves intervening [16] implies valuing [53] and "suggests enduring work that seeks improvement but does not necessarily succeed" ([30]:141). De la Bellacasa emphasizes that the term "care" holds different, sometimes conflicted, meanings and resulting practices may not be in the best interests of others [16]. Individuals act based on their understanding of how the world "should" be and these understandings are not always aligned. Mol et al. posit that a focus on care shifts our attention from people as rational actors with impartial judgements to the embodied practices requiring "attuned attentiveness and adaptive tinkering" [53]:15. This perspective, Jackson et al. argue, moves us beyond instrumental or functional relations between people and materials and, instead, focuses on the relationship between actions and meanings [36].

Building on prior work, the case of SNET attunes us to the *relational* elements of M&C, uncovering how these practices are informal, collaborative, situated, and ambiguous. We present a case where repair practices are inherently informal as they are undertaken by untrained, nonprofessional repairers whom have had to learn to repair on their own without the assistance of professional repairers or direct, reliable access to the WWW. As a result of the informality of these practices, as well as the economic, political, and material context of SNET, the resulting M&C work is deeply relational; it is so dependent on personal relationships that the relationships themselves need iterative repair as much as the material infrastructure people collaborate to maintain. Participation in SNET requires a reliance on relations within the family, the local community, and social connections outside of Cuba. Simultaneously, since collaboration is required, these continual repair practices also surface tensions and power dynamics among social relationships, which, in turn, require the continual M&C practices to attend to social relationships in order to sustain the wider network. Therefore, the relational encompasses both material and social repair practices that simultaneously facilitate and necessitate repair. A relational perspective of M&C practices orients us to their ambiguous nature as participants grapple with feelings that are seemingly contradictory; they encompass feelings of pride and collective agency, but also stress and frustration resulting from participants' perceptions that they must be innovative and collaborative because they have no other choice. Focusing on M&C practices through the observed and reported experiences of participants, we expand repair literature attending to the relational nature of repair practices in SNET, enriching our understanding of collaboration and innovation in CNs.

3 BACKGROUND

Like all sociotechnical systems, SNET is embedded within socio-political, economic, and cultural structures that are important to acknowledge when unpacking the intricacies of this network. Here we provide a short background on the history of the internet in Havana as well as Cuba's complicated political relationship with the U.S., highlighting the context in which SNET evolved. Since the end of the Cuban revolution in 1959, all business sectors have been under state ownership and Cubans' access to foreign press, entertainment, and other content has been restricted [6]. At the same time, the government has prioritized education and health initiatives across the country and it is estimated that 99.8% of the 11 million inhabitants in Cuba are literate [12].

Although Cuba became one of the first South American countries to connect to the WWW in 1996 [80], access for the majority of Cubans has been heavily restricted. In 2013, Cuba connected a high speed ALBA-1 fiber optic cable to Venezuela, enabling increased data transmission speeds and bypassing a reliance on the U.S. for high-speed internet access [6]. Regardless of this connection, access to the WWW did not not improve for the vast majority of the Cuban people (in 2014, only 5% had access [25]). In March 2015, the Cuban government introduced public, paid WiFi hotspots across the country, currently one of the only ways people can access the WWW. While these hotspots provide an opportunity to connect, they are prohibitively expensive and slow [23].

In addition to the history of the WWW in Havana, understanding M&C practices in SNET also requires attention to the historical, political, and economic conditions within which participation is embedded. This includes the complicated relationship between the Cuban and U.S. governments, marked by ongoing, military efforts by the U.S. to overthrow the Cuban government as well as covert, technologically-driven efforts to incite dissent among the Cuban people [3, 5]. For example, USAID has undertaken a variety of democracy promotion initiatives, from clandestine radio broadcasts in 1985 to the launch of ZunZuneo in 2012, a Twitter-like social network that purportedly was an attempt to "upset the balance of power between the state and civil society and create a push towards a democratic transition" [5].

Notably, in December 2014, the U.S. and Cuba announced that they would begin the process of normalizing relations [3, 75] and, in July 2015, formal diplomatic relations were officially re-established [19]. The two countries also agreed that Cuba would allow internet access for its people and the U.S. would facilitate access by permitting Cuba to connect to fiber-optic cables linking the two countries as well as allowing North American telecommunication companies to do business with Cuba's state-owned enterprises [75]. Although the U.S. government has stated that increased internet access should be a goal for Cuba, U.S. policy has also contributed to limiting information access in the country. This has occurred primarily through the U.S. embargo (which is still in effect), which often makes downloading software from servers hosted in the U.S. impossible, blocks websites for people in Cuba, and prevents companies and U.S. citizens from engaging with Cuba in a variety of ways [27]. The complicated, strained relationship between the U.S. and Cuba, therefore, underpins the nature of the engagements with SNET specifically and ICTs more broadly as the Cuban government seeks to both advance internet access while not accepting U.S. interventions due to ongoing efforts aimed at overthrowing the current regime.

Other factors contribute to the ways SNET participation unfolds on a daily basis. After the dissolution of the Soviet Union in 1991, Cuba lost the economic support of one of its most important foreign allies. Further, the ongoing US embargo restricted the investment and involvement of US-based institutions [1, 7]. As a result, in the 1990s, Cuba plunged into a period of scarcity [7]. Known as the "special period," food and resources were scarce and the majority of the population suffered from malnutrition. During this time, the term "*resolver*" took hold, describing coping mechanisms required in order to survive. *Resolver* literally means "to solve" or "to resolve," but, in Cuba, it is a cultural ideal describing the ways people collectively invent, make do, reuse, and persist despite hardships [58, 63]. As Cuba moved out of the special period and resources (particularly food) became less scarce, *resolver* evolved to describe more of an inventiveness beyond simply surviving. These practices are evident in everyday life in Cuba, from grocery shopping to repairing old cars [1]. *Resolver* acts as a mode of resistance to Cuba's external enemies (such as the U.S.), supporting the Cuban Revolutionary value of people working together in solidarity to resist neoliberal capitalism [58]. In SNET, the term *resolver* combines with a notion of natural "inventiveness," as participants work with what they have to maintain and care for a network suited to their local context.

4 METHODS

4.1 Data Collection and Analysis

Our data comes from fieldwork conducted by Michaelanne in Havana, Cuba, across three phases: April 2016, July-August 2016, and June-July 2017. During this time, she conducted in-depth, semi-structured interviews with 46 individuals—15 identified as females and 31 identified as males—ranging in age from 18-65 (see Table 1). She relied on referrals from contacts made during previous fieldwork and used purposeful, snowball sampling to recruit participants who referred her to additional contacts [67]. She interviewed individuals who had been part of the original creation

Node	Participants	Roles
AguaNet	4 females, 6 males	1 switch operator, 5 users, 4 family members
CentroNet	1 female, 3 males	1 subnode representative, 1 user, 2 family members
CorteNet	2 females, 2 males	1 subnode representative & switch operator, 2 users, 1 family member
CumpleNet	3 females, 4 males	1 subnode representative, 2 users, 4 family members
GamerNet	2 females, 2 males	4 users
LinkNet	3 males	1 game admin & switch operator, 2 users
SurNet	3 females, 12 males	1 admin, 1 informal admin & online moderator, 2 switch operators, 6 users, 5 family members

Table 1. Participants and Corresponding Nodes and Roles

of SNET as well as users who joined the network as recently as 2017. She also spoke with users' family members and neighbors who were involved in helping maintain the equipment.

