# Another Net Is Possible

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The term ‘spectrum’ describes the electromagnetic waves that are used to transmit everything: radio and television signals, cellular communications, and data from the Internet of Things. These waves are made of exactly the same stuff as the visible spectrum of light, but at frequencies invisible to humans. If you Google ‘spectrum allocation chart’, you’ll see a range of color-coded maps showing how these frequencies are divided up: there are blocks for military operations, blocks for Bluetooth communications, blocks for 4G, blocks for emergency services, blocks for medical devices, and even blocks for garage-door openers. Ever since the Titanic sank in a mesh of competing radio signals, spectrum has been owned by governments and controlled by national regulators. With the exception of a small set of frequencies that are allocated for unlicensed uses, such as Wi-Fi and Bluetooth, licenses for the use of the remaining frequencies are either allocated to public resources such as national radio broadcasters, or auctioned, at exorbitant prices, to network operators. And as, in recent years, the potential for monetizing wireless communications has continued expanding – 5G, contextual advertisements, virtual reality gaming, fine-tuned logistics and mobile payments – the issue of spectrum ownership has come to the fore: Is public or private ownership the best way to manage wireless communications, or should spectrum be a common resource to which everyone has access, provided they follow some basic rules?

Ever since radio amateurs built their own crystal sets and surfed the shortwaves, the history of wireless has been ghosted by alternative practices that have challenged the ownership and control of spectrum. Ham-, micro-, and pirate-radio community members cobbled sets together from everyday domestic items, and experimented with Morse, voice, and, later, packet radio, to share communications and images in a sort of proto-internet.[[1]](#footnote-1) Later, after the opening-up to experimentation of the ISM (industrial, scientific, and medical) bands, and the development of the 802.11 protocol,[[2]](#footnote-2) Wi-Fi too became a contested space, with calls for a wireless commons to be built, using open spectrum. Network activists were particularly excited by Wi-Fi as a space where users could experiment with the collectively managing communications, outside of both the state and the market. Some of the best examples include guifi.net, a community wireless network in Catalonia and Spain that currently includes more than 27,000 operational nodes, and initiatives such as the Consume Network in London (now closed), NYC Mesh in the United States, and Freifunk in Berlin, to name just a few. Much was also made of ‘war-driving’ and ‘war-chalking’ practices, wherein activists allegedly used aesthetic forms of mapping to mark the existence in public spaces of open and closed wireless nodes.[[3]](#footnote-3) Communities such as these advocated for a spectrum commons, through declarations such as ‘The Wireless Commons Manifesto’,[[4]](#footnote-4) and worked to develop blueprints for cooperation; including via the application of some of the basic principles of Nobel Prize-winner Elinor Ostrom’s work on common-pool resource management,[[5]](#footnote-5) and the development of extra-legal agreements such as the FONN Compact, the Pico Peering Agreement, and the Network Commons License.[[6]](#footnote-6) In time, innovations in Voice over Internet Protocol (VoIP), and hardware ‘virtualization’ (creating virtual versions of extremely costly cellular infrastructure such as base stations), pushed forward the development of not only open-source and community Wi-Fi networks, but also of open-source cellular networks.[[7]](#footnote-7)

## The Limitations of Networks

With the exception of large-scale projects such as guifi.net, community wireless networks have come to feel like a niche pursuit – an activity which was prominent in the golden age of Wi-Fi but which never gained traction. In the face of contemporary network politics, monolithic platforms, and large infrastructural rollout, it’s hard to stay optimistic about such practices. While this article acknowledges the limitations of community wireless networks, it also explores their demands for, and experiments with, different models of ownership and cooperativism, arguing that these have never been more important than they are now. So, too, that certain elements of their practices – in imagining, inventing, resisting – contain the seeds of other ways of networking in the world.

Often, the limitations of community networks are framed in terms of their technical constraints. Wi-Fi networks are limited by the technological affordances of 2.4 GHz and 5 GHz spectrum – they use waves that by nature don’t travel very far and are easily absorbed by weather and by the built environment – and by the power transmission regulations under which such networks operate: because Wi-Fi is communal, power is reduced to avoid interference. As a consequence, Wi-Fi networks favor ‘line of sight’ links, where wireless antennas are in view of one another. These characteristics tend to limit the scale and extent of community Wi-Fi networks. But focusing on the technical limitations of the communal spectrum risks overlooking the more troubling ideological limitations of community Wi-Fi network projects.

