Alternative Models of Connectivity: Reclaiming Networked Spaces

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ALTERNATIVE MODELS OF CONNECTIVITY: RECLAIMING NETWORKED SPACES

A Thesis
Presented to
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by
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ABSTRACT

Alternative networking is a growing field of study and practice due to advancements in computer networking hardware, and software protocols. Methods of integrating alternative networking configurations into infrastructure present enhanced forms of empowerment and embodiment for participants. Through an analysis of multiple hardware and software examples, this research suggests that practices of sharing and collaboration, which are embedded in the history of computer networking, have the potential to reinvigorate the notion of a virtual public sphere, and support the ideals of digital democracy.
ACKNOWLEDGEMENTS

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INTRODUCTION

The State of the Internet

The advent of computer networking brought with it promises of solutions and conveniences to work in favor of humanity, but it also introduced previously unfathomed problems and complications. Technology theorist Benjamin Bratton, channeling French philosopher Paul Virilio states, “the invention of any new technology is also the invention of a new kind of accident.”¹ The Internet, a product of many minds building upon the inventions of older minds, has been characterized as both a panacea and an instrument of oppression.² But, like any tool, it is only as effective as the human beings who wield it. There have been many hardware and software innovations used to create information networks that enhance and compliment the Internet. This research suggests that these alternative networking techniques have the power to promote digital democracy through challenging incumbent access providers by fostering community engagement and redefining our relationship with infrastructure.

In today’s techno-political climate, the Internet has been tamed by agents powerful enough to control one or more aspects of its utility. These include government


agencies and technology firms, who work together and against one another in a bid to claim maximum influence over the network. Technology firms create suites of products, that provide useful services to users, but also entrap them in walled gardens characterized by inoperability between providers. While these services are often offered to the user free of cost, these institutions collect data from the users by storing and analyzing communication and search history. This data is used to classify users into marketing demographics, which is sold to media buyers who target them with directed advertising. The government also has operations in place that amass and catalogue enormous amounts of data on citizen behavior online, including phone records and email communications. The most notable and far-reaching of these operations is the NSA’s PRISM program, which was revealed to the public by former NSA contractor Edward Snowden in June 2013. The Snowden revelations brought these actions into the public eye, but to many it reinforced what was already suspected; that the US government was performing surveillance operations on its citizens and worldwide. Yet, despite the disclosure of the PRISM program, true reform has yet to take place. Collective outrage has not led to mobilization against the NSA’s policies, and many Internet users in America and worldwide have been provided with ineffective means to protect their privacy.

For others, these privacy issues are not a priority, for network access is out of reach to them due to economic disparities stemming from unequal deployment of networks by Internet service providers (ISPs), and lack of technological competency. What is known as the digital divide affects a certain segment of our country, and it is
amplified along trends consistent with social and economic inequality. Members of lower socio-economic classes as well as minorities are disproportionally affected by the technology gap.

There are issues surrounding the political importance of network connectivity that fall prey to bipartisan disagreement and hegemonic sway. The influence of mass media on the population, as described by communications theorist and author Marshall McLuhan, has transferred to the Internet in tandem with its rise to cultural popularity. McLuhan suggests that the content of media is a distraction from its effects. Media is constructed to subtly make people self-identity in binary sides of agreement or disagreement with issues, eschewing discourse for what Susan Herbst has termed “numbered voices.” Mass media is vessel for ideology, and consolidation of viewpoints into organizations such as the Associated Press, presenting a limited viewpoint into policies and issues that are shaped by the biases of an elite. In *The Whole World is Watching*, Todd Gitlin outlines three defining characteristics of mass media that position it as a “core system for the distribution of ideology,” pervasiveness, accessibility, and centralized symbolic capacity. The latter of which, is defined by the uniformity of the messages we receive from the media. In the field of communications networking,


consolidation of access providers and content producers is a trend that continues to move forward, stripping autonomy and agency from their potential as a democratizing force.

This paper begins by examining the prehistory of the Internet, some of the notable innovations which spurred its development, and the sharing principles that defined it early on. The philosophy of openness and accessibility that motivated early technology visionaries created a cultural movement of free and open source software that persists to this day, and has been one of the strongest contributors of innovation to the field of computer networking.

The paper then examines the concept of digital democracy and the idea of Internet citizenship. The sharing practices, which underline many networking projects, have given way to a political understanding of the Internet’s effect on society and social responsibility. As the Internet developed into a major cultural tool, disparities have emerged, illuminating its inextricable ties to issues facing society at large. The research also examines some instances of using technology as a political tool, and the outcomes, both positive and negative, of its use in this capacity.

The research continues by discussing the relationship between network, infrastructure, and embodiment, highlighting developments such as wireless networking that contributed to a major shift in mobility and how networks contribute to the way we locate ourselves in space using technology. Activist movements surrounding the impact of networking on the environment and society are examined. Through the work of theorists such as Benjamin Bratton and Adrian Mackenzie, the model of the Internet stack is applied on a larger scale illuminating connections between ourselves and the planet with respect to the emergent networked world in a process which Bratton has labeled
“planetary-scale computation”. Bratton’s example of the Black Stack demonstrates the cause and effect scenario that computer networking exhibits on a massive scale.

Chapter 3 introduces the concept of alternative models of connectivity. The research first defines the traditional model of connectivity as commercial Internet access using a “last mile” Internet service provider, such as Comcast or Time Warner Cable. This model is problematic because it trades a level of convenience for freedom of access. As ISPs further consolidate, they shape the perception that adhering to this model is the only option for individuals to utilize networking technology, contributing to an impoverished view of the potential applications of communications networking. In a 2014 interview, Isaac Wilder, the co-founder of the Free Network Foundation, an organization committed to promoting alternative models of connectivity, astutely points out that when we talking about the Internet, we’re really talking about two elements that are independent. “We're combining a discreet, material collection of 45,000–odd autonomous communication systems, with the body of protocols and specifications, which allowed those networks to inter-operate… It's the networks and it's the protocols.” This distinction is important because the protocols, the written codes that govern computer networking processes, are in an intellectual commons, and are free to be used by anyone. Alternative models of connectivity can strive to alleviate some of the

7 Metahaven, “The Cloud, the State, and the Stack.”


9 TALtech, “A Brief Overview of TCP/IP Communications | TALtech,” accessed April 30, 2015,
undesirable conditions outlined in the previous chapters by innovating new ways to connect people, relying less on restrictive commercial models. Alternative networking projects can lead to community engagement, and in that vein they support digital democracy. The possible ways in which alternative networks operate are detailed here, as well as focus on some practical examples.

Chapter 4 examines a selected group of real-world use cases that have employed alternative networking techniques. All over the world there are many groups working towards providing new networking possibilities to the public, often under grassroots beginnings. Large scale initiatives, such as Catalina, Spain’s Guifi network are analyzed, as well as more localized projects such as Red Hook Wireless in Brooklyn, New York.

**A History of Networking**

In the 1960’s when the United States was deeply involved in the Cold War with the Soviet Union, researchers were considering the problem of the centralized communications infrastructure that was prevalent at the time. Due to the nature of the centralized model, communication hubs were at risk of being incapacitated by an enemy attack. At the time, telecommunications were achieved by routing a message through a central location, and then to its intended destination. The government exercised its authority through a protocol referred to as “command and control.” In this fashion, instructions could be sent from authority figures to the routing location, and then disseminated to their target. The inherent danger of this type of implementation is that, if

the routing location becomes destroyed or disabled, communications fail, and the network falls apart. The consideration is that this would lead to a catastrophic failure of the government’s ability to exercise command and control during wartime. As the threat of nuclear war was very high, the effects of dismantling the communications infrastructure of our country would be devastating, because it would lead to the lack of tactical options in the event of nuclear war. The centralized model of networking was demonstrated to be insufficient due to this Achilles heel, and so the concept of “survivable communications” was born.

A researcher named Paul Baran, working for the RAND Corporation, a military think-tank in the United States, introduced a new networking model that could overcome the major defect presented by centralization. Baran described a communications network where each node was connected to its nearest neighbors. This system, known as a distributed network, could withstand an attack on some of its nodes, while maintaining functional connectivity within the graph. Figure 1.1 shows Baran’s diagram of the three most common network types. His research on survivable communications was motivated by the belief that maintaining command and control would decrease the chances of retaliatory action caused by a disruption of communications.
The United States even published Baran’s work openly so the Soviet Union could benefit as well, and retain command and control of their own country. It was feared that miscommunication and misunderstanding between the two nations could be an unintentional catalyst to starting war; therefore, sharing this information was understood to be in the best interest of both sides. In 2001, Wired magazine featured an interview by Stewart Brand with Paul Baran where they discussed sharing the paper. “We published it! I gave a course on it at the University of Michigan in '65. We were a hell of a lot better
off if the Soviets had a better command and control system. Their command and control system was even worse than ours.”

Initially his peers at the research center deemed Baran’s network configuration as unfeasible, but he also developed a protocol for routing data in this manner, which he deemed “hot potato routing.” This protocol would evolve into a method called packet switching that would become one of the most important foundations of the Internet. Packet switching involves compartmentalizing data into smaller pieces, or packets, consisting of 1024 bits. Each packet contains header information that includes address, and sequencing information, which is used to reassemble the data in the correct order at its destination. Figure 1.2 is a model of a sample packet with a header and payload.

The Advanced Research Projects Agency (ARPA) included the process of packet switching into its ARPANET project, a direct predecessor of the Internet. Engineers at ARPA were seeking to find ways to network the various computer systems used by universities and research institutions across the country. One of the challenges faced by ARPANET was to discover a universal method for connection between the many different types of computer hardware that were used. This initiative eventually led to the development of communications strategy known as layering. In Inventing the Internet Janet Abbate describes this process as “dividing complex networking tasks into modular

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12 Janet Abbate, Inventing the Internet (MIT Press, 2000), 18
Layering is represented as a hierarchal model, where functions are passed top down between each layer before being transmitted across the network to a receiving node, where information is then passed bottom to top. This would become known as the network stack, and along with packet switching, become an elementary unit of the Internet. The stack model, and some of its evolutions and appropriations are discussed in further detail in Chapter 3.

The principles of packet switching and the network stack, along with several other important developments, led to the distributed structure of the Internet, which was most evident during its nascent years in the 1990’s. The indiscriminate nature of packet switching laid the foundations for the general ethos of openness that prevailed early on. In the 1970’s, a team called the Network Working Group (NWG) was looking for ways to invite discourse among various teams of researchers and engineers contributing to the ARPANET. They began distributing meeting minutes, and other documentation via Request for Comments papers. This invited deliberation and collaboration, and was a successful means to achieve consensus on policies. This practice of sharing and

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13 Ibid.

14 Ibid., 74
openness would continue to be an essential principle as ARPANET evolved and the 
Internet emerged.

**Free and Open Source Software**

The Request for Comments papers could be looked at as a predecessor to the Free 
and Open Source Software (FOSS) movement that emerged in the 1980’s. Usenet was an 
early discussion community that provided a space for computer enthusiasts to post 
messages and articles. As a result of its popularity, Usenet is considered to be a major 
catalyst for the FOSS movement, because of the ease with which people could share code 
across the network. In 1983, Richard Stallman, founder of the Free Software 
Foundation introduced the GNU General Public License (GPL), which outlined a set of 
standards to be followed by creators of free software. It is worth noting that “free” in this 
context refers to the freedom of distribution and modification of the software, rather than 
free of cost. One of the stipulations of the GPL declares that derivative works must 
inherit the same licensing conditions applied to the parent. This has occasionally caused 
tensions amid the FOSS community when corporations incorporate free software into 
their commercial offerings and charge for them.

15 Joseph Feller, Brian Fitzgerald, and Scott A. Hissam, *Perspectives on Free and Open 
Source Software* (MIT Press, 2007)., 51


17 Eingestellt von Florian Mueller, “FOSS Patents: More Evidence of Google’s Habit of 
GPL Laundering in Android: The BlueZ Bluetooth Stack and the ext4 File System,”
The GPL was a major influence on the early Internet community, and helped create a policy of sharing among programmers and tech enthusiasts. This openness was responsible for many of the services that developed much later, “such as Amazon.com, Google, and eBay, as well as… communication applications such as VoIP, BitTorrent, and other P2P services.”¹⁸ Open software more specifically refers to making the source code available for anyone to read and modify at will. The ideology behind this encourages collaboration and sharing to achieve the best quality output.

One very successful example of this was the Apache web server project. Apache is FOSS software that is used in 57.8% of all websites as of April 2015.¹⁹ Apache is a webserver, which means that it processes HTTP requests (the basic means of data communication on the web). Apache communicates on the application layer of the protocol stack, passing data one layer down to the transport layer.