Interviews were conducted in Spanish at a location of the participants' choosing and lasted from 30 to 90 minutes. During interviews, she asked participants about their experiences with SNET, their motivations, the activities they engage with, and the perceived impact on their daily lives and relationships. She also asked about the work of maintaining the physical and digital infrastructure, and how social norms and moderation interact with their use of the network. Additionally, she conducted participant observation among seven different nodes located in neighborhoods across Havana, the majority of which occurred in three of nodes: SurNet, CumpleNet, and LinkNet. She often met with participants in their homes, observing and participating in SNET-related activities. Interviews were conducted individually and in groups. Due to the ongoing nature of the fieldwork, the majority of group interviews also involved individual, follow-up interviews with participants. During fieldwork, Michaelanne wrote extensive fieldnotes. Our data also comes from online, follow-up interviews with seven participants throughout 2016 to 2019, which allowed us to gain a more holistic picture of participants' experiences over time. We were only able to conduct online, follow-up interviews with this small group because the majority of our participants do not have regular access to the internet.

After Michaelanne's fieldwork trips in 2016, she conducted thematic analysis on the interview and observation data [8, 11]. After conferring with the other authors and discussing emergent themes, she returned to Havana to conduct additional fieldwork in June and July 2017. She then coded all of the data iteratively over several months. The data continually surfaced themes of M&C and, therefore, she focused analysis on the ongoing strategies, actions, and motivations underscoring these practices. All authors discussed the codes and themes throughout this process, bringing diverse combinations of expertise in qualitative methodologies, CSCW, and Information Communication Technologies and Development (ICTD) research. . In the findings section that follows, we include data in the form of quotes from interviews supplemented with empirical data from fieldnotes and participant observation.

4.2 Ethical Considerations and the Role of the Researcher

Michaelanne is an ethnographer of Cuban descent and has been conducting ongoing research in Havana since 2014. David is an ethnographer who has studied diverse resource-constrained communities in Brazil and Cuba. Neha is an ethnographer with experience in social media and internet access research in the Global South. Amy contributes her expertise in studying sociotechnical systems for social computing.

Michaelanne's research in Havana initially focused on the WWW but, due to continued requests from participants, she began to focus on SNET. During initial, exploratory interviews with SNET users, participants communicated a desire for people outside of Cuba to know about SNET. Throughout fieldwork, Michaelanne regularly spoke with participants about her findings and themes that

had surfaced. Upon the publication of this paper, we have plans to translate it into Spanish and share it with our participants. In order to represent the lived realities of our participants, we include multiple quotes in their own words. These quotes are supplemented by the Michaelanne's fieldnotes and analysis, recognizing that researchers must grapple with power imbalances, as well as their own subjectivities [57] in the presentation of their work.

The research team thoroughly discussed potential risks to participants from conducting and publishing this work, especially since SNET is not officially sanctioned by the government and could be considered illegal. Participants assured us that the Cuban government is aware of SNET and has not attempted to disrupt it. SNET occupies a legal "gray" area along with other unofficial networks in Cuba (like El Paquete Semanal [22]). In addition to recent academic work [59], SNET has received international media attention [14, 24, 48], with members of the network appearing on camera or in photographs [24]. We consulted with participants regarding the threat to them and the network from the publication of this data. None of our participants objected to the publication of this study; in fact, the majority encouraged us to publish findings to bring awareness to the network they have created. To further protect participants, our consent form cautioned individuals to avoid topics they deemed controversial. Further, in accordance with our Institutional Review Board (IRB) protocol, we waived the documentation of consent. We anonymized all data in this paper and use pseudonyms for participants, nodes, and neighborhoods to further protect participants' privacy.

5 FINDINGS

We begin by offering a rich description of SNET, laying out its organizational structure, the roles of human actors, the purpose of the network, and the conditions contributing to regular breakdowns within the network. We then describe specific instances of M&C practices through a focus on the ongoing configurations of four material elements of the network—cables, switches, nanos, and servers. Next, we unpack the collective strategies that have evolved in anticipation of regular breakdowns. We conclude with user motivations for engaging in regular M&C efforts. Throughout, we highlight the relational nature of M&C work, attending to the ways that people individually and collectively care for the material elements as well as each other, and both the tensions and opportunities that emerge.

5.1 What is SNET?

SNET is composed of nine core nodes, or *pillars*, connected to each other through fixed wireless links. Each pillar connects tens of individual nodes through long-range directional WiFi and each node brings in up to 200 users [59]. Individuals connect to local nodes through Ethernet cables connected to the house of a nearby user who manages a local switch. Each of the nine pillars have names ending in "net," like WiFiNet or MonsterNet. It is difficult to estimate the total number of users since there is no central database of users and groups of people often share one registered IP address. Rough estimates put the number of connected computers between 10 and 50,000 [40].

5.1.1 The Evolution of the Gaming Network. In Havana in the mid 2000s, groups of friends began to meet in their homes to play video games, a practice more commonly known as local area network (LAN) parties [79]. The majority of these games were played on old, refurbished desktop computers that had to be transported from one house to another. Due to this labor-intensive process and the desire to play from home, people began experimenting with ways to connect computers among neighbors by stringing cables through windows, across balconies, and over rooftops. In a neighborhood south of the city center, Yordani, one of the informal admins of SurNet, began setting up a small network in 2002 at the age of 15.

Fig. 1. Cables across the streets of Havana (©Michaelanne Dye)

> *"I first threw a cable from my house to my friend's so we could game. Everyone said, you're crazy, that can't be done. Then, my neighbor next door said: I want it too. And so I was joining everyone's wires until this started to form. In order to create this we had to make a thousand inventions."*—Yordani (M, 32)

Yordani experimented with copper wires, insulated cables, metal rods, and other found materials to build his own antenna. Although some SNET users have more technical knowledge due to education or vocation, most were unaware of how to set up, maintain, or repair the material elements of a CN. Many learned how to build their network by asking friends, tinkering with equipment, and reaching out to people outside of Cuba. After being connected to several neighbors for a few years, Yordani and Mateo, who is now the current admin of SurNet, decided it was time to connect to a larger node. To do so, they had to find a way to extend their signal via WiFi.

> *"At first, we were lost in terms of WiFi and we figured it out on our own, testing how to go online, how to configure everything. We would ask someone who had internet at work, 'find this information for me, see what the server's manual says, how we should do it, because this is new to us.' They would tell us something but it wouldn't work. We had to keep asking and experimenting until we were able to build the nodes."*—Mateo (M, 43)

As local nodes began to form, users searched for used equipment from businesses or the grey market, including computers, servers, cables, antennas, routers, and switches, in order to expand

Role	Responsibility
Generals	Manage one of the nine backbone pillars. Have final approval of the general rules. Manage the main servers hosting digital content. Approve new web pages.
Admins	Manage node, connected subnodes, node representatives, informal admins, & users. Manage technical infrastructure, assign IP addresses to new users, & monitor user bandwidth. Host content on local servers. Often share duties with informal admins who are not formally recognized by the generals.
Subnode Representatives	Represent users at meetings. Manage equipment connecting the subnode to a main node.
Online Admins	Manage SNET webpages.
Online Moderators	Moderate content & activity on webpages in coordination with online admins.
Users	Manage their own equipment. Some also manage a switch in their home that connects nearby users to the local node.