### 1. Techno-Fetishism

At an ideological level, community network projects often conflate the specifics of their technical infrastructure with the kinds of social and economic behaviors the community network hopes to cultivate. Primavera de Filippi once argued that such technical infrastructure offered ‘an internet-native model for building community and governance’, for example.[[8]](#footnote-8) Thus, non-hierarchical, decentralized or distributed topologies are often held to actually cultivate equally non-hierarchical forms of interpersonal cooperation within the network, while technical features such as the ability of devices to dynamically connect, and for networks to form and reconfigure without the need for a centralized intermediary, are confused with principles such as democratic decision-making and non-hierarchical social structures.

Christina Dunbar-Hester’s work on cooperation in hacker, maker, and open-source radio communities shows that the opposite may be the case:[[9]](#footnote-9) there are practices at work in the imagined community of the wireless commons that are strongly exclusionary on the basis of education, gender, race and class. New entrants to technical and politicized spaces often experience resistance from the existing community – there is a need, or implied demand, for one to demonstrate that one should be accepted, via displays of different forms of linguistic, technical and/or social capital.

As one example, there is a significant gender gap in digital activist communities, and in radio activism in particular. As Christina Dunbar-Hester has said of micro-radio communities, ‘these practices have a long history of association with white middle-class masculinity’.[[10]](#footnote-10) This goes back to the exclusively male environments of early wireless clubs, synonymous with the fantastical ‘boy’ inventor,[[11]](#footnote-11) right up to the gender composition of mesh-networking communities today. Often, there is a denigration of women and a devaluation ‘women’s work’ within these networked activist communities, however closely certain historically and stereotypically ‘feminine’ forms of cooperation and communication may resemble the very forms of cooperation that these communities hope to cultivate.[[12]](#footnote-12) Issues of class and race are also sometimes overlooked in the construction of networked activist communities. Digital activism is often tied in with communities and practices that have high cultural capital.[[13]](#footnote-13) Then, there is also the cost of participation: when and if community networks engage in electronic forms of civil disobedience, the consequences may be much greater for people of color than for their white counterparts.[[14]](#footnote-14) Then again, there are instances when it is possible to argue (as Larissa Mann does, in her work on pirate-radio communities) that exclusion isn’t always a bad thing:[[15]](#footnote-15) in contrast to the agnostic openness of the open-source community, for example, a level of access-control can be part of what allows a group to form a coherent identity. All of which suggests that we have to let go now, if we have not done so already, of an idealized image of community networks as democratically ‘open’ spaces.

### 2. The Limitations of ‘the Commons’, as Understood Among Community Networks

Community networks may argue that radio spectrum is, and should be treated as, a ‘commons’, but the way this concept has been utilized doesn’t challenge contemporary property relations, models of progress or the subjectivities that capitalist networks cultivate. In 2001, a number of key individuals involved with alternative wireless networks penned the Wireless Commons Manifesto, a framework for developing a global, independent, open, public network. The authors stressed the need to scale and federate localized wireless networks so that they might present as a viable alternative to dominant commercial telecommunications infrastructure, and argued that: ‘the network is a finite resource which is owned and used by the public, and as such it needs to be nurtured by the public. This, by its very nature, is a commons.’[[16]](#footnote-16)

As in the above quotation, the most frequent representation of the commons in wireless activism equates the notion of a spectrum commons with that of public goods such as national forests or fish stocks. This pragmatic approach to ‘the commons’ as a particular kind of ‘resource’ that is conducive to collective ownership, akin to Elinor Ostrom’s definition of ‘common-pool resources’[[17]](#footnote-17) is quite distinct from thinking of it as a set of practices or subjectivities, as suggested by more radical theorists of ‘the common’ and ‘commoning’.[[18]](#footnote-18)

Ostrom’s work on common-pool resources is instrumental in demonstrating that not all goods need to be governed through private property, and suggesting that certain goods might be best provisioned in fluid or cooperative ways. However, nowadays, in the face of the broader sharing economy, this appears as good old common sense, rather than radical economics; and, in the context of community networks, the treatment of the commons as an economic good per se fails to challenge the ownability of communications.