At the risk of over simplifying, web servers are the engine that drives websites on the Internet, and Apache has been the market leader every year since its introduction in 1996.²⁰ As a FOSS project, Apache was developed by volunteers, many of whom had day jobs and could only spare a little time to work on it.²¹ Despite this, the project group used

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²⁰ Feller, Fitzgerald, and Hissam, *Perspectives on Free and Open Source Software*, 166

²¹ Ibid., 164
collaborative management styles and self-regulation to delegate workloads to volunteers. Apache’s role in the formation of the Internet as we know it today cannot be overstated. In 2005, Apache’s market share was as much as 70% of websites.\textsuperscript{22} The decline in use is also attributed to the open source nature of the project, for newer technologies such as Nginx, and offerings by Google and Microsoft were built on the knowledge and code presented by Apache.

\textbf{Ascension of the Big Five}

While openness as an ideology still drives many individuals and groups who develop Internet technology, the rise of a handful of tech giants has passed powerful elements of ownership and control to a few governing bodies. The most notable of these corporations are part of a group referred to as the Big Five. They include Apple, Microsoft, Google, Amazon, and Facebook, as seen in Figure 1.3.\textsuperscript{23}

As a result, these corporations have been driven through competition to strengthen and protect their brand and exert control over the way individuals use the Internet. The strategy employed by these technology firms is to develop products that engage users with their tech ecosystem, and promote reliance on their services. Many of these companies operate in unique but overlapping realms. They each have a notable strength, but compete upon a common ground: the commercial technology landscape. By

\textsuperscript{22} Ibid.

encapsulating their users, these companies are able to shape user behavior and them to their specific product.

One of the most notable examples of this is Apple’s iTunes store. Debuting in 2001 the iTunes store provided a convenient way for consumers to purchase music. However Apple implemented DRM, or digital rights management software, which bound the files to users devices. Users who purchased music were not allowed to share their libraries, or play them on unauthorized devices.\(^{24}\)

<table>
<thead>
<tr>
<th>Company</th>
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<th>Total Cash(^a)</th>
<th>Unique Users*</th>
<th>Engagement/ Data*</th>
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<td>8</td>
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<tr>
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<tr>
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<td>$76.5B^#</td>
<td>NA</td>
<td>800M</td>
<td>9</td>
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Source: Battellemedia.com

\(^a\)Sum of “cash and cash equivalents” and “investments” or “securities” from company 10-Q, most recent quarter

\(^#\)Post estimate, 12/6/11

\(^\)data from 2011 Web 2 Summit “The Data Frame” map, compiled from various industry sources. http://map.web2summit.com/

Figure 0.3: The Big Five and their worth

The most popular website in the world is Google.com.25 At its heart Google is a search engine, and as such it is the de facto gateway to the Internet for the majority of users. The third most popular website is the video service YouTube.com, which happens to be owned by Google. YouTube claims its 1 billion monthly users upload more than 300 hours of video each minute.26

These figures show the enormous amount of influence that the tech giants command in populations around the globe.27 It is in the best interests of the tech giants, as well as other commercial and government forces to spin the narrative that the Internet is comprised of (and indeed, supported by) mainly their products. The consolidation of entertainment and communication avenues is impeding the masses from understanding the stake that we all have in control of the Internet’s future.

There is a concern that generations down the line will not be aware of the level of control that one can wield by utilizing this technology. Imagine a world where Tumblr is your only blog, YouTube your only way to share videos, Spotify your only means of accessing music, Facebook your only way to communicate with friends. These are all amazing products in their own right, supported by legions of talented engineers producing sophisticated user experiences. But as these companies refine their services, so

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27 So much so, that many people aren’t aware of the platforms they are using is part of the Internet at all. Leo Mirani, “Millions of Facebook Users Have No Idea They’re Using the Internet,” Quartz, February 9, 2015, http://qz.com/333313/milliiions-of-facebook-users-have-no-idea-theyre-using-the-internet/.
do they also seek to maximize profits at the expense of user-autonomy. They are the
culture-makers, and their purpose is to gain as much market share as possible. Just as the
telephone conglomerates slowly bought out the rural telephone collectives, these tech
corporations make efforts to hook the consumer.28

Invasive Marketing Tactics

Marketers are using network technology in new ways to identify potential
customers and collect behavioral data. One method for this is to ping shoppers’ phones as
they enter a retail store. Wireless devices have several unique identifiers such as a MAC
address that is broadcasted by the device when probing for Wi-Fi networks. A retailer can
implement software that catalogs these MAC addresses, assigning them to a specific user
profile. When that user enters the store, certain attributes are stored; such as how long
they were inside, where in the store they spending time, and when they last visited. See
Figure 1.4 for an example of these tracking beacons at work. This technology, sometimes
coupled with video surveillance equipment, can gain large amounts of behavioral data
about individuals and can be used to target them with more specific advertising
campaigns. The New York Times reported this activity when a popular retailer,
Nordstrom, posted signs notifying customers that they were being tracked.29 Many

28 Tim Wu, The Master Switch: The Rise and Fall of Information Empires (Alfred A.
Knopf, 2010).

29 Stephanie Clifford and Quentin Hardy, “Attention, Shoppers: Store Is Tracking Your
Cell,” The New York Times, July 14, 2013,
customers were upset, but retailers claim they are disadvantaged by the tracking capabilities available to online stores, and this is a means to catch up.

Figure 0.4: Example of Retail Tracking Beacons

A New York company called Nomi offers tracking technology to vendors, including MAC address identification. Nomi recently got in trouble for their practices due to presenting inadequate security tactics, and misleading customers about their opt-out policy.\(^3^0\) The FTC took Nomi to court to contest these practices. Nomi claimed that they randomized the MAC address of consumers so individuals wouldn’t be profiled, but

their encryption scheme simply produced new identification hashes that remained identifiable to individual shoppers. They also allowed users to upload their MAC address to the Nomi database blacklist to prevent tracking, however shoppers were never told they were being tracked, nor were they aware of which stores were engaging in this activity, so the courts deemed the policy as worthless. Fortunately, in a victory for consumers, the courts instructed Nomi to fix their misleading consumer protection policies, placed some restrictions on how to continue their operations under threat of $16,000 fines per each violation.

Apple recently introduced MAC randomizing for their iPhones in an effort to protect consumer privacy and security. In doing so, this could combat the practice of MAC tracking in a retail store, because the MAC identification would be encrypted directly from the device itself. This feature would appear to be another victory for consumer privacy, however an investigation by analytics company AirTight Wireless discovered that certain specific conditions must be in place for the randomizing to work properly on the phone. AirTight Wireless reports that the iPhone device cannot be connected to a wireless network, and must also be in sleep mode. Consumer privacy is a growing concern, and fortunately there seem to be efforts made to protect this by some groups. Yet, these protections sometimes come with strings attached, so it is important to

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31 Ibid.
32 Ibid.
analyze their effectiveness. While some of Apple’s recent security initiatives indicate an appreciation for customer rights, they can be misleading.

**Net Neutrality, politics and hegemony**

With the widespread adoption of the Internet in society, one of the things that is bound to occur is a myriad of opinions and misinterpretations of Internet policies and protocols. Public discourse on Internet policy and governance has privileged the view of powerful technology companies who have, through their use of lobbyists and corporate strategists, made significant contributions to the public imaginary. It could be argued that those who control the language surrounding these topics can shape public understanding of the issues; this has resulted in a struggle to define the terms and indeed the language of this debate between the large corporate actors and stakeholders with opposing views. Due to the complex and seemingly impenetrable nature of programming code and protocols, it is difficult to ensure fair and balanced understanding of the surrounding issues, particularly when interested parties make efforts to sway the dialogue in ways that support their interests.

At the forefront of this battlefield is the concept of net neutrality. This concept is one of the fundamental topics of contention between the commercial interests and tech community. The term was coined by Columbia Law School professor and media scholar Tim Wu in his 2003 paper *Network Neutrality, Broadband Discrimination.* In the paper Wu describes the concept of an open and neutral Internet, contrasting it with the

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increasing control of private interests. His opening statement is a prescient analysis of what, 12 years later, is still the hot button topic in the Internet debate. He writes, “communications regulators over the next decade will spend increasing time on conflicts between the privates interests of broadband providers and the public’s interest in a competitive innovation environment centered on the Internet.”\(^{35}\)

Wu’s main concern is that the short term interests of the cable companies which were, at the time, rapidly becoming the ubiquitous and near-sole proprietors of Internet access that we see today, would stifle the long term potentials of Internet technologies in favor of commercial gain.

Today the discussion over net neutrality has entered the public spotlight as a central issue of debate, but is often misconstrued or improperly defined. In politics, net neutrality carries associations that are tangential to the issues first brought up by Wu in his paper. The mainstream media has polarized the issue into two diametrically opposed ideologies, which conveniently fit into a left and right political narrative, whereas in reality the issue is more nuanced and crosses political divides. Since the FTC has begun operations to change the practices of major telecoms, pundits have appropriated the argument, using it as evidence of increased, unwanted government interference.

Two of the largest Internet providers in the country, Comcast and Time Warner Cable announced in 2014, to much fervor, plans for an impending merger. Because these two companies together served a large percentage of the United States Internet users, many Internet rights activists looked at this as the formation of a monopoly with negative

\(^{35}\) Ibid.
implications for consumers. Comcast had acquired the television content producer NBC Universal in 2013, and that deal was also criticized because of the resultant situation of corporate vertical integration. By owning a content producer and the means of distribution, opponents argued Comcast would have an unfair advantage in the market, see Figure 1.5 for a layout of all Comcast/NBC's media properties. With so many channels of distribution, Comcast has the ability to expose its ideologies to a vast number of people. Another concern was the possibility for Comcast to prioritize NBC content over their competitors on the Internet. This seemed to materialize when Comcast was accused of slowing down the streaming speeds of its competitor Netflix, an entertainment video service. The public seems to oppose their business practices, as Comcast regularly finds itself on the list for “most hated company in America.” In April 2015


proponents of net neutrality were pleased to discover that Comcast had terminated the merger due to low expectations of its possibility for approval by the FTC.\textsuperscript{40}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{comcast_nbc_media_properties.jpg}
\caption{Comcast/NBC media properties.}
\end{figure}

A common argument levied against net neutrality asks, “why do we need to change the Internet? It seems to work just fine to me.” However, cyber attacks are becoming more and more frequent, and are predicted only to grow in the future.\textsuperscript{41} Part of the reason for this is because the protocols and practices used, such as the centralized


DNS, the HTTP methods, and authentication procedures are too dated, and have not kept up with advancements in computational power, browser handling, and security updates, such as patches.
DIGITAL DEMOCRACY AND THE PUBLIC SPHERE

Digital Democracy

Digital democracy is the application of democratic ideals to the context of the Internet and other digital technologies. The concept of digital democracy is polarizing in the tech world due to several reasons. When the Internet was first gaining popularity, there were many who saw in it potential for the reinvigoration of the public sphere, and as a driver of social change. This led to a phase in which some scholars and activists predicted a utopian near-future that would herald a new age of equality. Over time this did not materialize to the extent that was hoped. As events unfolded optimism for the benefits of the Internet was eroded. The big five technology giants emerged and ascended to dominance, which was seen as a blow to the open source ethos. Worldwide protests over income inequality dubbed the Occupy movement was slowly stamped out, and a once promising social movement in the Middle East, the Arab Spring, was crushed by their totalitarian governments, despite the early success in part related to the public’s use of technology.42 As a result, a backlash occurred, producing skeptics who saw more realism in the view that the Internet was a more utilitarian product that was subject to the same flaws as other societal institutions that perpetuate inequality.

Regardless, the concept of digital democracy lingered, and in fact it is still a vibrant area of interest for academics. Culture on the Internet has many subsets, and

42 Morozov, The Net Delusion., 9
different camps or beliefs co-exist. It is widely believed by proponents, that encouraging practices of digital democracy can be effective in promoting a more egalitarian society. It is also been widely reported that tech inequality is an important and very real issue that follows similar trends of inequality in other aspects. For instance age, race, and social class are variables proven to have a correlation with technological literacy.  

The Public Sphere

Often, particularly in the nascent days of the network, the Internet was presented as an opportunity to reinvigorate the public sphere and provide a democratizing force that could be used to support civic discourse. Technology itself does not have any inherent agency towards producing social change, rather it presents itself as a tool to be used by human agents for that end. The capacity for using the Internet as a tool for the public sphere is also dependent on an individual’s access and competency with the technology. This suggests that people who have easy access and higher competency using the Internet are at an advantage in employing the technology for this purpose.

The goal of the public sphere is to provide a space for discourse among participants to enact policies that are determined to be in the interest of the public good. Participants in the discussion are ostensibly trying to seek a consensus over policies that can be most beneficial to the public. Due to the varying degrees of private opinion,

43 Mossberger, “Toward Digital Citizenship.”


45 Ibid.
achieving this could be in danger of an unbalanced consensus that privileges those who have the best resources to participate, and are the most vocal. Therefore it is understood that facilitating and encouraging access to the most people will produce more balanced results.