Table 2. Roles on SNET

the network. Participants emphasized the independent, ad hoc manner in which they learned how to configure their equipment without relying on formal services.

5.1.2 Developing Roles and Rules. Around 2011, groups of nodes began developing processes for cooperatively maintaining their growing networks [59]. Since many nodes on SNET formed independently of one another, each area had to negotiate to determine who would be responsible for various tasks of their network. The governance structure evolved over time with each region deciding on roles and responsibilities among themselves.

> "By the time we grew to 200 [people], we had to find a form of administration... we had a meeting with 150 people in which 10 stood out. Now [at higher-level meetings], those leaders represent our area and vote on our behalf." —Mateo (M, 43)

Roles on SNET are determined by an individual's physical location in the network, when they joined, the type of equipment they have access to, technical knowledge, a willingness to undertake the work involved, and, for more formal roles, authorization from an admin. We have divided SNET roles into six categories (see Table 2); however, these roles often overlap, particularly since users are responsible for both the digital and technical infrastructure of the network.

The ability to join SNET is determined by several factors, including geographic location, social connections, and the ability to acquire and maintain the technical equipment. People must find a current user close to them who will allow them to physically connect to the network. Additionally, aspiring users must find an admin who is able to assign an IP address, which serves as their account. Admins have a limited number of IP addresses they are able to distribute to new users. Whenever admins give out an IP address to a new user, they are responsible for that user.

As nodes grew and interconnected, they often developed their own rules, which were reached by consensus among local admins and representatives. Once 30-40 people were connected to him, Yordani said, "*we had to create regulations to avoid problems, to maintain the infrastructure in case things were broken.*" Once the nine pillars were formed, the generals established the general rules of SNET along with penalties for rule violators, which include being banned from specific sites or being disconnected from SNET entirely from a period of an hour up to permanent bans for serious offenses. Although nodes can choose whether or not to follow the general rules of SNET, if they go against the general rules, admins or generals may decide to cut off that node's connection to SNET. Similar to other community-run information networks in Cuba (like *El Paquete Semanal*

[22]), SNET has adopted strict policies banning content the government might deem controversial, including politics, religion, and pornography.

> *"Normally it's like that everywhere in Cuba, they don't let you talk about political issues anywhere. There may be times that someone on SNET says something they shouldn't, and admins sanction them, even to the point of banning them. They don't do it because they want to, but to avoid reprisal. There is no forum for politics or anything like that. Almost all are about culture, to make and share memes and things like that."*—Enrique (M, 23)

Enrique's quote is indicative of broader cultural sentiments regarding a stated disinterest in politics [21]). Instead of viewing the need for self-censorship as limiting, some participants said this contributed to a friendlier environment. For example, Alejandro, a user from SurNet, said, "*you feel like entering in a good place because there is a strict discipline. Everyone respects each other. I have never had an offensive discussion in the four years I've been a member.*"

SNET also prohibits nodes from connecting the network to the WWW to avoid appearing as if they are in competition with the government-run telecommunications company, ETECSA. As a result, all digital content is uploaded from pirated copies or designed and maintained by users and hosted on local servers. Therefore, in addition to building the physical infrastructure, users had to learn how to build the digital network, as Antonio explained, "*We're not programmers. We didn't know how to make web pages, so we had to ask around and tinker a lot.*" As more users joined SNET, it evolved from a gaming network to a thriving "*mini-internet,*" with digital sites and services mirroring websites on the WWW. Each pillar hosts its own portal, which includes *TeamSpeak*, a chat forum for communicating among users. Additionally, users have designed websites that host community forums, social networking sites (SNS), dating services, classifieds, and content production communities. There are also sites that host copies of websites from the WWW, such as Wikipedia and Revolico, a Cuban Craigslist. A few users have WWW access in workplaces and will upload content from the WWW to SNET. In addition to content, people also share the latest software and operating systems.

5.2 Maintaining and Caring for SNET Equipment

> *"Maybe you have a technical service you can call to help with repairs. We don't. We put in technology and maybe it works one day, but the next day it's broken. So you have to learn how to fix it yourself."*—Idania (F, 26)

While the social, informational, and gaming aspects attract users to the network, we encountered a system where the majority of users' participation involves maintaining both material and social elements. One of SNET's rules is that each user is in charge of their own infrastructure, which includes acquiring and maintaining the equipment needed to connect to the network. In this section, we unpack participation on SNET through the M&C required to manage four material elements—cables, switches, nanos, and servers. Throughout, we illuminate the ongoing, innovative sociotechnical maintenance and care practices contributing to the sustenance of this network.

5.2.1 Cables. When seeking out participants to interview, people often told us to "follow the cables," noting that these artifacts would lead us to SNET users. The visible qualities of cables (mainly their colors) cause them to stand out against the often gray concrete landscapes. Although media outside of Cuba have described SNET as an "underground" network [24], cables strung across buildings, roofs, and streets lead to an increased visibility of users. Ethernet cables serve several purposes in SNET beyond the transmission of data; their material qualities impact the participation of other actors in the network in several ways. As Yordani said, "*We have to do things this way because it's a cable network, one user depends on another. If your cable breaks, everyone who is connected through you is affected.*"

Since cables have been designed for indoor use, they are particularly prone to break when placed outside, causing frequent disconnections from the network. In addition to the inconvenience of being disconnected, repairing or replacing cables involves re-enrolling nearby neighbors as peripheral participants in the network. Often, users must convince people who are not a part of SNET to allow them to run cables over roofs, across balconies, and through houses. When cables break, users need to access other people's property to repair or replace cables, which may involve extra negotiations. During fieldwork, we met individuals that wanted to be members of SNET but could not convince their neighbors to let them run cables through their homes.

Although cables are cheaper and easier to find than other equipment, the work of restoring the connection due to breakdowns can be difficult, especially if other equipment is affected. During a particularly rainy season, one of the cables on Ricardo's roof got a hole in it, causing water to run through the cable, into his apartment, and onto his computer console, damaging his computer and short-circuiting his setup. Ricardo was the connection point for two other users, who were also disconnected from SNET until Ricardo could repair his equipment. Luckily, a computer engineer from Ricardo's work assisted in salvaging and selling undamaged parts and purchasing a new console, a process that required several weeks.

The reliance on cables and people maintaining them often generates extra work for admins, particularly when users do not manage their equipment carefully. On an evening in 2016, Michaelanne accompanied Mateo on his nightly stroll as he checked on his users and their equipment.

> *"I like to make sure everything is going OK and solve little repairs before they get worse. The other day a user called, 'hey, a bus went by and cut my cable.' It's really a pain in the neck. I go over there right away to fix that cable because it's an important connection. But sometimes a user who isn't a major connection point says, 'Hey, the cable split,' and they don't know how to install the network connector. Over here we don't know anything about IT, you know, cables, computers. And I say, 'just a minute, give me a little time, I'll go over to your place after I have dinner.'"*—Mateo (M, 43)

Although some blamed breakdowns on mismanagement of equipment, there were other unpredictable factors that contributed to breakdowns, including equipment theft, wires being chewed by animals, or run over by vehicles. Mateo helps most of his users with repairs, but this involves additional work. As such, Mateo must prioritize the types of repairs he makes and when, negotiating between time available, users' technical capabilities, and the severity of the breakdown.