Furthermore, cooperation in the wireless commons often includes economic principles for incentivizing collaboration. The imagined user within the community wireless network is an economic actor who needs to be nudged in the right direction with appeals to self-interest. Ostrom goes a long way toward disproving Garret Hardin’s theory of ‘The Tragedy of the Commons’, which argues that individuals are too self-interested to manage resources without price or state regulation.[[19]](#footnote-19) In contrast, Ostrom documents many instances where communities have collectively managed goods outside of public or commercial control. Nonetheless, Ostrom’s rules for governing the commons tend to focus on competitive principles for managing cooperation. In line with this argument, Pierre Dardot and Christian Laval claim that Ostrom’s conception of the ‘commons’ supplies not only a system of rules that can be applied to the government of a shared resource, but also a set of inducements for structuring individual behavior. In this sense, they argue, Ostrom is part of the problematic of neoliberal governmentality, according to which ‘the conduct of individuals can only be led by a combination of incentives and disincentives’.[[20]](#footnote-20) By beginning from the assumption that users are selfish, we may inadvertently create rules that entrench those behaviors.

Just as the 2001 Wireless Commons Manifesto emphasized the need to scale beyond the locality of community networks and the propagation limitations of 2.4 GHz spectrum, the vision of the commons now held by community wireless networks is often based on a desire to build scalable alternatives to commercial or state infrastructure, something that’s increasingly difficult to accomplish in the face of monolithic platforms. ‘Scalability’ means that the scale of a project may smoothly be changed (usually increased) without change to the project’s structuring framework, and so to build, expand, and federate local relations.[[21]](#footnote-21) Scalability can be a very good thing, allowing alternative, non-market forms of cooperation to expand beyond a local level and so present as reasonable alternatives. However, the concept of scalability relies on a particular vision of what success or progress looks like, and it might not be the best one. The anthropologist Anna Tsing, for example, argues that scalability, wherein ‘progress’ is defined in terms of the ability to expand projects without transforming their framing assumptions, is a modernist project that requires project elements to ignore the messy indeterminacies of individual encounters,[[22]](#footnote-22) thus banishing, or overlooking, the kinds of meaningful diversity that might trouble or change things.

In sum, the ideology of ‘the commons’ that is most common among community wireless networks inadvertently reproduces many of the relations that they intend to work against. At the very least, they may be seen often to proceed from some of the same ideological assumptions that platform capitalism helps to reproduce – in this case, that: a) communication and social production are ‘things’ with definable boundaries that can be parceled out and managed; b) human agents are economic actors whose individual behavior needs to be nudged in the right direction; c) the directive to scale and federate should take precedence over the messiness of local relations.

Finally, it’sincreasingly difficult to speak of the commons today, when modes of open access, sharing, and cooperativism are no longer antithetical to the functioning of capitalism. Instead, these are now the very practices that shore up the system and keep things afloat. As neoliberal economies suffer through environmental degradation and falling profit margins, forms of social production such as these are now drawn inside the market, in a move which Paolo Virno refers to as the ‘communism of capital’,[[23]](#footnote-23) and George Caffentzis as the ‘neoliberal plan B’.[[24]](#footnote-24) If there was ever a moment when community Wi-Fi could be seen as diametrically opposed to commercial networks, that moment has passed. Increasingly, commercial networks see community-operated and maintained spaces as ‘positive externalities’ – free goods – to be exploited. One example is the now-common practice wherein commercial mobile networks offload their own congested traffic into open Wi-Fi networks.[[25]](#footnote-25) The complexity of the current situation makes it much harder to speak of open networks, or resistance in these spaces, as alternative to, or outside the dominant economic system.

## Imagining Alternatives

I found these issues hard to grapple with. If community networks and their alternatives are not the answer, where, and to what else, might we begin to look? Is it perhaps, rather, about asking different questions of existing network infrastructures? Instead of asking how community networks might present alternatives to commercial infrastructures and platforms, for example, could it be more fruitful now to ask what seeds of resistance and ways of commoning might be flourishing within these commercial spaces themselves? Imagining, or fictioning, offers one approach. At a Radical Networks event in New York,[[26]](#footnote-26) October 2015, Rob Ray and Adam Rothstein presented a speculative narrative, entitled ‘A History of the Future of Solarpunk Ham Radio Club’. Let’s start with their story:

In 2016, three coastal super-storms flooded most of the West Coast of the United States, destroying all critical infrastructure. A small, previously unknown group calling themselves ‘The Solarpunk Ham Radio Club’ emerged to fill the communications void. Building on the detritus of a failed infrastructure, they re-established autonomous networks of communication; drying out coaxial cable, rescuing speakers and batteries from abandoned vehicles and constructing antennas from salvaged tin cans and scrap metals.