Additionally the means of access to the Internet, and applications of discourse upon it, are provided by corporations who control this technology. As such, the most power of influence falls onto them, further unbalancing the opinions that are produced. As Zizi Papacharisi illustrates her paper *The Internet, the Public Sphere, and Beyond*, this “produces discourse dominated by the objectives of advertising and public relations. Thus, the public sphere becomes a vehicle for capitalist hegemony and ideological reproduction.” Alternative networking techniques, such as community broadband, and localized private networks offer a potential solution to this by cutting out the owners of the means of access, and engaging community needs directly. Not only does this allow community consensus on network access and infrastructure development, but it also offers opportunities for community moderation and regulation.

As Papachirisi points out, via Susan Herbst, the media often portrays public opinion by the use of polls rather than the results of thorough discourse, leading to the “numbered voices” phenomenon, where respondents are aggregated into binary positions.

\[46\] Ibid.

on issues, tabulating these results into a majority vs. minority model.\textsuperscript{48} This is not only reductive, but by disseminating opinions in the manner, it reinforces the need for individuals to take sides rather than engage in critical thinking. Because of the ability of the Internet to muster large groups of people into discussion areas, the distillation of opinion into yes or no responses is a danger.\textsuperscript{49} This is another advantage alternative networking configurations can have over the highly connected Internet. Smaller networks can benefit by providing a higher level of recognition for individual voices, and thus producing more meaningful discussion, rather than the roll-call approach exhibited by massive public opinion polls.

The most important feature of a public sphere is the capacity for discourse over bipolar agreement. However due to some features of the Internet, particularly the relative anonymity of users, true discourse is difficult to produce. Scientific American reports that “lack of accountability, physical distance, and the medium of writing” itself are major contributing factors to the difficulty of constructive online discourse.\textsuperscript{50} Rudeness and aggressive behavior not only prevent critical discussion from taking place, they may also discourage other potential voices from participating.

Community built network infrastructure has the ability to bind people together due to the collaborative efforts in construction and maintenance, as well as through the

\textsuperscript{48} Herbst, \textit{Numbered Voices}.

\textsuperscript{49} Papacharissi, “The Virtual Sphere 2.0.”, 233

ultimate goal of inclusiveness they present. Such characteristics may help to alleviate the symptoms of inappropriate online behavior due to accountability and mutual goals. Also, when taking into account the proximity factor, and the varied distribution of beliefs and morals, a global public sphere may not be the most favorable objective for creating consensus, and in fact localizing discourse could produce more egalitarian outcomes.\textsuperscript{51}

Papacharissi classifies the challenges facing a virtual public sphere in to three distinct categories: access, reciprocity, and commercialization.\textsuperscript{52} Access refers to the ability to access the Internet, and the quality of service available to individuals. Reciprocity refers to the quality and authenticity of online discussion, including the level of participation. It also includes the ability for geographically and politically disparate parties to find terms of agreement. The global nature of the Internet connects people from all over the world who do not necessarily share the same values or desired outcomes of social policies. Commercialization refers to the influence of economically driven business entities upon the attitudes of public and the ability to incentivize behaviors that support the marketization of their product. These factors, it is argued, reduce the possibility of democratic outcomes from the utilization of the Internet as a virtual public sphere. Papacharissi’s definitions are supported by the consensus that there is no true public sphere online and seem to indicate that prospects are not hopeful. However her analysis is insufficient to preclude the possibility of the emergence of a public sphere due to the lack of investigation into network alternatives to the Internet. The developments

\textsuperscript{51} Papacharissi, “The Virtual Sphere 2.0.”, 235

\textsuperscript{52} Ibid.
outlined in this paper of emergent network alternatives counter these challenges and show promise of a reinvigorated notion of a virtual public sphere.

**Benefits and Shortcomings**

It is clear that traditional models of connectivity have a tendency to discriminate against groups of lower socio-economic status. Access to the Internet through ISPs comes at a cost that may be out of reach for some. Additionally, infrastructure owners do not typically provide services to geographic locations that are not profitable or sustainable to be deployed. Alternative models of connectivity such as community designed mesh networks can circumvent the need to force alignment with an ISP by amplifying and sharing a few access points to the larger community. Initiatives such as Guifi, and Red Hook Wireless, which will be examined in more detail later in this paper, find ways to mobilize neglected communities to implement their own network infrastructure to serve a much larger number of people. An added benefit of community run networks is that they have higher levels of engagement and provide bonding opportunities due to the collaboration involved.\(^{53}\) Mesh networks using Wi-Fi technology by design are better applied to higher population density areas because of the necessarily limited distance between nodes.\(^{54}\) But rural areas can benefit from alternative networking techniques such

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\(^{54}\) Mesh networks are decentralized; each node is able to communicate with every other neighboring node. Contrast with the centralized model of traditional networks, where each node connects to a single routing node.
as free space optical (FSO) communication. FSO networks most commonly utilize laser light or LED technology to create data links between distances of up to 3 km.\(^\text{55}\)

However, an interesting aspect of community-led network infrastructure is that it actually inverts the notion that they typically are produced in disadvantaged communities, thus actually catering to communities that have less than satisfactory Internet service.

Geographically separate communities hold different morals and may not be able to find consensus on social issues. This is a hindrance to the idea of a global public sphere, but perhaps that should not be considered as an ultimate goal for proponents of a virtual public sphere. If focused on a local or regional level, a virtual public sphere becomes much more viable. The Internet’s development into a planetary wide network has fostered perceptions that a global society is the final outcome of connectivity. But it is worth considering that regional politics could work from the ground up to contribute to more egalitarian behaviors among the world’s many cultures. Additionally, perceived anonymity has the tendency to contribute to less courteous conduct online. Again, community initiatives can combat this behavior because in smaller groups, individuals are more likely to be recognized, as well as be motivated to be supportive of members of their social circle. Federated social networking services such as Diaspora are designed to emphasize community participation, by allowing individuals to join smaller networks based on region or like-minded interests.\(^\text{56}\) While this can sometimes have the echo


\(^{56}\) On Diaspora, user data is located on decentralized servers spread out across the user base. These servers form individual networks (known as “pods,” in Diaspora) as opposed
chamber effect of reinforced ideals, self-moderation is more likely to occur in these scenarios, and cultivate more reasonable interaction between individuals.

Co-option of participatory spaces by corporations is an issue facing constructive discourse within networked spaces. There has been an increased popularity of native advertising, online where commercial interests attempt to situate advertising content within the context of the platform its targeting. For example online journals or blogs may feature advertising content that matches the aesthetic of the site it is featured on, masquerading as original research. In this manner advertisers attempt to influence the audience to support their product, without contributing to valid discussion. Networks that are deployed by communities working together have greater control over who is able to join, and can be more vigilant against unauthorized or unrequested input. Further, networks operating privately, isolated from the Internet are not vulnerable to unwanted encroachment by commercial entities.

**Digital Citizenship & Participation**

An important component of digital democracy is the idea of digital citizenship, which is the understanding that much of our civic responsibilities are now possible to engage in online. Nearly every governmental resource and service is accessible online. The types of activities that can be accomplished online include “filing taxes, applying for to Facebook, which stores user data centrally on their own servers. This helps alleviate user data tracking practices and allows for greater user control over the privacy and visibility of their profiles.

57 Mossberger, “Toward Digital Citizenship.”
permits, paying tickets or fines, requesting birth and death records, renewing driver’s licenses, registering to vote… or submitting complaints.”\(^{58}\) The Internet makes managing these services easier from an administrative standpoint, as well as partaking in them by citizens. Using this evidence Mossberger illustrates that political citizenship in society is positively correlated with practicing digital citizenship online.\(^{59}\) Yet, these duties are not exclusive to the Internet and can be accessed through other means. As such, Mossberger acknowledges that the accessibility of political services online may not solely be strong enough evidence to demonstrate the urgency of promoting digital citizenship in society. However, she presents research that shows a link between Internet access and increased civic participation by way of enabling access to political news sources, fostering political interest.\(^{60}\)

**Internet-centrism**

Author and media activist Robert McChesney identifies two viewpoints that inform the discussion over how the Internet contributes to digital democracy. He co-opts the terms “celebrants” and “skeptics” from Robin Mansell, to categorize the opposing ideologies.\(^{61}\) Within the Internet research community, academics tend to project opinions based in one or the other of these views, he argues. The celebrants champion the

\(^{58}\) Ibid.

\(^{59}\) Ibid.

\(^{60}\) Ibid.

\(^{61}\) Robert Waterman McChesney, *Digital Disconnect: How Capitalism Is Turning the Internet against Democracy*, 2013., 4
Internet’s potential for democratization and civic participation. They see the Internet as a technology which can serve the public interest and strengthen egalitarianism in society. Conversely, the skeptics view the Internet as a false promise, co-opted by governments and corporate firms to control and, at worst, oppress the public. Of course, as McChesney acknowledges, “there is no Berlin wall” between the two ideologies, and intelligent people should recognize truths on both sides of the discussion to form a more holistic opinion. However, it can be helpful to isolate and analyze theories that emerge from each side of the debate in order to extrapolate the concerns surrounding networked technology and perhaps to alleviate the conflict in some way. Taken alone, neither viewpoint adequately provides a resolution to the concerns, but by selecting relevant arguments, we can form a more useful larger picture of the network’s role in democracy.

The Internet-centric celebrants see the democratic force of the Internet as unstoppable, but tend to overlook the reality that access to the network itself and its services are controlled by a small group of actors who provide them at a cost. Ironically, a major contributor to the restrictive nature of the Internet is the general public’s lack of knowledge regarding how networks work. The tech firms employ the strategy of walled gardens to encapsulate users within their product line. Users tend to become vertically associated with services provided by a single corporation, thus making it difficult to defend against unfair practices such as price gouging, or terms of service modification. Alternatives exist, particularly through the work of the Free and Open Source Software movement.

FOSS products are a huge benefit to alternative networking possibilities, because they enable a variety of ready-made services to be applied, and they foster prolific
communities for discussion and instruction. Alternative networks can circumvent some of
the restrictions established by the major tech firms by utilizing FOSS products and
embracing their philosophy.

**Media and hegemony**

Traditional media, such as television and radio, has been characterized as one-to-
many broadcasting. This is because the audience is passive in their reception of the
messages disseminated over the medium. The audience doesn't have the opportunity to
respond, and simply digests the ideas. Because the structure of the Internet is
fundamentally decentralized, the one-to-many model is shifted, and back and forth
communication becomes possible. Each node has the ability to deliver and receive
messages. This provides a level of empowerment to participants, which has the potential
to disrupt the paradigm of direct broadcasting. However, with the consolidation of
corporate tech entities, the many-to-many becomes filtered into a few-to-many model.
For example, the merger of Comcast and NBC/Universal creates vertical integration of
the content production, delivery system, and network access that is dangerously close to
all encompassing.

Yet, computer networking remains a powerful medium, far more democratic than
traditional broadcasting. Alternative networking can challenge the restrictions that are
becoming apparent within the Internet. By providing a collaborative and open
infrastructure for communication that is constructed by participants from the bottom up,
networks can be designed with the needs of the community ahead of the demands of the
technology.
As unidirectional communication systems, newspaper, radio, and television have a much easier time of disseminating the ideology of the few, to the minds of the masses. Control of these technologies allows a small group to manage a larger group by dictating, either overtly or subconsciously, the codes and behaviors that are to be followed by the population. As Todd Gitlin writes, referencing political theorist Antonio Gramsci, those who rule the dominant institutions secure their power in large measure directly and indirectly, by impressing their definitions of the situation upon those they rule and, if not usurping the whole of ideological space, still limiting what is thought throughout the society.62

This applies to those who control the means of mass communication in a society as well. However, alternative networks, as a multi-function communication technology, can defy command by a single entity, dispensing power equally and without discrimination by placing the means of access in the hands of users.

**Iceland’s Kitchenware Revolution**

As a relatively nascent technology, the Internet has flirted with enacting real change in the sphere of social movements in several ways. Twitter, for example, was a powerful tool for mobilizing protesters during the series of political upheavals in the Middle East referred to as the Arab Spring in 2011. But to facilitate the non-violent restructuring of an ineffective and unpopular political system of a first world nation calls to attention the democratic power of network technology.

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62 Gitlin, *The Whole World Is Watching*., 10
One instance of a cultural shift powered by the democratic use of technology is the so-called “kitchenware revolution” of Iceland in 2009. Named so because protestors drummed upon pots and pans, and other such kitchenware to create a cacophony in front of the government buildings; see Figure 2.1 for an example of this. In 2008, the country of Iceland experienced a major financial crisis that affected their economic and political landscape. In fact, that year a number of nations of the world, including the United States and the United Kingdom, were also severely affected by the economic crash. What sets Iceland apart from these other incidents, is how rapidly they bounced back, and how drastically they shifted their political system subsequently. Manuel Castells writes of this revolution, “while provoked by the economic crisis, [it] was not only about restoring the economy. It was primarily about a fundamental transformation of the political system that was blamed for its incapacity to manage the crisis, and its subordination to the banks.”