5.2.2 Switches. Switches[3] are equipment that connect multiple individuals to the rest of the network. Miguel and Carlos are next-door neighbors who live in adjacent, bottom-floor apartments close to the city center. Six months after connecting to their local SNET node, LinkNet, a lightning storm "fried" their switch. Several months later, the two found a nearby neighbor, Jonny, who also had a broken switch preventing him from connecting. Carlos and Miguel paid to fix the switch, and Jonny agreed to let them connect to SNET through him. However, Jonny moved the newly-repaired switch to the house of the user ahead of him in the network, replacing the switch that connected Carlos and Miguel to him with an older one. This increased Jonny's connection speed, while causing Carlos and Miguel's connection to lag, making it practically impossible to connect.

The two contacted their local admin, who held a meeting and decided that their money would be returned to purchase a new device. Miguel went through the work to find a switch for sale and the neighbors reconnected to SNET for a few days until being disconnected again. They went to talk with Jonny who told them their switch model was slowing the entire network. Miguel exchanged the switch again for a brand new one, however, Jonny said that their new switch was

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[3]Participants used the term "switch" to include both switches and routers.

not compatible with his equipment. Their local admin suggested all parties meet again to resolve the issue however, Miguel and Carlos did not want to risk losing more time and money. They also had the feeling that they were unwanted in the network.

> *"It seems that it was not convenient for those higher up in the hierarchy that we were there, because we were not like other long-time users that they had listen to. We did not suit them and in the end we stayed out, well, we were kicked out."*—Carlos (M, 28)

Carlos and Miguel were newer users and did not carry as much social influence as others and, therefore, Jonny did not risk as much by excluding them from the network. On SNET, there is no formal rule regarding moving a switch from one house to another, or trading out a switch to prioritize one's connection. However, there is the social norm of talking with the users who will be affected, or seeking permission from an admin. According to Miguel and Carlos, Jonny was able to make this decision without consequences because of his social connections and by blaming the problem on the technical failure of the switch. According to Miguel, *"I lost interest in connecting. You depend on many people ahead of you and if they don't want you to connect, then you're out."*

Despite these complications, in August 2017, both Miguel and Carlos were trying to re-connect to SNET through a neighbor a few blocks away, but had yet to find a way to manage the data loss that would occur from the length of cable required. Both said they would continue trying different solutions to reconnect. "*We make do with what we have,*" Carlos said, "*this is how things are in Cuba. Maybe one day we'll have access to the internet. But I don't see that happening anytime soon.*"

Since switches connect many users to SNET, the M&C process is highly collaborative. We spoke to several users who described issues with switches breaking down or users not properly caring for the equipment. Some were more successful than Carlos and Miguel in negotiating new management configurations among their nodes. In a small node within AguaNet, Edel, a young switch operator, was not managing the equipment properly according to the users who connected through him. In this case, the users did not go speak to an admin. Instead, they spoke directly to Edel (who was also their friend) and convinced him to let them move the switch to another user's house. One user, Yaritza, described the change as "*a mutiny*" but said, now, their connection is better maintained and Edel does not have to do the extra work required to manage the switch.

5.2.3 Nanos. Wired nodes require wireless bridges (or access points) to connect to nearby nodes, pieces of equipment that connect two wired nodes through a WiFi signal. Participants referred to wireless bridges as "nanos," short for NanoStation, a popular wireless bridge model. Similar to cables, nanos are prone to weather damage when placed outside.

> *"We need to use what we can find. We Cubans are natural inventors. We use plastic containers to create houses for our nanos, that are normally used inside a house, to protect them. We have to constantly work at it. Our main node's nano got fucked up by a lightning bolt. So, we had a meeting with all the users and negotiated a price that each node would pay based on the number of people to buy another device. There is a lot of unity in the network, because if one is affected, everyone is affected."* —Antonio (M, 29)

In addition to revealing creative practices required in M&C, breakdowns reveal the deeply relational nature of such practices. As CumpleNet's subnode representative, Antonio is committed to caring for his neighborhood's connection to SNET. To do so, Antonio must cooperate with others, including his parents and grandmother, who help him maintain the equipment when he is away from home. Additionally, Antonio has to rely on people outside of Cuba. When he is unable to figure out how to repair a piece of equipment, Antonio travels to a WiFi hotspot and emails one of his friends in the U.S. asking him to Google potential solutions and email them to Antonio.

In some cases, the work undertaken during breakdowns creates stronger social relationships, or as Antonio said, "unity" due to the entangled web of relations within the network, but it also creates additional work. During a humid evening in July 2017, Michaelanne was waiting to meet up with Mateo, the admin of SurNet, during one of their regular meetings. Arriving two hours late, Mateo pulled up to his apartment on a motorcycle with two boxes of equipment strapped to the seat. After apologizing for being late, he explained:

> *"I have to repair everything. The other day, the nano that connects us to a main node broke. I went over there, took down the nano and saw it was damaged. I had to get on Revolico on SNET. I called a man across town that had a repaired nano. We bought it, brought it here, put it together and it worked. But I wasted all day on that."*—Mateo (M, 43)

Managing technical breakdowns can be an arduous process. Throughout our fieldwork, Mateo mentioned that his work on SNET had created tensions within his marriage since he was dedicating so much time to it. While admins undertake much of the M&C work required to manage SNET, users also undergo a lot of effort to join and stay connected to the network. For example, Idiani and her brother, Jasiel, live in a neighborhood on the northeastern border of Havana. Both are active players of DOTA and initially connected to their local node, CorteNet, in 2016, by running a cable from their house to their next-door neighbor's, who managed the local nano. Convincing the neighbor to let them join was easy; however, they way he managed his equipment caused Idiani and Jasiel to frequently lose their connection:

> *"It appears this man didn't know much about technology. He fried his nano once in a storm and, after, he would turn off all his equipment and the rest of us neighbors were left without a connection for hours many times."*—Idiani (F, 26)

Fearing equipment failure due to thunderstorms, Idiani's neighbor regularly disconnected his equipment, which, in turn, disconnected the users who were connected through him. Idiani reported the situation to one of her good friends who happened to be a node admin in the area. Within a few days, the admin met with the neighbor and decided to move the nano to Idiani's house. She now manages the nano along with the connection of 12 other users, including the former nano operator. Idiani said the neighbor accepted this change, adding, "*I do a much better job of taking care of the connection. We have technical issues sometimes but I don't disconnect the equipment unless I have to. Now I can play DOTA with fewer interruptions.*"

5.2.4 Servers. Servers are important pieces of equipment within SNET for information storage and for monitoring the activity of users, particularly in relation to bandwidth usage, which is a crucial due to the material limitations of the network.[4] Yordani explained, "*I configured [the server] to let me know when someone exceeds their traffic limit. When the bandwidth is saturated, that user gets automatically disconnected for a day.*" SNET is composed of reused and repurposed materials, which have to be carefully and artfully maintained.