This was not so much about rebuilding as it was about working *within* disorientation, distress and breakdown. The new infrastructure that grew up was a ‘Jugaad’, built via the quick-and-dirty engineering of whatever was readily available:[[27]](#footnote-27)ad hoc mesh-networks and phone systems; low-powered FM; packet-radio internet; hacked FRS and GMRS radios, and a D-star repeater controlled by a Raspberry Pi. The members established skill-shares, and taught analog radio and basic electronics. The Solarpunks couldn’t duplicate the old infrastructural models, but nor did they want to. Through making-do and repurposing, they found ways of working together and learning from one another, and these practices made their networks resilient in a way that monetary investment alone could not have.

As described here, the Solarpunk Ham Radio Club is a ‘degrowth’ movement for amateur radio makers. ‘Solarpunk ham radio’ indicates a shifting away from many of the features of information capitalism, such as centralized network control and ubiquitous surveillance; it also constitutes an attempt to move past some of the common pitfalls of digital activism, and to establish a new ethics of communications infrastructure. The Solarpunk Radio story featured here reimagines relationships to communications and the materiality of networks, where connectivity relies as much on social bonds as technical architecture. The model stresses self-governed networks and peer-production, but with a focus-shift from universal service provision to individual applications and use-cases, and from macro-level infrastructures to quite local and situated innovations. There is also an emphasis on material ingenuity, in the ways the networks are designed and implemented.

I find this story useful as a blueprint for beginning to rethink commoning in community networks: not as a project that requires decentralized topologies or scale or economic incentives, but as a set of practices that can support, nourish, and innovate from subject-positions of precarity and disillusionment.

This Solarpunk-imaginary has echoes of Lizzie Borden’s *Born in Flames,* a 1983 film that depicts a future pirate-radio community peopled by black and queer women who – finding that they are still marginalized in the aftermath of a social-democratic revolution that has failed to bring justice to women and minorities, and is instead backsliding into pre-revolutionary white-patriarchal structures – use wireless media to ‘reformulate desire and rekindle hope’.[[28]](#footnote-28) Two pirate radio stations run by women – Radio Ragazza and Phoenix Radio – come together to contest the situation by troubling mainstream representations of their post-revolutionary society. Using guerilla tactics, they take over mainstream media in order to ‘redirect meaning […] reclaim the language’.[[29]](#footnote-29) Like the Ray and Rothstein’s Solarpunk-imaginary, Borden’s film constitutes anti-capitalist critique; the film can also be read as a critique of left-hacker culture and its promise of a universalism and equality which, in practice, threatens to betray its constituent social movements, and all of their most radical possibilities. Both the Solarpunk fiction above, and *Born in Flames*, model ways of using infrastructure as a mode of resistance; in both cases, a radical aesthetics is performed from a position of precarity and disequilibrium. Significantly, both of these fictions describe ways of working *through* dystopia, creating political agency in situations that may seem hopeless or beyond redemption. See also, Anna Tsing’s work: ‘What emerges in damaged landscapes, beyond the call of industrial promise and ruin?’.[[30]](#footnote-30)

### Inventive Material Practices

As well as being a speculative imaginary of how our networks could be otherwise, The Solarpunk Ham radio story models some of the possibilities of existent inventive material practices that run counter to network capitalism, including the hacking, repurposing and reverse-engineering practices inherent to community wireless networks, Shanzai phone culture,[[31]](#footnote-31) and Indian Jugaad culture.[[32]](#footnote-32)