The 2008 financial crisis brought the country to a halt. Sparked by widespread corruption stemming from the privatization of Iceland’s banks, the economic crash stirred a revolutionary air amongst the people. After a series of protests in 2008 and 2009, the Icelandic ruling class was forced out. The most dramatic development to come from Iceland’s political revolution was not the governmental changeover, but the level of civic participation that ensued. A previously unseen form of social collaboration was introduced, wherein the government actually turned to the people asking for input on the formation of a new constitution by way of online social media.

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63 Manuel Castells, Networks of Outrage and Hope: Social Movements in the Internet Age (Cambridge, UK; Malden, MA: Polity, 2012.), 31

64 Ibid., 38
In 2012, The Organization for Economic Co-operation and Development (OECD) ranked Iceland number two in the world, for highest percentage of households connected to the Internet, at 94.6%. This permeation of Internet literacy in Iceland proved to be integral in facilitating the collaboration amongst the population in creating the document that was to become Iceland’s national constitution.

A constitutional assembly counsel (CAC) was established, which then utilized several popular social tools on the web in order to create a dialogue with the people with three main directives. The world’s largest social networking website, Facebook, was the main platform on which discussion and debate was staged. For instant updates and direct

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interaction, the micro-blogging service Twitter was utilized. Lastly, to bridge the physical gap and bring events and personalities closer to the people, photos and videos were shared via official channels on the media content hosting sites Flickr, and YouTube. To have this level of public participation and collaboration is unprecedented. It is rare that a government would choose to reach deep into its base of citizenry to research and gauge the desires of its people. This may be one of the first real examples of the Internet as a cultural necessity in modern history.

Iceland’s example shows the ability of the Internet to subvert the ruling ideology of a culture in an unpredictable way. As evidenced by the continued disregard by bankers and politicians of the warning signs prior to the economic collapse, hegemonic powers will stop at nothing to maintain control over a population. However, channeled through the use of Internet technologies, and powered by a nationalistic bond, the counter-hegemony asserted by the Icelandic population overruled the failed practices of the elite. Iceland’s kitchenware revolution was spurred by a reaction to a major crisis, and this may be a contributing factor to its initial success.

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NETWORKED SPACE AND INFRASTRUCTURE

Situating Cyberspace

In order to better understand the role of networks in our culture, it may be helpful to consider where they are situated. Recognizing their location can provide insight into their significance and function. There are two values to consider when discussing networked space. The first is the material space, occupied by cables, antennas, and facilities devoted to housing and maintaining them. This is the infrastructural space, acting as a corporeal representation of networks. The second is the more intangible, meta-space, often referred to as cyberspace.67 This meta-space has its own rules of time and distance, which aren’t required to be in sync with reality. Content on the network, such as websites and apps, are hosted on servers located in the physical world, but due to the fact our senses cannot perceive the transfer of data at the speed which electrons travel through copper or fiber-optic cable, the illusion of instantaneous communication is fostered in our minds.

67 The term “cyberspace” was coined by Science Fiction author William Gibson in 1982. The United States Military has been using the term since at least 2006, when it instated a Cyber Command division of the US Strategic Command.
Networked Infrastructure

Traditionally, infrastructure has been relegated to the background, where even the intrusive support beams try to remain unseen. The structures and devices that work silently to take on society’s heavy workloads often have unintentional or hidden effects on culture. With regard to computer networking in particular, infrastructure can take the form of lengthy CAT-6 cables, large server rooms, and bulky Wi-Fi access points, to name a few examples.\(^6\) Despite the inherent physicality of these elements, designers and architects work hard to make them as unobtrusive as possible. Tucked within the walls, and strung above the ceiling, miles of Ethernet cables connect wall ports to repeaters and routers in any given office building. The act of hiding “offensive” infrastructure elements has been in practice for centuries for reasons of safety as well as aesthetics; exposing electrical wires in the home could have deadly consequences. The implications of this are that discussions surrounding the role of infrastructure and its cultural effects have been very limited. The seeming innocuousness of infrastructure has provided it with a respite from scrutiny.

The proliferation of Wi-Fi over the last decade has brought attention to the unforeseen implications of mobile computing. Adrian Mackenzie suggests that the cultural shifts afforded by Wi-Fi have placed computer-networking infrastructure in a more prominent position for analysis,

the different practices, motifs, and performances of space, sociality, embodiment, and control entwining in Wi-Fi need then to be situated in the context of the

\(^6\) CAT is short for category, also referred to as Ethernet cables, these are the physical connections between computers and the wired internet infrastructure. CAT-6 are newer successors to the CAT-5 cables, which are still common in wired networks.
ongoing development of new media and computer networks as sites of cultural construction of identity, value, mobility, work, space, and time.\textsuperscript{69} Positing Wi-Fi as a site of “cultural construction” provides a context for understanding how networks can be reflective of societal organization. We use networks as extensions of ourselves by storing data (photos, emails) and sharing them with one another as part a new perception of space and time. Additionally, these networked spaces remove and redefine borders, constructing new, virtual infrastructures and shaping different types of relationships between space, and ourselves.

Wireless altnets are a natural extension of this idea, in that they represent a kind of dimensional shift in the notion of Wi-Fi. Products like the Flutter wireless whose nodes boast a range of up to 1 km, can enable communities and social groups to develop networks an order of magnitude larger than a home Wi-Fi network, perhaps not to enterprise scale, but they can expand the geotechnical space into innovative new territory.\textsuperscript{70} While single homes may have networks situated within the boundaries of one property, whole neighborhoods could interconnect to produce a larger community networks that contribute to the “construction of culture,” or community that Mackenzie describes.

The strategy of the technostructure typically privileges the demands of the technology ahead of the needs of the community. Limitations of technology or the design generally dictate the structure of the network. Network cables are limited by bandwidth in

\textsuperscript{69} A. Mackenzie, “Untangling the Unwired: Wi-Fi and the Cultural Inversion of Infrastructure,” \textit{Space and Culture} 8, no. 3 (August 1, 2005): 269–85, doi:10.1177/1206331205277464., 270

\textsuperscript{70} See Appendix i
how long they can be before losing effectiveness. CAT-6 cables, the current standard in wired networking, can run about 100 meters safely. This limitation imposes a design constraint on the network. To extend this, infrastructure designers can install powered bridges or repeaters to amplify the signal. Again, this imposes additional restrictions such as the need for server rooms on each floor, and so on. This presents an overly limited view of the possibilities for technology and infrastructure integration. It becomes sort of a physical manifestation of technological determinism, and as such tends to stifle innovation.

This analysis can be applied to understanding why Internet Service Providers are reluctant to provide services to rural or geographically impractical areas. Because they are thinking first of the technology, the desire to provide extraneous services becomes less important. The major investments ISPs have in infrastructure drives them to maintain the status quo by promoting traditional infrastructural arrangements out of self-interest. Mackenzie writes, “according to cultural theory, corporate assimilation of the new communications technologies tends to reject the relevance of places or practices that it does not create or manage.”\textsuperscript{71} Deploying and maintaining networks comes at a cost to the ISPs, and rural or geographically remote areas increase this expense due to the difficulty of installing network infrastructure. As ISPs are generally profit-driven, they can be unwilling to provide services to these locations due to the overhead in cost.

Alternative models of connectivity can invert the traditional approach of technology led innovation, by providing an opportunity for user-led innovation to expand the range of possibilities available to communities. Building community networks is a

\textsuperscript{71} Mackenzie, “Untangling the Unwired.”
valid option for some areas, thanks in part to the advancement in wireless networking hardware.

**Stacktivism**

Technology has been widely adapted by activist causes, and has increased the approaches available to them. The ease with which data can be transmitted has expanded the range of measures activists can take advantage of to produce social change. This has given way to a subset of technologically motivated activist movements, where participants have taken advantage of social networking, encryption, and advanced wireless communications technologies to this end.

One such subdivision is called Stacktivism, which is a research methodology adopted by activists, seeking to bring awareness to network infrastructure in the name of social responsibility. The term derives from “the stack,” referring to the protocol stack in network computing. These protocols are the link between the physical infrastructure and software interfaces used by humans. The most well known of this type of stack is the Internet Protocol suite, consisting of seven interoperable layers working together to transmit data on the Internet, however this activity comes at a cost.

Stacktivism attempts to place the effect of networking infrastructure in context with the environment. Environmental concerts can be a contentious point; often they are glossed over, or reframed in the face of scrutinizing the practices of tech companies. In particularly, the tech world has increased its focus on providing cloud services, promoting that term as a catchall describing data hosting for personal and business usage. The usage of this term is misleading for several reasons. It seems to imply an ephemeral
and ecological connotation, and it positions networking as an environmentally friendly activity. The cloud is “out of sight, out of mind,” and suggests that when interacting with the cloud, your data floats safely and comfortable in the atmosphere. Google provides a number of cloud services, including a suite of productivity apps, and data storage. However Google’s datacenters are very real, and very large, with an ecological footprint to match. Jon Koomey, a climate solutions researcher, issued a 2008 report declaring 2% of United States energy usage, and 1% of world usage is consumed by data centers.\textsuperscript{72,73} 

A 2011 Greenpeace report also suggests that the major technology companies are not doing enough to reduce their impact on the environment. There seems to be very little transparency from the companies regarding their ecological footprint. According to the Greenpeace Dirty Data Report Card, Google, Amazon, and Twitter were each assigned a letter grade of F with regards to their transparency.\textsuperscript{74} While it is not an easily managed issue, these concerns will require a major effort and cooperation within the industry.

Jay Springett, who coined the term stacktivism, asserts “we cannot have a conversation about something whilst it remains unseen.”\textsuperscript{75} This implies a necessity

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towards transparency and openness with infrastructure, specifically with regards to the network stack. As the world becomes increasingly connected online, the infrastructure continues to remain a hidden element to most people. Awareness of the infrastructure is limited usually to when it fails. For example, when the Internet goes down in a building, or the power goes out at home. Infrastructure owners take great pains to hide the wires and antennas that do the physical work of transmitting data.

The “invisibility” of infrastructure also serves to mask its other associated effects, such as environmental impact and humanitarian cost. Casting a light on infrastructure serves to increase awareness and understanding of its impact on society. Matt Ratto, an Assistant Professor at the University of Toronto analyzes the pitfalls of invisible infrastructure, highlighting the adverse effect of ignorance.

By removing our knowledge of the glue that holds the systems that make up the infrastructure together, it becomes much more difficult, if not impossible, to begin to understand how we are constructed as subjects, what types of systems are brought into place (legal, technical, social, etc.) and where the possibilities for transformation exist.  

At its worst, obfuscating the nature of how systems work by making them proprietary strips our ability to exert control over these technologies and trade freedom for convenience.

The Emergence of the Stack

The infrastructure components that work together to form the Internet are part of a standard called the Open Systems Interconnection (OSI) model. This model was first developed in 1978 as a response to the myriad of proprietary connection models that had been established by hardware manufacturers at the time. This model directly established the networking standards which we use still to this day, and which are referred to as “the stack,” shown in figure 3.1.

![Figure 2.1: The OSI model of the stack](image)

Developed by the International Organization for Standardization (ISO) in 1978, the Open Systems model was innovative early on, in part because the ISO had never

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77 Abbate, *Inventing the Internet.*, 167
attempted to standardize a current and evolving technology before.\textsuperscript{78} Their goal was to provide a universal means for computer systems to communicate on the network, indiscriminate of the host operating systems or platforms.\textsuperscript{79} The ISO built upon the layering scheme laid out by ARPANET (discussed in Chapter 1), developing the seven functions that are still in use today. Janett Abbate describes each layer and its purpose as follows:

The physical layer specifies how the network interface hardware will regulate the physical and electrical aspects of connections between machines. The link layer translates the flow of electrons across the physical medium into an ordered stream of bits, and decides when to transmit or receive messages from the medium. The network layer handles addressing, routing, and the host-network interfaces… The transport layer [provides] end-to-end control functions. The session and presentation layers… provide enhancements over transport service. The application layer… provides specific services, such as file transfer, remote login, or email.\textsuperscript{80}

The establishment of these layers was meant to provide a template with which protocol designers could work with; the ISO was not attempting to define the protocols themselves. The significance of the seven-layer network stack is felt today, whereby it presents a useful template, which network theorists can utilize to make sense of the causal relationships between interoperable elements of the networked world.