> *"They are very old machines. These ports are no longer manufactured. . . For us to assemble this equipment we have to look for old plates, but these plates tend to be damaged because the manufacturers make them to last 5 years, no more, otherwise the capitalists would not survive. . . the one I have is 13 years-old and it has finally given out."*—Yordani (M, 32)

Changing material forms make technologies more difficult to repair [62] and, "corporate values in repair impact local repair worlds" ([31]:8). In Havana, people anticipated items breaking, partially because they believed technology had been designed to be replaced. One evening in July 2017, Yordani had pieces of his server spread across the kitchen floor. Yordani described how he works to make equipment last longer than it was designed to, emphasizing that Cubans have the skill of

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[4]See section 5.3.1 for an in depth description of the management of bandwidth.

repairing and reusing broken things. Due to this breakdown, Yordani had monitor user activity manually: "*it's really annoying to do it this way because it's time I'm spending. My time.*" He explained maintaining SNET is like a second, full-time job, leading him to enroll the help of his spouse, Daylin, and other SNET users to help him collaboratively repair breakdowns. Daylin, a veterinarian, said, "*at first, I didn't know anything but I learned how maintain computers to help Yordani. Now, I know a bit of everything.*" Daylin described proudly how she learned to repair equipment and became interested in joining SNET, as a result. Even with the help of Daylin and others, Yordani said he is unable to do all the work himself and, for that, he relies on Mateo.

> "*The day Mateo leaves, I won't have time for this because every five minutes someone will need help. The work he does, I can't do it. There are people who don't want to be an admin, because it's a lot of work. But in the end it has tremendous power.*"—Yordani (M, 32)

Yordani's quote is indicative of the ambiguous, seemingly contradictory nature of M&C practices. In the case of admins, although they have "tremendous power," as Yordani describes, these benefits are also accompanied by a large amount of (unpaid) work. Therefore, while certain positions in SNET have more power and privileges, they also involve increased negotiations between a variety of people and materials and, according to Yordani, the increased work often overrides the benefits of these positions.

5.3 Anticipating Breakdowns

Due to regular breakdowns and the ongoing M&C work required, users have developed organizational strategies based on local conditions in an attempt to minimize breakdowns and subsequent work, three of which we describe in this section.

5.3.1 The Copy Schedule. As more users joined SNET, the network became overloaded, often making it difficult to connect. In response, nodes began implementing a "copy[5] schedule," rules dictating when particular activities are permissible.

> "*The main objective is the game. That's why there are times to do certain activities. The game schedule is most of the time, from noon to 2 or 3 am. You can't copy then because that has to go through a main node. It slows down the network and those who play would be affected.*"—Madelin (F, 20)

Highlighting the network's leisure-based principles, the copy schedule prioritizes gaming during peak hours. Users are only allowed to download and upload content from the hours of 2 a.m. - noon (during which time gaming is prohibited). As opposed to other CNs that extol network neutrality as a virtue [2, 61], due to the technical limitations of the network, SNET users actively prioritize certain digital engagements over others. Node admins, like Yordani, are responsible for monitoring uploads and downloads, ensuring users adhere to the schedule to prevent network disruptions. Julio, a user from CentroNet, explained, "*Those who manage servers have the power. If they detect you copying out of schedule, they may prohibit you for a day or longer.*" Indeed, the ownership and location of the servers did imbue those who managed them with a form of power, while also increasing the maintenance work required to manage and repair the equipment.

> "*Nobody wants to be an admin; it's a job for pleasure, not for money. Everyone wants to have the big A [on chat], from some points of view that's very important. An admin has advantages that a user does not have. For example, with admin permission I can do what I want, without limits. I can copy outside the schedule.*"—Yordani (M, 32)

On chat forums, admins are designated by a red "A" next to their username, a feature Yordani refers to as a sign of privilege In addition to preventing network breakdowns, the schedule serves as a

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[5]The term "copy" refers to uploading or downloading multimedia content.

small reward for admins, permitting them to upload and download multimedia content at all times of day. Although the schedule has assisted in managing bandwidth to a degree, as more users join, it does not always adequately prevent network breakdown. As a result, some admins have limited the number of new users they accept into their node for fear of overloading the servers.

5.3.2 "When There is Rain…There is No Network". Due to its tropical climate and location in the Caribbean Sea, Cuba is prone to regular thunderstorms and hurricanes (especially during the rainy season from April-October). Michaelanne conducted her fieldwork during the rainy season, which provided insights into the ways participants and the network interact with the weather. She observed users repeatedly collecting cables and routers so they would not be damaged during storms. Once a storm passed, participants had to redistribute and connect equipment to reestablish their connection. Participants often spoke about the weather as an active agent in the network, describing it as an "enemy" of SNET users. Although we never saw it in formal rules, participants said users have agreed to suspend activities during storms due to the disruptive nature of the weather.

> *"One of the rules is when there is rain everything is disconnected and there is no network…it's a measure we take to protect the equipment. When I see that it's going to rain, I call my grandmother and tell her to disconnect my equipment."*—Yaritza (F, 26)

Participants adjust their activities to adapt to the unpredictability of the weather. This requires enrolling the assistance of people that are not members of the network. Yaritza, for example, has taught her grandmother how to disconnect her desktop computer, cables, and other related equipment when there is a storm and Yartiza is not at home. The weather, therefore, requires people to forge relationships with non-users in an attempt to prevent further breakdowns. Similarly, Enrique taught his mom, Gloria, how to disconnect his equipment during rainstorms. As a result of caring for Enrique's equipment, Gloria ended up becoming an active user.

> *"If this is so important that he calls me in a panic telling me to pull out the cables from the wall, I had to see for myself what it was all about. Now, there are days when I'm connected more than Enrique. It's great. Look at what they've built. I'm very proud."*—Gloria (F, 47)

We had similar conversations with other mothers, fathers, and grandparents of SNET users around the city whose children and grandchildren had taught them how to disconnect equipment to preserve the connection to the network. Despite precautions, inclement weather continues to jeopardize the technical infrastructure, especially due to users forgetting or not being able to disconnect their equipment when away from home.

5.3.3 Establishing a Tax. Before SurNet was connected to SNET, the admins held meetings each time a major piece of equipment was damaged, often collecting money from node representatives to replace equipment that could not be repaired. However, this process became laborious. When SurNet grew to 150 members, Mateo and Yordani realized they needed to be better prepared:

> *"Every time equipment broke we had to stop everything 15, 20, 30, days, either trying to fix it or find a replacement. We realized it's more feasible to have the money ready before equipment breaks. Then you don't have to go looking for it because it's impossible to find equipment…those things aren't sold in stores. So if it appears at a good price, we buy it and save it. And when lightning strikes or something breaks, I'm ready."*—Yordani (M, 32)

Mateo and Yordani met with representatives from each node who agreed to collect a monthly tax from users (about 1 CUC per month[6]) to sustain the network. In order to avoid SNET appearing like a business (which would make the network illegal), the regulations state that users cannot profit

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[6]1 CUC = 1 U.S. Dollar. The average salary in Cuba is 25 USD/month [54].

from the network. Yordani maintains a website tracking the funds collected and what they are used for, facilitating transparency and trust within his node, as users are able to see that their financial contributions assist in sustaining their network and that Yordani is not profiting from it. In 2017, the generals adjusted SNET's rules, requiring each user to pay a tax so that the network could be better managed overall. It took several months for Yordani and Mateo to reach an agreement with their general, who wanted to hold all the money SurNet collected so whenever new equipment was needed, Mateo or Yordani would have to request the money.

> "Now I can't say I won't pay because it's in the regulation and they'll disconnect me. But we achieved an agreement … we only have to give them 10% of what we collect. Almost nothing. There are places that give 100%. With [the admins] we've always gotten along well, except for that point: the money. The truth is we don't want to be disconnected. But it bothers me that I've created all this and another comes and controls it."—Yordani (M, 32)

We found other instances of tensions resulting from implementation of the tax, including users that complained about SNET becoming a business. The decentralized, ad-hoc structure of SNET has led to different norms across nodes, revealing diverse values and ways of managing the network.