Inventive material practices have been a part of community radio cultures from their inception.[[33]](#footnote-33) In the early days of amateur radio, makers shared details of the best domestic materials with which to build radio sets, including bicycle parts, steel bed frames, and cake tins; the Quaker Oats can was a particular favorite.[[34]](#footnote-34) More recently, Katrina Jungnickel’s 2016 sociological study of backyard Wi-Fi technologists describes the rich material cultures of community wireless networks, involving scavenging, gleaning, signal stumbling,[[35]](#footnote-35) and various ad hoc modifications to off-the-shelf electronics.[[36]](#footnote-36) Today, many wireless communities around the globe hold workshops in, for example, antenna-building; maker sites detail how to home-make radio antennas and waveguides with coffee cans, electric fans, Pringles tins, and kitchenware,[[37]](#footnote-37) while software radio communities are putting together powerful devices that can mimic base stations, using cheap USB television tuners sourced online.[[38]](#footnote-38)

Collated by the artist Roel Roscam Abbing, *Pretty Fly for a Wi-Fi* is an archive of wireless antennae built from everyday materials. Pots and pans, cans and plastic, discarded kitchen implements, and other trashed items are combined with careful calibration. For the project, and as a testament to a vision of alternative infrastructure, the artist built, tested, and documented these experimental designs for antennae, revisiting ‘their histories, origins and uses’ in the process.[[39]](#footnote-39) One image shows a plastic CD-container spool, now-defunct, at the center of an antenna; others feature, respectively, a used-sardine-can antenna casing; a sieve; a wok, a plastic water-bottle, and a potato-steamer. Each object evokes an alternative internet, engaging the individuals and groups who have tried to reconfigure the dominant infrastructure to meet specific needs and desires. These inventive material practices, often falling somewhere between art-making, critical design interventions, and responses to material necessities, articulate a challenge to the business models of the platform and the commercial network, as follows:

First, these inventive practices provide a necessary antidote to the proprietary nature of network infrastructure. Two significant developments in open-source wireless networking have emerged from willfully inventive actions such as these, in which proprietary hardware devices were opened, examined, and played around with until the engineer in question could reliably reproduce their schematics. In 2004, the Catalonian engineer Ramon Roca purchased a bunch of Linksys wireless routers on a trip to California. His examination of them would become the starting point for guifi.net, the world’s largest independent wireless network, running through Spain. Likewise, the open-source programmer Harald Welte’s 2006 decision to reverse-engineer some base stations he purchased on eBay formed the basis for much of the open-source cellular software underpinning the Rhizomatica network.[[40]](#footnote-40)

Second, the pedagogy that surrounds inventive material practices such as these itself often embodies a belief that both this knowledge, and the signals it enables to be conveyed, are themselves a kind of commons. If you attend a NETworkshop at Weise7,[[41]](#footnote-41) or at Radical Networks,[[42]](#footnote-42) for example; or an antenna-building BattleMesh workshop;[[43]](#footnote-43) you’ll see that material know-how is circulated and given away for free.

Third; making, tinkering around and taking things apart helps to make both the models and the politics of wireless systems more explicit. Sending a file over a packet-radio network, or delving into what it takes to build your own ad hoc mesh, introduces a user to the ins and outs of communication protocols. As such, this sort of ‘messing around’ is so much more than ‘just’ messing around – it’s a political practice. And, while we shouldn’t idealize these practices, and need also to recognize the ways in which they are often reincorporated into commercial systems, we should also recognize the spaces in which they occur as those of imaginative and materially discursive resistance to capitalist enclosure. We might go so far as to suggest that it’s in these kinds of practices, rather than in manifesto-style calls for open access, that ‘commoning’ truly occurs.

 

 

Fig. 1-4: Roel Roscam Abbing, *Pretty Fly for a Wi-Fi*, 2014.

### Local and Offline Networks

One of the most intriguing aspects of the Solarpunk Ham radio imaginary is the way it abandons typical modernist ideas of progress and success when it looks to the future of community networking. These are networks where scalability and seamless global connectivity are no longer desirable end-points. Instead of viewing the often limited, often closed spaces of community wireless networks as signs of failure, could we start to think of these as blueprints for other ways of networking in the world?