Implementation of the Open Standards Initiative’s model was wildly successful and was a major victory for open software. By the late 1970’s proprietary systems and software had become the de facto standard, eschewing the earlier sharing policies

\begin{itemize}
\item \textsuperscript{78} Ibid., 168
\item \textsuperscript{79} Ibid.
\item \textsuperscript{80} Ibid., 170
\end{itemize}
prevalent during the initial boom of computer and networking development in the 1960’s. Large manufacturers could monopolize on networking hardware, forcing consumers into being locked in to a narrow selection of products, and incompatibility with competitors. Leading developers were in a position to have a monopoly over the emerging networked world. “If IBM became master of the network market, it would have a share—willingly or unwillingly—of the world power structure” said the French government in a 1978 issue of Electronics magazine.\(^\text{81}\)

The introduction of the OSI “significantly shaped the way computer science professionals thought about networks.”\(^\text{82}\) Henceforth, the OSI model and its principle of layering, now popularly known as the stack, substantially influenced all discussions of computer networking. Manufacturers adopted the open standard, and it was particularly popular in nations that felt trapped by the pressure to conform to proprietary models such as such as IBM’s. “[Open Standards] are seen as the last hope for saving what remains of the indigenous computer industry.”\(^\text{83}\)

**Wireless Networks and Infrastructure**

Of the seven layers of the stack, Wi-Fi operates in a space that spans between two of them, the physical layer (PHY) and the link layer; or to be more specific, the Media Access Control (MAC) sub-layer of the link layer. The MAC layer is designed to

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\(^81\) Ibid., 172

\(^82\) Ibid., 171

\(^83\) Ibid., 172
organize and monitor access to the network for more efficient and logical network management. While the infrastructure supporting “clothesline” network technology is very well situated in the physical layer (e.g. the cables and ports), wireless networking inherently exists in both realms. It simultaneously exists as a “new modality of communication infrastructure,” while being an invisible component of the chain of connectivity. The use of radio waves allows devices to join networks in a versatile and ad hoc manner, producing an unstable and disorganized characteristic that crosses physical boundaries and introduces a geo-political element of connectivity that can be difficult to administer. There is a mobility afforded by wireless connectivity that lends itself to freer interaction with physical space for users. To interact with the network, the user is no longer tethered to the infrastructure, and physical space is reshaped by allowing movement. Of course, the “invisible” infrastructure still exists and continues to exert its influence—move out of the signal radius, and you’re no longer connected.

Mackenzie co-opt the terminology of the layered network configuration to identify two perspectives informing the understanding of Wi-Fi’s role in constructing space. He identifies the MAC layer as a strategy for “rendering something visible,” that being the connection between radios using the Wi-Fi protocol. Ultimately he concludes this may be a less desirable perspective with which to view Wi-Fi’s relationship with infrastructure and communication. The promise of “freedom” offered by Wi-Fi in regards to the MAC idiom, is underpinned by an expectation of accomplishing more “work” for

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84 Clothesline networks are a colloquialism referring to wired networks due to the lengthy category 5 and 6 cables resembling clotheslines.

85 Mackenzie, “Untangling the Unwired.”, 276
the user. This is supported by corporate subsidies of wireless “hotspots.” For example, a major industrial manufacturer of wireless chips, Intel, has made great efforts to provide wireless access points in public locations such as airports, hotels, and cafés, as well as promoting their existence to the public, seen as potential customers.\textsuperscript{86}

Partners such as McDonalds and Starbucks, were leaders in integrating public Wi-Fi access points into their infrastructure, which seems to suggest an interest in binding commercialism with network access.\textsuperscript{87} The result of these initiatives attempts to produce touchstones of open access associated with commercial infrastructure under the guise of mobility. Yet these configurations are exclusive by nature. Security for wireless networks is a top concern for system administrators, and efforts are made to prevent unauthorized access by those lacking proper credentials. The freedom gained by uncoupling workstations from walls is only applicable to individuals who are in turn still tied to the network by way of their permitted access. These restrictions produce invisible barriers to “unwanted others.”\textsuperscript{88} Thus, using the MAC idiom to situate wireless networks inherently reinforces a degree of top-down control that attempts to separate the information contained within, from people who don’t have the right of access. “The MAC idiom practically negotiates the redrawing of the boundaries between public and private space,

\textsuperscript{86} Ibid., 277
\textsuperscript{87} Ibid., 278
\textsuperscript{88} Ibid., 278
between corporate and noncorporate, between individual and collective spaces” Mackenzie laments.\textsuperscript{89}

The other side of the coin, the PHY idiom, or the physical layer, takes a more inclusive view of the properties of wireless networking. Unrestricting the infrastructure is made possible by the Wi-Fi protocol and associated hardware. This allows for more a more open take on using physical spaces to incorporate communications infrastructure, therefore producing more desirable outcomes by allowing people to congregate.

Alternative networks, such as community Wi-Fi initiatives, can create even more nuanced networked spaces, and can be produced in a wide array of locations. Breaking down barriers to wireless access can redefine the capabilities of infrastructure. Wireless community networks often subscribe to the terms in the Wireless Commons License. These guidelines outline policies and recommendations for open adoption by any community wireless projects. Because many of these initiatives do not have a sturdy financial backing, the Wireless Commons License is an attempt to provide a useful resource to aid in implementing effective community networks. By applying Mackenzie’s PHY idiom, wireless infrastructures can become a space for public participation and collaboration, encouraging community involvement. Comparing this to the closed and exclusive nature of wireless networks developed under the principles outlined by the MAC lens, open Wi-Fi networks produce an altered view of space and infrastructure that is more beneficial in the context of democratic policies. The invisible infrastructure is a more inviting and interpersonal space that can facilitate discourse between groups and individuals.

\textsuperscript{89} Ibid.
These two idioms represent binary modes of examining the same thing, wireless networking. By contrasting them, we can see that elevating certain characteristics produces vastly different results. One view sees the potential for wireless networking to be used as an implement of division, separating classes of people into those with or without access to the network. The other shows promise of inclusiveness that supports an ethos of sharing and cooperation. Mackenzie suggests that the mobility afforded by Wi-Fi should be presented as “a mobility in infrastructure itself,” referring to the virtual space created by networks as possible “site[s] of collective work.”\(^90\) With this viewpoint, networked infrastructure can be positioned as a place bridging the gap between the real and virtual.

Using alternative networks to that end enhances our ability to exist as digital citizens, and help to clarify the ways in which networked cultures can interact with emerging networked spaces. In order to foster a more open and democratic model of connectivity, it is essential that wireless networks apply standards of openness to their implementation. When integrating networking and infrastructure, a new form emerges that exhibits influence on human interaction. Networked infrastructure produces space that is greater than the sum of its parts. These two situations are inextricably linked in the modern world. Geography exerts influence over technology and vice versa. If they are thought about as a unit, it is more effective for agents to harness these resources and shape them to our benefit. In a future where all objects will have a networking capacity, it makes sense that networks themselves will be commodity. By inverting the commercial

\(^{90}\) Ibid.
infrastructure model, we are able to reclaim networked spaces by taking advantage of the power of collaboration.

The Black Stack

Benjamin Bratton, a network theorist and Associate Professor at the University of California, San Diego, has appropriated the metaphor of the Internet stack to consolidate the many technological facets of computer networking and place them in context with humanity, culture and our relationship with the planet. In Bratton’s version of the stack, the Black Stack, there are seven layers that are interoperable and form the basis of action and communication between agents interacting in the modern age.91 The layers he defines, from the bottom upwards, are as follows. Earth, Cloud, City, Network, Address, Interface, and User. In accordance with the stack model, each of these elements forms a column of action through which communication occurs at the bottom layer, thus resembling a “U” shape. As an individual takes action, each layer is activated from top to bottom, crossing to its adjoining column at the Earth layer. In Figure 3.2, a single column of Bratton’s stack is presented.

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91 Metahaven, “The Cloud, the State, and the Stack.”
Bratton asserts that it is difficult, if not impossible, for the agent (represented by the User layer) to be completely aware of the effects and implications associated with activating each layer, due to the obfuscated nature of computing and its relationship to the environment. For example, when the user interacts with the Interface layer, the address layer sends data to a receiving address by communicating over the network, for example using a server. The server, a physical object, has energy costs to maintain, as well as the impact of its infrastructural placement and construction. There are numerous procedures that were invoked upon fabricating the components, such as obtaining materials and financing individuals to contribute to the project. Each of these are inextricably linked by the manipulation of resources.

The cloud layer, in Bratton’s example, could be represented by tech entities such as Google. By appropriating the word “cloud,” Bratton is subverting this nebulous and
misleading term, as it is understood by the mainstream culture, repurposing it for his vision, while at the same time acknowledging its newfound permanence in our lexicon. Bratton’s cloud is not simply an advancement in data hosting for personal and business convenience, but a governing body that has analogs to the Westphalian state. Companies like Google are enacting more and more policies that resemble services issued by the State, such as identity politics and mobility services that are diffusing into the real world. The jurisdiction of the cloud is widening to provide influence in societal functions such as assigning geographic limitations governing user behavior. One example of this influence is regional restrictions on content. YouTube, for example, may let users view certain videos if they are located in the United Kingdom, but the same content is not available if they are located in the United States.

This assertion of power can have unexpected and dangerous results as is evidenced in a 2010 border dispute between Nicaragua and Costa Rica. Figure 3.3 shows a map of the two countries and the contested area. Nicaragua authorized an initiative to dredge 33 kilometers of water along a river bordering the two countries. It is alleged by a Costa Rican news agency that this was justified by examining the area using the Google Maps service, which erroneously displayed the border by nearly 2.7 kilometers.\(^{92}\) A Google representative acknowledged the error in the Google Maps service, while adding, “by no means should they be used as a reference to decide military actions between two

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However, this incident illustrates the very real authority that is held by non-state actors such as Google.

Figure 2.3: Disputed area between Nicaragua and Costa Rica

The shift that Bratton describes of State actors taking on elements of the cloud, and vice versa, can be easily applied to alternative networks. The space that now exists online that we call cyberspace, can be split off into numerous sub-divisions, each with its own set of rules governing space.

**Splintering and Network Fragmentation**

While currently we look at cyberspace as a unified meta-space produced by the cooperation of the pieces of the network, it is easy to apply this concept to alternative networks that are not connected to the Internet. Each isolated network would produce its own space, or world, in which cyber-personas populate. Indeed configurations such as

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this are emerging in various forms already all over the world. Additionally, Privacy and security on the Internet is becoming a more widely accepted topic of consideration for entities that utilize the Internet. Because of this, researching the efficacy of developing network alternatives will become a relevant subject for exploration in the near future.

The revelations of the National Security Agency’s PRISM program have ignited concerns of privacy, leading some countries to consider hosting and managing private within their borders.\textsuperscript{94} Rather than using services such as Google and Dropbox, these nations develop their own similar services that can be controlled and maintained by themselves. Because these, and many other similar service providers are United States corporations, they are considered insecure due to NSA snooping concerns.

There is a strong opposition to this practice, mainly by the corporations and interests of technology companies. Geographic splintering of the Internet would result in increased difficulty for the tech giants to continue providing the type of unified services that they specialize in. This would produce a lessened ability to collect user data, which is their main economic commodity. The data that these corporations harvest provide incredibly detailed information on people’s habits, which is then used to produce targeted marketing and advertisements.

Entities all over the world are looking at alternative means of engaging with cyberspace for these reasons. In yet another example of cloud and state swapping roles, there has been an initiative in some geopolitical arenas towards fragmentation, or splintering of their networks. Fragmentation of the Internet has also been referred to as

\textsuperscript{94} The NSA’s PRISM program allowed the United States to monitor all communication entering and exiting its borders. Because many of Google’s servers are located overseas, this provided the NSA with near blanket access to global communication.
Balkanization, but some view this as a pejorative term which trivializes the violence and bloodshed associated with the breaking up of the Balkan peninsula in the 19th century.

Regardless, the association with political boundaries is apt. Yet, the initiative by state actors to contain their networks within national borders, restricting how the networks are able to interact with the wider Internet has been discouraged by some analysts. Still, many countries are seeing this as a viable measure of security for national data. Still, the NSA spying programs have provided an impetus for countries to demand tighter control over network communications.

Brazil is one of the most prominent nations to implement the process of fragmentation. After the PRISM scandal broke, their president, Dilma Rousseff vocally opposed this practice, condemning the NSA’s international spying initiative. “Without the right of privacy, there is no real freedom of speech or freedom of opinion, and so there is no actual democracy… without respect for [a nation’s] sovereignty, there is no basis for proper relations among nations.” Brazil began enacting a policy to re-examine their nation’s network infrastructure and protect its data from inside its borders.