5.4 Motivations Underpinning Maintenance and Care

Participants are motivated to undertake M&C work for a variety of reasons, the first of which is the gaming aspect. SNET grew out of a desire to play digital games and the regulation maintains that "the game" is the ultimate purpose of the network. Participants described the ability to play games from their home as a luxury.

> "I don't want to sit on the curb in the heat paying lots of money for slow internet. It's disgraceful. To connect on SNET at home, that's amazing, you know? It's a change from what we had before. There are issues but really, it's fantastic. We've done good work despite hassles. Imagine, we're just regular people and look what we've built."—Ronaldo (M, 27)

Ronaldo is referring to the WiFi hotspots opened by the Cuban government in 2015 [23]. Participants said they preferred using SNET because the hotspots were laborious, expensive, and too slow to meaningfully engage with the internet. To that end, participants turn to SNET to be able to use social networking sites, download music and movies, and search for information.

> "This is the only way for us to get closer to the internet, which everyone wants. There are those who have internet access and put things on pages [in SNET]. Then we all eat from there, so to speak."—Jasiel (M, 23)

In addition to facilitating access to content from the WWW, SNET provides an avenue for people to create and share content, similar to other informal networks in Cuba, like El Paquete Semanal [22]. Yamirka, a user from CentroNet, described SNET as, "*an alternative media platform within the Cuban space,*" highlighting how, increasingly, people are inserting original content into SNET. However, unlike El Paquete, SNET facilitates valuable real-time interaction with content and users. Simultaneously, participants said SNET did not quite measure up to having full access to the WWW. Yamirka described SNET as *"a fake internet because it gives you a false illusion that you're connected and you can see everything."* However, participants regularly compared SNET to the WWW, often describing services and sites in terms of popular online platforms, like Enrique, who said SNET, "*is like Facebook, but with less people.*" While he enjoys downloading music and playing games, SNET also provides access to academic content and collaboration with other students.

> "In Cuba, students are at a disadvantage because we don't have access to the internet like you do. On SNET, I can get material from my buddies who live across town. I also find information for projects on the forums."—Enrique (M, 23)

SNET provides access to information, education resources, and classifieds. Antonio refurbishes old cars and, through SNET, he is able to purchase parts directly from home, saving him time and money. However, Michaelanne often tried to connect to SNET with Antonio but, many times, either specific pages or the entire the network was inaccessible. Even if he is not able to get on SNET Antonio said, "*I still care for the equipment because I'm caring for everyone's connection. I do it out of goodwill, I guess. It's part of being a good neighbor...of being a good friend.*"

In addition to helping others care for equipment, participants spoke of the importance of social connections made through SNET. While the network fosters online communities, community groups on SNET host in-person meet-ups throughout the year.

> "*The most important thing about SNET is the relationship between all users. It's like a family. At the events, I meet people I've known for years on SNET but never in person. It was as if we'd known each other our whole lives.*"—Alejandro (M, 65)

Although users experience periods of disconnection from the virtual community due to continual breakdowns, they maintain contact with others by going to in-person events, which serve to reinforce their membership. Although SNET has thousands of users, the majority of the population in Havana is not connected. However, participants described M&C work as a way to increase access to a type of internet in Havana, from which many can benefit. In fact, participants said there have been discussions with the Cuban government about making SNET legal.

> "*There's talk of how to legalize [SNET]...The day they legalize it, it will be more flexible. We won't have to take so much care with what's said because the job of enforcing the rules will be on the government. This is a country where the control of all information has to be on the government...that's how things are managed.*"—Yordani (M, 32)

Many spoke with skepticism regarding both the legalization of SNET and whether widespread, in-home internet access would ever be achieved in their lifetime. Until then, participants said they would have to keep experimenting, fixing, and collaborating.

> "*We all have to sacrifice and cooperate with everybody—it's all or nothing. We all use it and depend on certain equipment. After so many problems and so much work, to just quit all of a sudden? No, when you've come so far, you can't go back.*"—Mateo (M, 43)

Although Mateo described M&C as arduous, he also said this work motivates his continued engagement with SNET. The desire for internet and the cooperative engagement required continue to feed into a system that must be made and remade by thousands of volunteers, providing an innovative, adaptive mini-internet particularly suited to Havana's local context.

6 DISCUSSION

Through an investigation of the management and anticipation of breakdowns in SNET, our work foregrounds the ongoing, collective efforts required for SNET's maintenance and care (M&C), and the values and motivations underpinning these practices. In this section, we unpack the contributions of our findings for repair, CNs, and CSCW literature respectively. First, we describe how the case of SNET surfaces the inherently relational elements of M&C practices. We then turn our attention to CN literature, describing how our findings contribute a richer understanding of the qualities and outcomes of CNs through an attention to M&C practices. Finally, we contribute to CSCW work focusing on repair practices as innovation through a discussion of cultural perspectives and tensions underpinning the M&C practices in this network and the subsequent problematic elements embedded in the framing of these practices as "innovative."

6.1 Relational Repair in a Broken World

In 2012, Jackson et al. proposed a thought experiment for CSCW, asking researchers to imagine a recessionary informatics through broken-world thinking, focusing on the ways communities "organize to sustain, manage, re-purpose, or simply live with what they have" ([37]:1). Building on their work, we contribute to prior repair literature through a case that surfaces the deeply relational nature of M&C practices, which we consider to be repair practices that are inherently collaborative and encompass both material and social elements that simultaneously facilitate and necessitate repair. SNET attunes us to the informal, collaborative, temporal, and ambiguous nature of M&C practices, underscoring how the relational nature of repair practices are so dependent on personal relationships that the relationships themselves need iterative repair as much as the material infrastructure people collaborate to maintain.

Specifically, attending to the relational elements of M&C practices underscores their informality; that is, M&C work in SNET is conducted outside of traditional repair spaces and among people who are not professional repairers. While work has begun to attend to more informal, distributed repair practices, such as the favelas of Vitoria, Brazil [56], there is usually a centralized form of repair support (such as the LAN houses in the case of Vitoria). In contrast, participants in SNET have had to learn to repair on their own without the assistance of professional repairers or centralized methods of support. Further, due to restricted WWW access, participants are not able to Google solutions directly and instead have to rely on people in and out of Cuba to troubleshoot solutions on their behalf (like Antonio described).

As a result of the decentralized and informal nature of these practices, M&C work in SNET is dependent collaboration among people with whom participants have a personal relationship. Due to the economic, political, and material context of SNET, M&C requires a reliance on relations within the family, the local community, and social connections outside of Cuba. Simultaneously, since collaboration is required, these continual repair practices also surface tensions and power dynamics among social relationships, which, in turn, require the continual maintenance and repair of social relationships in order to sustain the wider network. Therefore, M&C encompasses both material and social repair practices that simultaneously facilitate and necessitate repair.