In an effort to incorporate more-than-human entities into networks, the artist Tega Brain designs wireless routers to function according to particular environmental constraints, so that seamless connectivity is no longer the end goal. In the 2016 device-series *Being Radiotrophic*,Brain has created three wireless routers, devices that are normally designed to pick up broadband signals and transmit them through an urban space as effectively as possible, and made their signals contingent on haptic external elements. ‘An Orbit’ produces signals that wax and wane with the lunar cycle, while ‘The Woods’ is a hybrid house-plant/router whose connective properties are disrupted if the plant isn’t watered frequently enough. ‘Open Flame’ associates internet connectivity with a lit candle, cutting out whenever the candle is extinguished.[[44]](#footnote-44) Much like Anthony Dunne and Fiona Raby’s explorations of electromagnetic connectivity and associated devices in *Hertzian Tales*, these speculative objects are material prompts to rethink connectivity.[[45]](#footnote-45) In Brain’s devices, wireless is not the seamless, global mesh of the 5G-imaginary. Instead, the devices probe, disrupt and cause the viewer to speculate about the kinds of contingencies and care that communications may require in future.

Larissa Mann’s research concerns pirate-radio stations run by diasporic communities in Brooklyn, which, Mann suggests, are a way for marginalized communities to claim space for themselves, to build and reinforce their own communities through language and culture, and to circulate important information and resources. In contrast to the idea of radio as a boundless broadcast medium, many of these pirate stations operate within very localized geographies. And, far from offering the kind of open access that is so often extolled in certain forms of alternative media, access to participation in these stations must be negotiated. In terms of material practices (and despite the relative density of licensed radio stations in the New York area), it is notable that these communities continue to use analog broadcast technologies instead of availing themselves of internet alternatives such as online messaging, social media or digital radio technologies.[[46]](#footnote-46)

Here, these community networks present with material practices that are *not* integral to the sphere of cutting-edge digital practices such as open-source, blockchain and decentralized mesh networks, but, rather, as revenants of contemporary communication technologies’ past. These networks are not scalable, nor do they strive for scalability; they are neither distributed nor decentralized, but, rather, localized, finite, pragmatic; perhaps even closed; and they may be managed in agonistic ways. How do these networks allow us to think differently about the limitations of wireless media? Might we view their characteristic propagation and physical interactions with specific environments as unique strengths, rather than as limitations? Perhaps we might also re-think the roles of noise and positive disruption in our networks? Could these, in a real sense, be contributing more-than-human agencies to our networks, enabling more-than-human connectivity?

Practices such as these offer other models for the commons and the community network: models that are not governed by ideas of progress, scalability, techno-social democracy, or by game-theory models of human cooperation. Such practices may be hidden in plain sight; often they emerge from very pragmatic relationships at the margins of neoliberal capitalism, from crisis and ruin and from not having enough. They are not utopian or ideal; they exemplify micro-strategies that a) work and b) embrace positions of pragmatism, of precarity; of locality rather than scalability; and of difference, agonism and even discord, rather than technologically enabled cooperation; of seamfulness and patchiness rather than seamless connectivity.