Augé-Places and Coded Spaces


In *Networked Publics* Kazy Varnelis employs the thoughts of anthropologist Marc Augé as a fascinating lens through which to look at online culture. Augé defines a separation between “places” and “non-places,” referring to physical spaces where people congregate or pass through. Using his terms, a “place” connotes a notion of togetherness, relationships and community, while the non-places are more sterile, purely functional and devoid of emotion and connection. It is an interesting take on the human relationship with infrastructure. Augé argues that pure “places” are disappearing as our world is being taken over by non-places. For example he lists some non-places as “airports, airplanes, freeways, parking garages, but also refugee camps and shantytowns.” They do not support quality human interaction, and instead guide people to perform functions of utility, such as participating in commerce, or at their worst, oppressing people by taking away choice.

These descriptors illuminate the notion that valuable human relationships are in symbiosis with their environment. Take, for example, large sporting arenas where thousands gather to watch an event together. The infrastructure is both inspiring to us with their dizzying structure, but also they are brought to life only by our presence. The intertwined connection between person and place is even more dynamic when using Augé’s example to categorize the ties that bind us.

Extrapolating further, it becomes easy to understand how are interaction with networked spaces produces meaning as well. In cyberspace, the infrastructure is flat—there are no awe-inspiring arenas to marvel at. And though the worldwide “series of

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97 Varnelis, *Networked Publics*, 18

98 Ibid.
tubes” is indeed an unknowable super-structure, it is not made visible, and not sensed in the same way. However, alternative networks that are integrated into a visible space can marry the physical and the virtual spaces in exciting ways.

Author Jason Farman in *Mobile Interface Theory* studies this concept of embodiment through technology by situating it within the human condition. He explains that our relationship with space goes beyond simply existing within space, but rather that “space is constructed simultaneously with our sense of embodiment.” Rather than thinking of our relationship with space as unconnected, Farman suggests that consciousness itself produces space. Embodiment is the process through which we interact with space, and that “those interactions dramatically change the essential character of space.” This applies to networked space as well. When we interact with objects, people, and even “bots” or rudimentary forms of AI, we are constructing space that’s as real online, as it is in the physical world.

**Geographic Scope**

Globalization and localization can work in concert and should be considered as two sides of the same coin. The adage “think globally, act locally” is applicable in the alternative networking movement. Much of the character of the Internet has been ascribed to its ability to connect the entire world. There is a benefit in this, to social and

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99 Senator Ted Stevens in 2006 referred to the Internet as a “series of tubes,” and was widely criticized in the media due to the overly reductive nature of the metaphor.


101 Ibid.
economic applications. People tend to be more conscientious toward members of their same group, and global networking can produce feelings of inclusiveness. Conversely, local strategies have a positive impact on using resources that can be obtained without the expended energy of transporting them across large distances.

Alternative networks can add networking infrastructure to places that don’t have it, and can be done without intervention from major players like ISPs. In other words, it can be accomplished by activist organizations or local communities working together. Additionally, alternative networks can be made privately and hidden, thus providing local free network initiatives the ability to add network infrastructure surreptitiously as deemed necessary.
Alternative networking is a broad term that refers to anything that falls outside of the traditional model of connectivity. The traditional model is where the end user connects via “last mile” access from an ISP who, in turn, connects via backbone access from a Tier 1 provider. In this example, the ISP is the gateway between the consumer and the Internet. The ISP may own or lease the last mile infrastructure, and therefore commands a large amount of control of how the data is shaped, and how the infrastructure is deployed. Comcast, the country’s largest Internet provider, has been criticized for only providing infrastructure to locations where it is commercially advantageous, thus leaving out rural and poor areas that do not meet this criteria. Because many of the important protocols and specifications that comprise the Internet have been classified as open source, computer networking can exist and be functional on its own, without needing to abide by the traditional model.

Fortunately, there is a host of emerging technologies on the market that will make development of alternative networking much easier. What was once the exclusive realm of geeks and computer enthusiasts can now be utilized by artists and activists. In the past decade, the evolution of web design and other coding practices has swiftly jettisoned into

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the realm of creativity and craft. This paradigm shift has set a precedent for other technological endeavors, and computer networking has the potential to follow a similar trajectory.

There are many tools that are available now to construct new networking arrangements. Along with the rise of “maker culture” in the past few years, creative hardware manufacturers have introduced dozens of microcontrollers—small, use-specific computing devices—to the market.\(^{103}\) Products like Pinnocio mesh networking “scouts” and Spark Core Wi-Fi development boards are approximately the size of your thumb, and come with out-of-the-box configuration. These emerging tools have the potential to bring alternative networking into the mainstream.

**Characteristics of Alternative Networks**

The proposal of this research is that alternative networking can improve digital democracy and combat the widening technology gap by adhering to two principles. First, alternative networking should be able to provide a low barrier of entry to set up. And second, it should be able to provide useful and desirable services. Adhering to these two principles will give alternative networking a shot at more widespread adoption.

Networks are sometimes viewed as mere infrastructure, or a means to an end. Because people use networks as tools to access information online, the perception exists that networks are static and utilitarian, but this should be reconsidered.

When referring to networks in this context, the allusion is to the elements of the network stack that work together to produce networked spaces. This includes not just the

\(^{103}\) See Appendix iv.
topography, the nodes and edges, but also the server units, including processors, memory, and disk storage. It also includes the software that runs on the server, as well as network cards that packetize the information and prepare it for delivery over using the protocol. There are many “moving pieces” that work together to give the impression of a single unit, and so this entire unit should be understood as “the network.” It should be noted that each element that comprises the whole, is included a part. When these components are working in concert, they produce networked space, or cyberspace.

Digital technology has a mystique surrounding it that can give the impression that it is impenetrable or unattainable to the common individual. One of the reasons for this is its dense and complex syntax, which, to the unfamiliar, can be daunting to overcome. Though there is a learning curve, it is not insurmountable. At this stage in open source development, many mature projects are fully realized; and with the help of large discussion communities, learning how to work with technology is easier than ever before. The continuation of this trend of inclusiveness will be important for further adoption and propagation.

Dominant ISPs are able to provide extremely high bandwidth speeds to many people due to their control of the last mile infrastructure and vast financial resources. Newcomers like Google Fiber are offering major competition to the incumbent ISPs by providing even faster speeds and lowering the price of access, though this too is accomplished with the benefit of a hefty financial backing. Alternative networks are mostly small-scale, and community driven. They do not have the resources to compete with ISPs, and that is not their intention. Rather than focusing on bandwidth and throughput, alternative networks aim to provide more versatile avenues of connectivity.
Even so, in order to make a successful contribution to the community, an alternative network must be able to provide an acceptable end-user experience that facilitates adoption. While bandwidth intensive applications such as large-scale video streaming, a la YouTube.com, may be a long way off, there are many services that can be integrated into an alternative network to make people embrace them.

**A Simple Home Network**

One common example of an altnet would be a home network utilizing a system called Network Attached Storage (NAS). This method is very popular and easy to set up. There are several operating systems designed around this system that can be configured in minutes. A NAS is a centralized system, which means it has a single server that hosts all of the data, and serves it to properly configured devices on the network. The beauty of this type of network is that it doesn’t require Internet access to work. With just a server system and a router, a NAS can be deployed nearly anywhere. The specialized operating system can also host numerous additional services such as media streaming and folder synchronization. Therefore someone using a NAS can easily create their own services similar to Netflix and Dropbox on a private network. Again, due to the open source nature of these services, they are accessible to anyone with the technical skill to set it up; and because of the deep community involvement associated with these open source projects, the products are mature and the barrier of entry is fairly low. Keeping the barrier of entry low is important, because it allows for a much wider spectrum of individuals to learn how to build and configure this type of network.
It is easy to see how a NAS can easily bring cloud-like services into homegrown alternative networking scenarios with the appropriate hardware. Although this hardware is not cheap, there is not a substantial cost associated with it; a decently performing NAS can be built with around $500. But what if we need to bring the overhead down below that figure? There are a plethora of emerging microcontrollers, radio devices, and software solutions that are cheaply available and perfect for deploying alternative networking solutions.

**Implementation of Alternative Networks**

Alternative models of connectivity can protect us from the monopolization of the Internet by “state” or “cloud” entities. Because the building blocks are available to everyone, people can take advantage of the vast resources and create custom architectures to suit the needs of their particular implementation. In doing so, people can help close the digital divide, support digital democracy, and have the potential to reinvigorate the public sphere by engaging their community.

Creating and deploying networks, whether isolated or linked to the Internet, will become as easy and commonplace as building a webpage or starting a blog. Advancements in website and blog hosting service gained popularity in the early 2000’s thanks to services provided by the now defunct webhosting companies Tripod and Angelfire. It stands to reason that personalized networks can follow in these footsteps thanks to the popularity of small wireless integrated microcontrollers and recent advancements in the field of software-defined radios (SDR).
SDRs are an area that has become prevalent among network enthusiasts. This is software that handles takes on some of the workload that make hardware radios on embedded systems more complex, allowing for simplified hardware that can reduce cost for manufacturers and hobbyists. Typically open source, SDRs can provide powerful capabilities to hardware radios, and have been reported to intercept cellphone communications and detect IMEI-catchers (phony cell towers, used in man-in-the-middle attacks by hackers and government agencies.)

Another networking field that is gaining momentum is mesh networking and ad hoc networking. Often they work in tandem, providing versatile configurations for networks. Ad hoc networking operates on tier 1 of the OSI model, the physical layer, whereas mesh networking operates on layer 3, the network layer. Because ad hoc only enables single device-to-device connections, by incorporating mesh router, nodes in the network can all talk to one another. This type of configuration can be implemented in nodes placed in cars, telephone poles, buildings stoplights, bridges, and other infrastructural locations to provide pervasive and ubiquitous networking all over. Figure 4.1 shows a diagram of an ad hoc mesh network, featuring both fixed and mobile nodes.

Developments in miniature infrastructure devices are gaining popularity due to the ease in which networking interfaces can be integrated into PCB boards. Made possible by advancement in wireless networking technology, they have the ability to deploy network infrastructure rapidly and flexibly. These devices, such as the Pinoccio,

104 A man-in-the middle attack is when an attacker intercepts communications between two entities without their knowledge, obtaining potentially private information.

105 See Appendix ii
and Flutter wireless, can be powered by small, rechargeable batteries, and have powerful radios to broadcast their signal.\textsuperscript{106} While the throughput is currently low, inventive developers can skirt around this by using creative programming techniques. For example, server applications have been written to require less computational power. Nginx and Node.js are two very lightweight alternatives to the Apache web server (detailed in the Introduction), which is one of the worlds most popular, yet requires a more powerful system to operate.

Pervasive, ubiquitous networking is rapidly moving into the mainstream, and it is imperative for the public to stay ahead of the curve and take control early on to prevent state and cloud entities from monopolizing the services. Mastering low cost networking hardware and emergent protocols are of key importance to maintaining openness in network infrastructure.

\textsuperscript{106} See Appendix iii
New hardware advancements can make it easy to deploy alternative networks for personal, business and other use. New protocols can help prevent against certain types of hacking and cyber attack. These advancements are helping people take more control over technology, and networking should follow this trend.

Google project loon

Google has been working on a project using ad hoc mesh routing to bring connectivity to remote locations. The world is vast and there are far reaches of the planet where installing the physical infrastructure required to connect to the Internet seems unfathomable. Taking a cue from weather balloons, which can collect information about atmospheric conditions, Google is designing its own version of a balloon containing Wi-Fi transmitters that share a signal with one another, and connect to an antenna on the
ground. The balloons are capable of distributing their signal nearly 500 square miles. Figure 4.2 shows the scale of the balloons as two technicians work on them.

This initiative, dubbed “Project Loon,” is a result of Google’s secret Project X team, which does research and development on some of the more outlandish and speculative ideas holding “moon shot” status. Google Glass, and the self-driving car are two other products that have emerged out of Project X.

The methodology behind these types of projects seems to be: start with a big idea, and work your way backwards from there. In other words, put the concept ahead of the execution. The project has advanced to the point where Google is in talks with telecommunications providers to bring Loon to the mainstream. Senior Vice President Sundar Pichai said in a recent interview with *Verge*, "We think the model is really beginning to work, and we have started large-scale testing… We’ll be working with carrier partners around the world so they can build their services on top of our backbone."\(^{107}\) The project has high hopes and can be reflective of the future possibilities for audacious alternative networking techniques.

In addition to hardware components, there are a number of emerging network protocols which add to the practice of building alternative networks. Right now, approximately 90% of Internet traffic uses the IPv4 protocol, with IPv6 swiftly becoming a practical alternative. CJDNS is one project using IPv6 which implements an encrypted IPv6 network, and is intended to be a viable and secure alternative connection method than IPv4.\footnote{\textit{IPv4} the most popular network addressing system, allows for over 4 billion naming addresses, which are quickly running out. The IPv6 naming scheme allows for a potential of $3.4 \times 10^{38}$ addresses, a number far outside of the realm of reasonable computation.} CJDNS is that it treats each node in a distributed, non-hierarchical fashion. As a result the protocol lends itself to being used in mesh networking applications, the founder’s stated goal is “to have every node connected directly by physical means; be it
wire, optical cable or radio waves.” CJDNS is a recently developed IPv6 networking protocol that it is not compatible with IPv4. What this means is, you cannot access sites directly from the “surface web.” As development continues, CJDNS networks will create de facto alternative networks by nature of the separation it produces.