An attention to the relational aspects of repair work surfaces how M&C practices emerge in these ways because participants have to contend with temporal, situated, and cyclical non-human elements, such as weather patterns, which have become intricately connected to the maintenance infrastructure of SNET. Participants regularly spoke about how the weather was "an enemy" of SNET users, thereby assigning agency to an element of nature due to its disruptive capability. In fact, one of the reasons that repair practices are deeply relational is due to the unpredictable, temporal, and situated elements of the weather. This has resulted in the rule of "when it rains, there is no network," and the subsequent training of family members to assist users in adhering to this rule. In SNET, participants not only contend with material elements and other users, they must also regularly consider actors that have traditionally been considered to be "outside" CNs, such as the weather and non-users (family members, neighbors, and contacts outside of Cuba whom they must rely on to acquire resources). The relational nature of M&C practices orients us to the blurring boundaries within networks and between material and digital elements.

We see how participation in SNET is situated, as participants artfully move through their communities with a knowledge of who and where to turn to in order to piece together the social and material support required to sustain the network. However, this also orients us to the fragility of the network and these practices. In addition to the fragility of material elements contributing to disconnections and tensions, the relational nature of M&C practices also attunes us to the fragility of social relations. For example, in the case of Miguel and Carlos, they were ultimately disconnected

from SNET due to a breakdown in their relationship with Johnny. While prior repair literature has encouraged us to consider how our world is much more unstable than we realize [34], in the case of SNET, we encounter a system where participants are inherently aware of the fragility of the social and physical infrastructures, challenging previous perceptions regarding the (in)visibility of infrastructures. In their work among Brazilian favelas, Nemer and Chirumamilla question what forms of difference a backdrop of legal informality and persistent precarity lends to the notion of "infrastructure" [56]. The authors ask, if not always functional, if not steadily reliable, how do infrastructural objects and systems gain meaning in people's everyday lives and practices? Through this case of relational M&C, we suggest that the visibility and precarity of infrastructures facilitate moments of collective agency and community solidarity as users must contend with the fragility of infrastructures in artful, creative ways.

At the same time, these practices surface tensions, which orient us to the ambiguous sentiments that accompany M&C practices as participants grapple with feelings that are seemingly contradictory. M&C practices encompass pride and collective agency, while also contending with the reported stress and frustration resulting from participants' perceptions that they *must* be innovative and collaborative in this way because they have no other choice. Through a focus on the relational nature of M&C practices within a network where materials are regularly breaking down, we reframe perceptions of participation in CNs while also complicating traditional notions of technical innovation. In the sections that follow, we further unpack how this orientation to M&C practices contributes to prior work among CNs as well as CSCW literature focused on innovation through repair.

6.2 Community Networks in a Broken World

In this section, we contribute to CN scholarship through an attention to the relational nature of M&C operating in a broken world, thereby complicating prior assumptions around the affordances of CNs. First, we highlight the role of leisure as a driving force in shaping M&C practices in SNET. Second, we illuminate how M&C practices draw on and shape community ties, while also fostering tensions. Finally, we discuss power entanglements that caution us against indulging in romanticizing the local nature of CNs.

Emergent ICTD research has emphasized the role of aspirations in shaping technology adoption and use [44, 77], and prior work has also highlighted the importance of non-instrumental gains that individuals and communities derive from technology use [41]. We confirm these findings for CNs throughout our study, where we found that participants were motivated to undertake M&C practices out of a desire for gaming, like with the copy schedule. A common challenge among CNs is to motivate people to find value in CNs, and educating users to maintain the equipment [38, 60, 73]. We argue that these efforts might be more successful if they prioritized non-instrumental uses of CNs that align with the aspirations of their users. We agree with Nemer's argument for paying attention to non-instrumental technology use in his study of social media use in Brazilian favelas [55]. Being in greater alignment with users' desired outcomes is also likely to result in sustained engagement around the CN in question.

Our findings highlight how SNET is maintained through collaborative acts of care. Moments of breakdown reinforced the reliance on social connections, revealing how SNET depended on shared values of collaboration, cooperation, and interpersonal support [76]. Not all actors engaged in M&C practices were equipped with technical knowledge. For example, parents and grandparents regularly disconnect equipment during storms because they cared about SNET users, namely their children and grandchildren. Care contributes to ideas of responsibility and commitment, motivating individuals to undertake M&C practices in the assistance of others, like Antonio who maintains his neighborhood connection because it is *"part of being a good friend."*

Breakdowns in SNET were not only material, they were also social, complicating our perception of positive community outcomes resulting from CN engagements. As Heuts and Mol discuss, tensions may arise as tomato farmers choose among taste, appearance, and feel in their valuation of tomatoes [30]. In SNET too, participants must choose ways of caring, like Mateo, who tries to balance the time available, the level of repair required, and the importance of the breakdown. As a result of these decisions, certain people are disconnected for longer periods or completely, as in the case of Miguel and Carlos. CN scholarship has advocated for formalized management guidelines to ensure sustainability, fair treatment, and scalability [2]. While M&C practices practices were not standardized, building clear guidelines into when and how people must care diminishes their autonomy to make locally appropriate decisions. As recommended in prior scholarship on invisible work [10, 68], making these interactions more visible or standardized may jeopardize what makes these acts of care so successful.

Examining M&C practices also complicates egalitarian notions of decentralized, sociotechnical infrastructures, surfacing power tensions embedded within engagements [34]. Although SNET facilitates access to digital services where it would otherwise not exist, moments of breakdown also highlight tensions from varying positions of power—from neighbors who can prohibit users from stringing cables through their balconies to admins whose management styles impact the experience of others. Mohan and Stokke have discussed, for such cases, the tendency to romanticize "the local," thereby downplaying social inequalities and power relations that our study brought to light [51]. Although CNs have been said to facilitate more inclusive access [20, 47], our findings demonstrate how certain users have been excluded from the network. Further, SNET is not widely available to people in Havana due to many reasons—cost of equipment, distance from the nearest node, limited router slots and IP addresses, as well as unwillingness by some admins to connect new users.

Not only are there power structures at play within the network, there are power structures acting upon it as well. Prior work describes user autonomy as a distinctive feature of CNs, emphasizing a commitment to free speech and resistance to surveillance and repression [2, 20, 50]. Although some CNs may seek to enable individuals to challenge preexisting power structures [15], SNET members actively avoid challenging the Cuban government by banning activity that may be considered subversive, thereby sacrificing user autonomy for network autonomy. Due to the labor involved, participants did not view network autonomy positively; instead, they would much rather have the government assist in these endeavors. Similar to instrumental arguments for technology use, overly positivist framing of CNs as "sites of grassroots mobilisation and resistance" ([51]:263) risks ignoring power asymmetries entangled in these networks, as well as participants' desire to have more assistance from formal structures in the maintenance of this system.

In sum, our study of SNET—a CN in operation without external intervention—highlights that there are several benefits that CNs afford for communities that are unconnected or under-connected. However, there are also tensions that surfaced, suggesting factors that might be considered in CN-based interventions. First, interventions should prioritize users' desired outcomes over instrumentally driven designs. Second, if researchers and practitioners wish to encourage more participation and community-ownership among appropriators, this must be accompanied by a careful attention to the increased labor and potential power imbalances, which may not be as visible without a focused attention on the ongoing M&C work required to sustain such systems.