1. See for example, Susan J. Douglas, *Inventing American Broadcasting, 1899-1922*, Baltimore, London: Johns Hopkins University Press, 1987; and early accounts of amateur radio activities in The Marconigram, later Wireless World, which featured a regular supplement on set construction and technical assistance for enthusiasts. [↑](#footnote-ref-1)
2. IEEE 802.11 is part of a set of Local Access Network protocols used for implementing wireless local access networks (WLANs) in frequencies including the 2, GhZ and 5GhZ bands. The base version of the standard was released in 1997 and subsequently formed the foundation protocol for Wi-Fi network products. [↑](#footnote-ref-2)
3. War-driving produced online maps, while war-chalking was a practice where open and closed nodes were marked in physical space using spray paint or chalk. War-driving continues today with websites such as WiGLE.net [↑](#footnote-ref-3)
4. Cory Doctorow, Paul Holman, Bruce Potter, Adam Shand, et al., ‘The Wireless Commons Manifesto’ (2001), https://github.com/greyscalepress/manifestos/blob/master/content/manifestos/2002-12-30-Wireless-Commons-Manifesto.txt. [↑](#footnote-ref-4)
5. Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge: Cambridge University Press, 1990. [↑](#footnote-ref-5)
6. See, respectively, ‘The Compact for a Free, Open & Neutral Network (FONN Compact)’, https://guifi.net/en/FONNC; ‘Pico Peering Agreement v1.0’, http://picopeer.net/; ‘Network Commons License’, https://wiki.p2pfoundation.net/Network\_Commons\_License. [↑](#footnote-ref-6)
7. The best example of the latter is Rhizomatica in Oaxaca, Mexico; an open-source phone network that operates in the absence of rural cellular infrastructure. See Rhizomatica, https://www.rhizomatica.org/. [↑](#footnote-ref-7)
8. Primavera De Filippi, ‘It’s Time to Take Mesh Networks Seriously’, *WIRED Magazine* (2 January 2014), https://www.wired.com/2014/01/its-time-to-take-mesh-networks-seriously-and-not-just-for-the-reasons-you-think/. [↑](#footnote-ref-8)
9. Christina Dunbar-Hester, *Low Power to the People: Pirates, Protest and Politics in FM Radio Activism*, Cambridge, MA: MIT Press, 2014. [↑](#footnote-ref-9)
10. Dunbar-Hester, *Low Power to the People*, p. 187. [↑](#footnote-ref-10)
11. See Douglas, *Inventing American Broadcasting*. [↑](#footnote-ref-11)
12. Hilary Wainwright, speaking at procomuns meetup, Barcelona, March 2016. [↑](#footnote-ref-12)
13. Juliet Schor, ‘How to Build and Sustain Cooperative Platforms’, presented at Platform Cooperativism, The New School, New York, 15-16 November 2015. [↑](#footnote-ref-13)
14. For example, Stephen Dunifer, white, of Free Radio Berkeley was threatened by the FCC with a significant fine for operating a pirate radio station, while Mbanna Kantako, the black instigator of a similar free radio station in the Bay Area, experienced intimidation, destruction of personal property and imprisonment for continuing to operate. Lorenzo Komboa Ervin, ‘Attack on Black Liberation Radio’, in Ron Sakolsky and Stephen Dunifer (eds) *Seizing the Airwaves: A Free Radio Handbook*, Scotland: AK Press, 1998, pp. 117-120, p. 119. [↑](#footnote-ref-14)
15. Larissa Mann, ‘Pirate Radio: Nonlinear Innovation for Autonomous Culture’, presented at Radical Networks, Berlin, 2018. [↑](#footnote-ref-15)
16. Doctorow et al., ‘Wireless Commons Manifesto’. [↑](#footnote-ref-16)
17. Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge: Cambridge University Press, 1990. [↑](#footnote-ref-17)
18. See, respectively, Michael Hardt, ‘The Common in Communism’, *Rethinking Marxism*22 (3) (2010): 346-356; Peter Linebaugh, *The Magna Carta Manifesto: Liberties and Commons for All*, Berkeley: University of California Press, 2008; David Bollier, ‘Commoning as a Transformative Social Paradigm’, *The Next System Project* 28 (2016), https://thenextsystem.org/commoning-as-a-transformative-social-paradigm. [↑](#footnote-ref-18)
19. Garrett Hardin, ‘The Tragedy of the Commons’, *Science* 162 (3859) (1968): 1243-1248, https://science.sciencemag.org/content/162/3859/1243. [↑](#footnote-ref-19)
20. Pierre Dardot and Christian Laval, *Commun. Essai sur la révolution au XXIe siècle*, Paris: La Découverte, 2015. [↑](#footnote-ref-20)
21. Anna Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*, London: Princeton University Press, 2015. [↑](#footnote-ref-21)
22. Tsing, *The Mushroom at the End of the World.* [↑](#footnote-ref-22)
23. Paolo Virno, *A Grammar of the Multitude*, London: Semiotext(e), 2003. [↑](#footnote-ref-23)