While not inherently a network unto itself, CJDNS is designed to route traffic primarily over private mesh networks. The protocol is a response to the existing protocols of TCP/IP, which were written decades ago and are becoming less effective to provide security and reliability on the Internet. As the Internet has grown significantly since its inception, the current practices are seen as inadequate by proponents of CJDNS and mesh networking. The key principle that CJDNS is built upon is encryption and integrity. Many of the security issues facing sites on the Internet, particularly DDOS attacks, are due to manipulation of flaws in the TCP/IP system. The protocols written decades ago by ARPANET have become a kludge. In tech-language, a kludge is a pejorative term to describe something that was hastily built and assembled in a messy fashion, using disorganized parts. For vulnerabilities and security issues, patches are written and overwritten again to meet new requirements, this alternative has been written from the ground up to provide superior performance.

One flaw of current networking architecture is centralization; CJDNS is intended to be used in a distributed configuration. Traditionally when a user types a human-


111 Ibid.
readable web address into their browser, this is sent to a centralized domain name server (DNS), where it is matched with the appropriate, numeric IP address. This is problematic because as the database grows, performance issues arise due to the large amount of entries the server must quickly analyze. The CJDNS system does not centralize IP addresses, but rather auto-generates them cryptographically and are uniquely assigned to hosts.\textsuperscript{112}

**Isolated networks**

With so many options for hardware and software, building networks has an exciting future in front of it, and the capability to invert the traditional models of connectivity. Anyone from hobbyists, to enterprise entities can design and build a unique network topography to suit their needs.

Networks can probe for objects due to the inherent nature of wireless connectivity—the call and response action of a device pinging an access point, or vice versa, and the exchange of unique MAC addresses. This action, gives a network more agency and allows for networks to be used as tools of discovery, or as Bratton might view it, jurisdiction over access.\textsuperscript{113}

Networks are inherently jurisdictions, they allow or deny access to individuals or objects based on their credentials. In Bratton’s model of the stack, the cloud layer represents online jurisdictions, or “polis” as he calls them. Alternative networks such as

\textsuperscript{112} Ibid.

\textsuperscript{113} The Stack: Design and Geopolitics in the Age of Planetary-Scale Computation (Simon Fraser University, Vancouver, B.C., 2014), http://www.bratton.info/projects/talks/the-stack-design-and-geopolitics-in-the-age-of-planetary-scale-computation/.

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private isolated networks, or infrastructurally integrated geotechnical networking are logical extension of this concept, further marrying the geopolitical aspects of the state, with the cloud, on a smaller scale.

I think cloud and state entities, as they merge, will develop into smaller groups of networks, creating micro-states, or cloud-polis,’ and carrying with them an aura of mystique, desirability and exclusivity. Networks can exist in a wide variety of states and configurations. Whether centralized or distributed, hierarchical or mesh, connected to the Internet or isolated, networks can be deployed to adapt to many scenarios.

A common criticism regarding iso-nets is about practicality. People question the necessity for isolated, private networks based on a utilitarian perspective of networks. But the network does not have to be posited as a tool, it should be viewed as a space for human interaction. And as such, it does not require an explanation for its application. Social behaviors can be produced and organized around many phenomena. Psychology has taught us that people find meaning in causes or affiliations. One of the most successful developments of networking technology with regards to sociology is social media. The corporate leaders in this field are Facebook, Twitter, Google, Linkedin, Tumblr, and Instagram. Each of these services has millions of subscribers who interact with one another in cyberspace regularly. Also, massive multiplayer online games (MMOG) follow suit with enormous amounts of people participating with one another. While certainly there is a refined aspect and a cutting-edge presentation style about these services, but it could be argued that the social aspect is the most compelling reason people participate in both online social networking, and MMOG’s.
Some of the emergent technologies that can be used to design alternative networks are not powerful enough to accommodate today’s most popular network services, especially graphic-intensive MMOG’s and high-definition video streaming. Rather than view this limitation as a detriment, it can be better reframed as a funnel for creatively coded applications. Sometimes restrictions can provide an infrastructure for inventiveness, such as Twitter’s 140-character “tweet” limit, or their companion video service, Vine’s, six-second video loop. Internet Relay Chat is another very lightweight, but fundamental service that can be installed on an alternative network, providing a simple but effective method for communications.

A technological advancement that would facilitate the proliferation of networks such as these would be the ability for network interfaces cards to simultaneously connect to multiple wireless networks, managing the connections seamlessly. Most common network cards in computers and mobile devices are designed to connect with one network at a time. With multiple connection interfaces, an individual could be connected to their enterprise Wi-Fi, and a boutique iso-net at the same time, while also sharing a separate mobile access point with friends nearby. The user would deliberately manage this variety of network connections, with data being selectively transmitted over each network.

With that in mind, alternative networks have a precedent for producing social space, and there’s no reason that this space should be assigned strictly to the Internet. Private, or isolated alternative networks will provide unique experiences within their own networked space. This understanding will place these emerging networked spaces in a viable position for adoption and development, particularly because of the attraction of harnessing and defining relationships, rules and experiences within networks.
Future Evolution

It was not long ago when building websites was the exclusive domain of knowledgeable individuals with a strong background in computers and programming. It started as an underground phenomenon, paralleling the rise of programming in the 1980’s. Writing and hosting a website in the 1990’s required a lot of skill due to the fact that the technology was still relatively new. The Hypertext Transfer Protocol (HTTP) was conceived by Tim Berners-Lee in 1989, and its first documented version (v.09) was released in 1991. However, the concept took traction, becoming more popular each year. Instruction manuals and guidebooks exposed HTML code to enthusiasts all over the world, creating a large community of architects to design the web. Many other web-programming languages such as JavaScript, PHP, & MySQL followed suit. The underground community soon evolved into a major business sector, and now the Internet industry is worth over one-hundred billion dollars worldwide. After Berners-Lee, HTTP and HTML, dozens of languages and protocols have started as small, homegrown entities, and risen to fame by exponential growth in participation. The vast majority of these projects are adopted due to the accessibility afforded by FOSS guidelines, as well as providing useful or necessary services to the community.

Alternative networks big and small have a future along these lines. In no small part due to the decreasing size and cost of hardware technology, particularly innovations in wireless, networking projects are becoming more and more frequent. Ten years ago the

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consumer market was populated with relatively few hardware networking options; wireless routers were about it. Succeeding this, USB Wi-Fi dongles became popular because they could add wireless capability to a desktop or another machine without it. Now wireless chips can fit in the size of a dime and can be attached to nearly anything. This allowed hardware manufacturers to fit them into smartphones, which proliferated their widespread adoption within the last five years.

This should be encouraging to individuals who are interested in building their own “boutique” network infrastructure. With networking hardware following the cycle of Moore’s law, it is easy and affordable to build and deploy personalized networks, and incorporate a virtual space into any physical space.115 The research suggests there is a growing interest in the field, with the many resources and communities of developers offering their support.

**Cognitive networks**

Another advancement that seeks to enhance the versatility of alternative networking is the introduction of “cognitivity” to communications technology, in this case, networking. The concept behind cognitive networks is an extension of the field of cognitive radio, and a logical next step in its development. The main feature of both technologies is the concept of cognition—more specifically adaptation of procedures to suit changing environmental conditions. In the case of cognitive radio, the unit will dynamically change its wireless channels to make the best possible connection in a

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115 Moore’s Law says that the number of transistors able to fit in a dense integrated circuit doubles approximately every two years. It is sometimes used to account for the explosion in computer development from 1980-2000, and also looked at as self-fulfilling prophecy.
particular scenario. For example if the area is saturated with wireless signals on channel 1, a device enabled with a cognitive radio feature will switch to a different channel with less interference.116

The cognitive network takes this concept further by embracing the whole stack. While cognitive radio only utilizes the physical and link layer, cognitive networks take advantage of each compositional layer of networking.117 Networks already have certain properties that give it a sort of “self-awareness.” For example they must understand how many connections exist at a given time, and they know how to route incoming and outgoing data. Researchers in the field of cognitive networking are making advances that enhance these capabilities, and add even more dynamic decision-making functions. Imbuing senses upon networks will allow for less necessary intervention from human agents. This will lead to proliferation of cognitive networks in the future. Cognitive networks will be able to learn from their surroundings and make decisions based on input. Additionally they will be able to learn from their mistakes by avoiding repetition of unsuccessful procedures. Because of this, network cognitivity will be an important trait to integrate into alternative networking configurations.

**Sensor Networks**

Alternative networking techniques can be beneficial to humans in other ways beyond impacting social relationships and decreasing the digital divide. Thanks to

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117 Ibid.
developments in shrinking network hardware, sensors can be embedded with communications devices to aid us in better understanding the relationship we have with our planet.

The Internet is not only populated by the human actors creating and engaging with content.\textsuperscript{118} There are many artificial, automated agents communicating with one another that exist without human interaction as well. For example many delivery systems have sensors that report their whereabouts to tracking databases to maintain efficient routes. Data, taking the form of barcodes and QR codes, traverse the Internet helping to provide accountability to the supply chain. The past decade has seen a rise in appliances that communicate over the network. This is popularly referred to as the “Internet of things,” because of the myriad of networked objects that perform their functions quietly amongst one another until human input is required. Security cameras, weather sensors, and even home automation utilize network connections with increasing frequency. Consumers can control home thermometers, lighting, lawn irrigation, and property access by using Internet connected devices. These services ostensibly make our lives easier by consolidating management to personal devices and automation.

Machines can now interact with the physical world by way of sensors in increasingly complex ways. While it is still a developing field, sensor networks have great potential to be used to help the environment and provide an effective interface with humans and the physical world. Wireless sensor networks have many applications to enhance environmental and human safety in ways that would not have been possible even

a decade ago. They detect subtle changes that would be imperceptible to humans, and
provide feedback to environmentalists who monitor fragile ecosystems. The amount of
data that can be catalogued helps ecologists and biologists form complex models that can predict trends and produce robust analysis of current conditions.

In addition to being able to provide scientists with more accurate models of environmental conditions, sensor networks can be beneficial in other ways. The devices can be deployed in locations that would be dangerous for humans to observe close-up for a long period of time. Scientists are utilizing these networked systems in Northern Ecuador to monitor volcanic activity for example.\textsuperscript{119} They can also provide information on pollution levels in high-risk urban areas. They can be deployed in mines to alert workers of unsafe conditions. They can be deployed in rivers and lakes to monitor human impact, or in the ocean to study changes in the Jetstream.

By augmenting our ability to protect the environment, sensor networks act in service to humankind as a whole, providing enhancements to our perceptions of events taking place in the environment. They are a valuable addition to the pantheon of alternative networking techniques due to their ability to present heightened awareness, and act as an interface between the planet and ourselves.

\textbf{Altnets Conclusion}

In most alternative networking projects, users possessing a strong working knowledge of technology are the ones who typically initiate community-led innovation.

Because these projects require an initial configuration of hardware and software, those who have a background in related technology fields comprise the community. If the project gains traction into the wider community, people who have only a cursory knowledge of the technological aspect, fall into other roles suited to their capabilities. Political skills such as management and organization, as well as non-technical design such as promotion and advertising, prove valuable in community construction. So, as the community grows, the concentration of technology enthusiasts diffuses as others lend their skills to the project. This helps adjust the scope to a more inclusive place, allowing for increased levels of participation, and more democratic representation of the group. Because of this inclusive trait of alternative networking, the ability for developing a public sphere around the technology increases.

This research explores the emergence of network alternatives to the global Internet. New spaces for computer networking to exist are waiting to be discovered. This could be through new and updated protocols, and also through the use of advanced new technology. Wireless routing hardware is becoming more specialized and can be adapted to use for smaller, private network solutions. What is special about this is that individuals and groups that participate in this concept will be bringing their own interests, skills, and motivations to the table. With these tools, the paradigm of the Internet can be re-evaluated.
USE-CASES

RONJA and User-Initiated Innovation

One of the valuable outcomes for adopting alternative models of connectivity is to bind participants together over a mutually beneficial outcome. By nature, community designed networks involve teamwork between individuals and groups to construct effective networks that are reliable and produce favorable results for network access. This is exhibited by the user collaboration among alternative networking projects such as Guifi in Catalina, and RONJA technology developed by a group of technology enthusiasts in the Czech Republic in 2001. RONJA stands for Reasonable Optics Near Joint Access, and it is a networking technology that uses visible red light to transmit data between devices. The RONJA project was established under the precept that its users should control the network. Aside from providing enhanced, dependable network connectivity, the project was a great case for the benefits of employing user-initiated innovation in an alternative networking environment.120

The field of innovation studies (IS) has done research on the efficacy of various forms of innovation. In particular IS research has looked at user-initiated innovation to determine the motivations and outcomes of movements in the field. One conclusion that has been drawn is that users innovate to fulfill a perceived inadequacy in current commercially available models. In his article *Free Space Optics* researcher Johan

120 Soderberg, “Free Space Optics in the Czech Wireless Community.”
Soderberg problematizes this supposition for not considering political motivations among user-innovators. Soderberg’s research claims that the IS model is only half sufficient because ideals among groups innovating from the ground up, particularly in the technology community, are also driven by goals stemming from political factors surrounding commercialization and co-option of technology by profit-making entities. A more robust understanding of the value of user-initiated innovation takes into account both factors.