6.3 The Broken World as a Site of (Necessary) Innovation

Throughout our fieldwork, we heard the colloquial phrase, *"If necessity is the mother of invention, Fidel Castro is the father."* Attending to the relational nature of M&C practices problematizes previous scholarly efforts to "legitimize" repair practices through an innovation frame. While researchers have advocated for a consideration of repair practices as innovative [17, 34, 74], Lucy

Suchman draws our attention to the ways that, "projects to reclaim creativity, invention and the like might themselves be reproductive of a specific, cultural, and historical preoccupation with these particular values" ([72]:1690). Suchman encourages us to question the value placed on innovation itself, asking, "must those not presently identified as creative be shown in fact to be inventors in order to be fully recognized?" ([72]:1690). In this section, we unpack some of the tensions that our work surfaces in regards to the framing and consideration of participants' practices as innovative. In solidarity with our participants, who were eager to describe their work as innovative, we simultaneously highlight the innovative elements of repair practices as defined by participants, while also questioning dominant perspectives of innovation that reinforce a universalist, progressive framing of sociotechnical engagements, as well as questioning the value placed on the term "innovation."

Our focus on M&C reveals innovative practices—supported by participants who regularly spoke of themselves as inventors, making do with the materials they had to rework social and technical configurations. For example, there was Antonio, who built "houses" to protect his nanos, or Yordani, who configured his server to notify him when users had violated the copy schedule. In her study on Facebook use in India, Kumar highlighted how socioeconomically disadvantaged youth operated within a culture of *jugaad*, "innovative and improvised solutions that arise as workarounds or shortcuts in response to the scarcity of resources" ([43]:4). Our participants spoke analogously of Cubans as natural inventors, showcasing a culture of *resolver*, or making do in the face of breakdowns, limited equipment, and exclusion from internet access. Bandura argues, "among the mechanisms of personal agency, none is more central or pervasive than people's beliefs about their capabilities to exercise control over events that affect their lives" ([4]:1175). Engaging in M&C reinforced participants' confidence in their own abilities, as they exercised agency at an individual and collective level to drive innovative, experimental practices.

Crucially, however, through an attention to M&C practices that necessitate collaboration and innovation, we also attend to the ambiguous and problematic elements entangled in these practices (as well as the problematic elements entangled with a framing of such practices as innovative). Anthropologist Ravinder Kaur argues, "*jugaad* stories function as ideology; they renarrate the creativity of the poor as promises and hope and mobility despite inequality"([39]:315 quoted in [32].) We envision a similarly problematic trajectory for M&C practices and cultural ideologies of making do if attached to traditional perspectives of innovation, whereby "the poor" are not only able, but expected, to work hard in order to improve their circumstances. While M&C practices in SNET imply creativity and agency, they are also intimately linked to the need to *luchar* (struggle).

Sandvig's work with Digital Tribal Village (DTV) in Native American lands demonstrates how participants downplayed technological innovations that made DTV appear different from traditional internet access models [64]. They aspired to create a network that was as close to the internet as possible because they wanted equal opportunities to internet access. Sandvig described this as appropriation towards parity: "you will design a system that is as different as it has to be so that you can be the same" ([64]:192). Our participants also regularly valorized elements of SNET that mirrored the WWW, such as social networking sites that looked like Facebook. Unlike Sandvig's participants, SNET members did not downplay their innovations. Instead, they spoke about their contributions with ambivalence. Participants simultaneously expressed awe and wonder in their accomplishments alongside frustration and discouragement, saying their achievements reminded them how they lacked affordable and useful access to the WWW. Currently, WiFi hotspots in Havana are slow, expensive, and limited to a few public spaces [23], a model of internet access that some, like Ronaldo, described as "disgraceful." Participants expressed beliefs that, in countries outside of Cuba, internet access was pervasive, affordable, and easily maintained, and that they had to undertake M&C work in this way because "*this is how things are in Cuba.*"

Glamorizing M&C work as innovation runs the risk of fetishizing and othering individuals in these communities, ignoring the conditions that necessitate these practices and the accompanying feelings of neglect and exclusion. As Sandvig cautions, "there is a danger in cherishing the adaptability of the oppressed, who must adapt by necessity because they have no other choice" ([64]:193). Relatedly, Nemer and Chirumamilla uncover how repair practices in Brazilian favelas demonstrate ingenuity and creativity, while also foregrounding the systemic instability and wider exclusion of individuals in this community [56]. Our research participants aspired to be able to choose their access to the WWW, instead of having to participate with SNET because there was no alternative. Discourses around innovation have been located within capitalist notions of linear progress, preoccupied with "speculative extraction of future economic value" ([16]:694). In contrast, M&C practices are locally situated in worlds of shifting tensions, where breakdowns, not progress, are considered the norm [53]. M&C practices also operate within hegemonic structures that reinforce narratives of a "need" for WWW access in order to "catch up" to the rest of the world while, at the same time, limiting the ways in which participants are able to engage in ways they find meaningful. For example, Yordani said that the technology he uses has been designed by capitalists in order to break down. The fact that participants felt that they could only approximate a version of the internet (instead of having widespread access to the WWW) reinforced the notions that they must make do with what they have, accepting that the internet produced, while novel and inventive, does not truly encompass everything they desire. At the same time as people describe their work as innovative, they also were keen to remind us of the structural limitations within which they move and operate. These structural limitations recursively reinforce the ingenuity and resourcefulness of Cubans.

In sum, ongoing tinkering, experimentation, and collaboration enable the sustenance of a network that provides a form of internet for thousands of people. However, lest we romanticize the M&C work required, we also note how, in addition to accepting breakdowns as normal, our participants considered this work to be arduous—like Miguel and Carlos, who spent months trying to reconnect to SNET, or Antonio, who said he has to constantly work on SNET due to continuous breakdowns. Further, although users emphasized the collaborative nature of the network, they also recognized the power tensions within it, and their feelings of exclusion from the WWW. Among participants, feelings of pride in collective and innovative M&C practices exist in tandem with feelings of frustration and even sadness. Incorporating innovative but necessary practices into perspectives of repair runs the risk of putting the onus on individuals to "make do" with what they have, thereby avoiding a critique of the national and global structures of power that impact the way that people move towards leading lives they have reason to value. While we join with others in advocating for more CSCW work attending to local practices across a variety of communities, we also question the value of labeling these practices as "innovative" and advocate for more attention to be paid to the ways that participants themselves derive meaning and value from their practices, instead of advocating for their importance because "we" (researchers) label them as innovative.

7 CONCLUSION

This paper presents an investigation of the management and anticipation of breakdowns in SNET—a community network in the city of Havana, Cuba. We highlight how, through maintenance and care (M&C), Cuban citizens have appropriated, built, and reworked technologies to develop a network uniquely suited to their context, while also grappling with tensions arising from these ongoing efforts. Our findings foreground the inherently relational nature of M&C work and the resulting technological innovations as participants care for multiple sociomaterial elements of the network, as well as the underlying values that motivate these engagements. By adopting a broken-world perspective [34, 37], we uncover the opportunities and conflicts present in a sociotechnical system that must be made and remade on a regular basis. All infrastructures contain inherent vulnerabilities

that require continuous maintenance, which often remains invisible [28, 68]. Similarly, SNET is maintained within a delicate balance as individuals negotiate between multiple elements, however, these practices are highly participatory and visible. This visibility and precarity fosters community solidarity as people contend with infrastructural fragility in creative ways. Understanding SNET expands our sense of what is possible and at what cost it is achieved. Perhaps more importantly, we see patterns that are more broadly applicable, surfacing how the kinds of situated, relational M&C practices we see in SNET happen in a variety of ways across all sociotechnical communities.

8 ACKNOWLEDGEMENTS

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