24. George Caffentzis, ‘The Future of “The Commons”: Neoliberalism's “Plan B” or the Original Disaccumulation of Capital?’ *New Formations* 69 (2010): 23-41. [↑](#footnote-ref-24)
25. Unknown Author, ‘More than 60% of global mobile data traffic will be offloaded onto WiFi networks this year’, *Fon.com* (Madrid, 07 April 2017), https://fon.com/pr-mobile-data-traffic-will-offloaded/. [↑](#footnote-ref-25)
26. Radical Networks is a series of conferences held in New York and Berlin, at which this kind of imaginative engagement with the actual and speculative possibilities of wireless activism is currently ongoing. [↑](#footnote-ref-26)
27. Jugaad is a form of innovation, common in India, in which technical fixes are improvised using available resources. For more, see Amit S. Rai, *Jugaad Time: Ecologies of Everyday Hacking in India*, Durham, NC: Duke University Press, 2019. [↑](#footnote-ref-27)
28. *Born in Flames* (dir. Lizzie Borden, 1983). [↑](#footnote-ref-28)
29. Betty Sussler, ‘Lizzie Borden by Betty Sussler’, *Bomb Magazine* (October 1983), http://bombmagazine.org/article/333/lizzie-borden. [↑](#footnote-ref-29)
30. Tsing, *The Mushroom at the End of the World*, p. 18. [↑](#footnote-ref-30)
31. Roel Roscam Abbing and Dennis de Bel, *R&D: A Low-end Rich Media Publication*, Rotterdam: WORM Parallel University Press, 2014. [↑](#footnote-ref-31)
32. Rai, *Jugaad Time*. [↑](#footnote-ref-32)
33. See, for example, the work of The Critical Engineering Working Group, https://criticalengineering.org/, and the artist/engineer Surya Mattu, https://www.suryamattu.com/#/. [↑](#footnote-ref-33)
34. Douglas, *Inventing American Broadcasting, 1899-1922*. [↑](#footnote-ref-34)
35. Arguably, this attitude extends not only to hardware and software interventions in wireless networks, but also to the mapping of radio signals and network connections. ‘Stumbling’ is a practice wherein community network users move through a geographic area in the vicinity of their network, to see if they can locate the signal of the network and form a new network connection. If a signal can be identified, a line-of-sight base station will be installed to extend the network. The term ‘stumbling’ captures the embodied and imprecise nature of the practice (not unlike the opportunistic ‘poking around’ involved in ‘circuit-bending’ on the listen for new connections), which is quite different to the ‘polarity calculations’ of commercial engineering. [↑](#footnote-ref-35)
36. Katrina Jungnickel, *DIY WiFi: Re-imagining Connectivity*, London: Palgrave Macmillan, 2016. [↑](#footnote-ref-36)
37. See, for example, Diana Eng, ‘Listening to Satellites with a Homemade Yagi Antenna’, *MAKE: PROJECTS* (18 December 2012), https://makezine.com/projects/make-24/homemade-yagi-antenna/. [↑](#footnote-ref-37)
38. In 2013, hackers started to repurpose USB television tuners in order to reach a range of frequencies from 24 MHz to over 10000 MHz. Such tuners currently cost approximately 20 € and are readily available from Amazon and Alibaba, for example. Combined with open-source applications such as GQRS, broadcast signals can easily be turned into readable data. Marc DaCosta describes applications including downloading images form weather satellites as they fly overhead; tracking airplanes that fly nearby; and even using information from unintentional radio emissions to reconstruct computer interfaces. Marc Da Costa, ‘How To Explore The Hidden World Of Waves All Around You’, *Vice Magazine* (18 December 2017), <https://www.vice.com/en_us/article/59wpmn/how-to-explore-the-hidden-world-of-radio-waves-all-around-you> [↑](#footnote-ref-38)
39. ‘Pretty Fly for a Wi-Fi’, http://v2.nl/archive/works/pretty-fly-for-a-wifi. [↑](#footnote-ref-39)
40. Andrew Back, ‘Building a GSM network with open source’, *The H* (26 March 2012), http://www.h-online.com/open/features/Building-a-GSM-network-with-open-source-1476745.html%3Fpage=2. [↑](#footnote-ref-40)
41. The Critical Engineering Working Group, NETworkshops, e.g: https://criticalengineering.org/courses/networkshop/. [↑](#footnote-ref-41)
42. Radical Networks, https://radicalnetworks.org/. [↑](#footnote-ref-42)
43. BattleMeshV12 Events, https://www.battlemesh.org/BattleMeshV12/Events. [↑](#footnote-ref-43)
44. Tega Brain, *Being Radiotropic* (2016), http://tegabrain.com/Being-Radiotropic. [↑](#footnote-ref-44)
45. Anthony Dunne, *Hertzian Tales: Electronic Products, Aesthetic Experience and Critical Design*, Cambridge MA: MIT Press, 2006. [↑](#footnote-ref-45)
46. Mann, ‘Pirate Radio: Nonlinear Innovation for Autonomous Culture’. [↑](#footnote-ref-46)