In many technology projects, the free and open source (FOSS) model of development is a foundation for their beliefs. Sharing and collaboration, rather than preventing intellectual property from being restricted for profit, is a defining characteristic the FOSS movement. The Czech wireless initiative studied by Soderberg conforms to the same ideals.\textsuperscript{121} It is an important distinction, because proponents of this model see the philosophy of openness as contributing to a greater good in society. This belief solidifies a political motivation for their networking innovations. Wireless networking in particular has minimized the necessary infrastructure for building networks and generated excitement toward the possibility of decentralization of communications networks that support democratic and civic ideals.

Indeed one of the founding tenants for the Czech RONJA project states that “anyone lacking previous knowledge of electronics should be able to build the device.”\textsuperscript{122} RONJA achieves this end by providing detailed schematics of hardware configuration, as

\textsuperscript{121} Ibid.

\textsuperscript{122} Ibid.
well as ensuring that the transmitters and receivers are built using easily accessible, off-the-shelf components.\footnote{Ibid.}

The technical details of building a RONJA node include, in part, the innovative use of everyday objects which, in keeping with the hacker mentality, are culled together in what might appear to be a haphazard manner. Figure 5.1 shows a RONJA transmitter and receiver pair, illustrating user ingenuity. Soderberg cites the use of “pineapple cans” which could be viewed as analogous to the way in which some people have employed “Pringles” cans to amplify Wi-Fi signals far beyond their intended range. Colloquially referred to as a “cantenna,” inventive tinkerer’s simply install a small Wi-Fi antenna inside of a cylindrical metal can to directionally guide the radio waves. While electronics hardware can be purchased to achieve the same ends, the philosophy of user control within RONJA, strived to provide components that were not proprietary, nor cost prohibitive for users. Another example of this was implementing a common magnifying glass to focus the optic signal, even though commercial optical lenses were available at a higher cost. Using such unorthodox methods allows costs to be reduced significantly; Soderberg estimates a RONJA link can be produced for less than 100 euro.\footnote{Ibid.}
The RONJA devices did not use Wi-Fi radio signals however, they employed the technique of free optics. This configuration uses LED light in its transmitter, and a photodiode in the receiver. When facing one another in a position with a clear line of sight, the LED “blinks” rapidly, and the photodiode converts the signal into electronic charges, which are then interpreted as binary data by the computer network. In the early 2000’s, the 10Mbs speed of free optic communication was a major enhancement over Wi-Fi technology, which operated with much less throughput. This, coupled with a

125 Ibid.
transmission distance of over 1km, made RONJA an appealing means of networking and brought about widespread adoption to the effect hundreds of RONJA connections.  

**Guifi**

Of all the alternative networking projects, Guifi is would probably be the largest. At the time of this writing (@guifinet on twitter updates every day) there are 28,109 actives nodes on the network. It is a community owned, mostly wireless mesh network located in Catalonia, Spain. By setting up a node, individuals extend the network, and agree to share their connection with others. Guifi has become the touchstone for community built networks due to the unprecedented adoption of its services in Spain, and even other parts of the world.

By virtue of being community owned and operated, Guifi exhibits characteristics associated with community led initiatives. Particularly the transition from technically minded collaboration, to a more inclusive environment providing opportunities for individuals who don’t posses technical knowledge. The early stages of a community built network are typically lead by operatives with a strong background in deploying network infrastructure. This is essential to solidifying the foundation of the network and maintaining functionality. As the network grows, however, political elements are introduced, such as enacting social policies around its use.

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126 Ibid.

127 See: [https://twitter.com/guifinet](https://twitter.com/guifinet)

The pioneers of Guifi anticipated this and developed the Wireless Commons license (WCL) to provide a template that could be adopted and applied by organizations seeking to deploy community networks. Adhering to the tenants set forth in this document provided a means for the network operators to ensure consistency and operability as the network grew. The WCL outlines policies regarding network management, use of the wireless spectrum, security, liability, and services. Additionally, four main tenants are issued elaborating on its function. Translated from Spanish, they read:

You are free to use the network for any purpose, unless you are affecting the network availability and/or the freedom of the other users.
You are free to know how the network works, and its components.
You are free to use the network for any type of communication and promote it.
By joining the free and open network, you are helping to extend the network in the same conditions.\(^{129}\)

By outlining these concepts, the creators demonstrate a commitment to grow as an organization, and provide a useful service to their community. Notably, transparency is a featured as an important concept contributing to its development, which fosters collaboration and opens the door for improvement by user contributions, as illustrated in Figure 5.2.

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In *Wireless Commons against the Digital Divide* three researchers from the University Pompeu Fabra in Barcelona, provide an analysis of the Guifi network. The paper investigates the characteristics that have led to the widespread success and adoption of the organization, despite being established in a rural town in Spain, a country with one of the lowest percentages of Internet adoption in Europe.\textsuperscript{130} Their conclusions attribute this to a mixture of “geographic, demographic, and even socio-political components.”\textsuperscript{131} Catalonia is comprised of mountainous and desert climate conditions that seriously hinder the deployment of traditional networking models. Spain’s leading telecommunications operator, Telefonica, left rural residents without reliable broadband access. Another contributing factor to Guifi’s popularity was the allure of community engagement. Guifi’s thorough documentation provided instructions for adding nodes based on all levels of technical proficiency. It was viewed by the population as a unifying

\textsuperscript{130} Oliver, Zuidweg, and Batikas, “Wireless Commons against the Digital Divide.”

\textsuperscript{131} Ibid.
social experiment, and participants were provided with technical support, reflecting the inclusive goals laid out by the wireless commons license. This even included sponsoring of nodes for people who didn’t have the means to purchase the required componentry.

**Isaac Wilder and the Free Network Foundation**

Another organization concerned with providing open access to the Internet is the Free Network Foundation. The FNF was founded by Isaac Wilder and Charles Libel in 2011, with the purpose of providing resources for activists and enthusiasts of developing free and open networks. Wilder and Libel were fortuitous, in that their projects were developed at the same time that the Occupy Wall Street movement began in New York City in 2012. The group found likeminded people at the movement who were interested in their networking initiatives. Their first successful project was a something called the Freedom Tower, which was a nine-foot tall antenna that broadcast secure wireless Internet to protestors at Occupy, and underprivileged areas.¹³²

**Red Hook Wireless Network**

The Red Hook wireless networking project is exemplary of the power alternative networks can have to engage in community involvement while combating social inequality. Red Hook Wi-Fi is built using mesh networking infrastructure, where nodes are placed in strategic locations on rooftops in the densely packed neighborhood. Born from the dissolution of communications infrastructure after Hurricane Sandy debilitated

much of New York City in 2012, the Red Hook wireless initiative promotes community engagement and empowerment of the youth.

The project employs “digital stewards,” comprised of students who wish to learn about networking technology. The digital stewards are paid hourly to maintain the mesh nodes, and are trained on the technical specifications of the complex mesh networking procedure. The technology training is a component of the Red Hook initiative, which is a community learning center for youth in the area. According to their website, 75% of participants in the Wi-Fi program go on to gain employment or further their education.\(^{133}\)

Providing Internet access to neighborhood residents is one of the main goals of Red Hook Wi-Fi, but the networked is designed to be operative even if the Internet goes down. In an interview with the New York Times, Robert Smith, a digital steward, describes the goal of the Red Hook network to exist as an independent platform for communications for the neighborhood in the event that access to the Internet becomes disrupted.\(^{134}\) Providing network services and technology training to the community as other benefits as well because it typically leads to expanded innovation. Stewards at the RHI learn other cutting edge skills like 3D modeling and website design.\(^{135}\)

By focusing on community engagement and development, Red Hook is shown to subscribe to the idea that networking projects should be thinking locally. “The general


\(^{135}\) Red Hook Initiative, “Red Hook WIFI | Red Hook Initiative.”
narrative of Silicon Valley is, build an app and change the world.” Explains Joshua Breitbart, a programmer who designed the software Red Hook uses, “there should be room to say, ‘Build an app and change my neighborhood.’” This supports the notion that community networking projects are just as valuable on a smaller scale as they are on a global scale.136

Hyperboria

Seattle has a history of utilizing technology for activist purposes. In November 1999, the city played host to a large-scale mobilization movement protesting the World Trade Organization’s international conference being held there. One thing that set the “battle for Seattle” apart from other protests was the widespread use of “cybercasting,” or video streaming the events taking place during the protests.137 The website indymedia.com hosted these live streams, and their viewers totaled 1 Million, more than the news agency CNN’s coverage during the protests.138

One of the largest mesh networking projects in the United States is also hosted in Seattle, called Hyperboria. This network uses the CJDNS protocol described in Chapter 3. Users of Hyperboria are building the network infrastructure apart from the Internet by using some of the technologies described in this paper, such as long range mesh networking antennas. While Hyperboria started in Seattle, cities across the country are

136 Cohen, “Red Hook’s Cutting-Edge Wireless Network.”

137 Thomas Vernon Reed, The Art Of Protest: Culture And Activism From The Civil Rights Movement To The Streets Of Seattle (U of Minnesota Press, 2005).

138 Ibid.
building their own networks and forming “meshlocals” or local groups dedicated to working with this technology.

Hyperboria is considered a “darknet,” meaning a communications network designed to protect privacy and promote security. The more the network emphasizes these characteristics, the more “dark” it is.\(^{139}\) The security and scalability of the network, thanks to the implementation of the CJDNS protocol, makes Hyperbora a project worth following.

**Conclusion**

Computer networking has evolved significantly since it was first conceived. The collaborative and open nature of its foundational codes is imprinted upon its DNA, fostering connections and cooperation to help bring about social good. By presenting humankind with new interfaces to find our place in the world, communications technologies will become intertwined with its effects. However, it is a tool, and it can be used for purposes both positive and negative. If participants continue the practices of sharing and community engagement, the future of alternative networking has the potential to place greater control of the democratic aspects in the hands of the public. By wresting the means of access from the gatekeepers, and constructing new spaces for communication, the possibility of a public sphere becomes much more viable.

The potentials of alternative networking will become evident as the practice matures. The trend of networking hardware and computer chips shrinking in size

produces new products that are rapidly emerging, allowing for more versatile integration of spaces and networks. Enthusiasts will continue to develop networking projects that, over time, become adopted by a broader cross-section of the public, bringing unique skillsets that enhance the possibilities of the network.

Much like the evolution of the HTML language from a modest style guide for transmitting documents, to the innovative and creative craft we see today, networking will evolve into a more tangible and substantial practice. These characteristics indicate a reflection of the past promises of democratization, amplified, and offering hope for the emergence of a new virtual public sphere. Reclaiming networks by implementing alternative techniques will yet again shift the balance of power among network communication infrastructures, and the democratizing potential of computer networking may be presented. These alternative models of connectivity will face a trial as they become more widely adopted, and it is up to those who continue to work with the technology make a constructive impact. By sharing work, and providing support for one another, the architects of the future can maintain the ethos that propelled computer networking to the magnitude we see today.
REFERENCES


APPENDIX

i. The Flutter wireless is the result of a Kickstarter campaign to develop high-range wireless nodes that can be deployed in mesh scenarios. Its range of 1km far surpasses its competitors. It costs approximately $40 for one board. http://www.flutterwireless.com

ii. PCB, or printed circuit boards are hard, flat boards that have circuitry embedded (printed) upon them, along with other microchips. They are one of the most common means for integrating electronics with hardware. Recently there has been an emergence of companies offering to produce PCBs at a low cost, which has led to a growing culture of non-corporate electronics manufacturing.

iii. The Pinoccio is similar to the flutter wireless in that it is a wireless mesh node. While it has a smaller wireless signal radius, it is designed to easily incorporate additional chips (called “backpacks”) that extend its functionality. The Pinoccio also has a well-supported development interface on its website, where users can write and share code used for projects. https://pinocc.io/

iv. Maker culture is a subset of do-it-yourself (DIY) culture that makes ample use of 3-D printing technology and wireless networking advancements (see Appendicies i, ii, and iii). The focus is typically a convergence of robotics, 3-D printing, computer programming and networking.