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An initial assessment of cooperative action in Wi-Fi networking

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Abstract

In the development of past infrastructures, cooperative and amateur action has been a vehicle for diffusion, experimentation, innovation, popularization, and the provision of new features or services. 802.11 (“Wi-Fi”) cooperatives are now proliferating. This user study considers three cases of cooperative action in the discovery, development, and provision of 802.11 (Wi-Fi) networks: (1) mapping and “Warchalking,” (2) open-source portal software, and (3) the provision of service as an alternative to paying for a commercial subscription. It finds that these co-ops exist primarily to build elite expertise, but that it may be possible to direct these skilled groups toward societal goals.

Keywords: Wireless; Innovation; Popularization; Infrastructure; Unlicensed; 802.11

1. Introduction

Free or low-cost wireless Internet access is now being produced across the urban developed world by groups of cooperating individuals. The proliferation of these Wireless Internet “co-ops” has produced claims that “ad hoc, self-organized networks of grassroots users…now challenge existing technologies, regulatory regimes, and industries” (Rheingold, 2002: see Chapter 6) but “whether wireless guerrillas blanket the world with inexpensive high-speed Internet access before the big players crush them remains to be seen” (p. 133). The prospect that they might success has captured the imagination of many in the popular press and beyond, leading to conclusions such as: “While [this] might not be the best technical solution for the last mile…[it] is the most

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cost-effective'' (Escudero, 2003, p. 1). At the most extreme, cooperative Wi-Fi has been hailed as ''a broadband system built by the people and for the people'' that means, ''everything you assumed about telecommunications is about to change'' (Negroponte, 2002).

This ''guerrilla'' movement is no surprise to scholars of telecommunication policy. ''Infrastructures'' are often thought to be large-scale projects best attempted by large entities: governments build roads and telecommunications companies provide phones. But historically, co-ops also built roads, and farmers provided their own phones—although sometimes not very good ones. When is a decentralized, cooperatively run communication infrastructure a significant alternative to the centrally driven, commercial systems that have historically prevailed? The research literature on utility and communication infrastructures answers, ''almost never,'' or ''only in the early stages of a system.'' In electricity (Hughes, 1983), radio broadcasting (Douglas, 1989), and the telephone (Fischer, 1992), amateur and co-op involvement in early phases of a system's development produced innovation and popularization benefits, and in a few cases amateurs and co-ops appear to remain significant in the longer-term: from the Ocean Spray agricultural co-op in the US to Scandinavian broadband collectives. This user study considers 802.11 (Wi-Fi) related co-ops in the US and UK, assesses their role in system development and the likelihood of any benefits to society in the context of this previous research, and considers what role public policy action and further scholarly research might play in realizing any benefits from co-ops.

Previous research predicts co-ops to be a vehicle for experimentation, innovation, diffusion, popularization, and the provision of new features or services. As Schuler (1994) has noted for Community Networks, these loose groupings of people might be dedicated to a number of very different tasks, from education to provision. Similar to Fischer's (1987a) analysis of rural telephone co-ops, each role might also trigger different weaknesses (disorganization, unreliability, lack of expertise) and also strengths (flexibility, heightened awareness of public-interest concerns, low cost). The study employs empirical research in three case studies in an embedded, multiple-case design sampled to replicate earlier findings about co-ops (after Yin, 1994). Each case concerns a different area of wireless Internet service: discovery, development, and provision. For network discovery, it analyzes Wi-Fi mapping as a low-tech, cooperative version of federated network discovery services like *Boingo*. For development, it analyzes co-op produced *NoCatAuth* software as an alternative to the commercial gateway demons found on devices like 3Com's Home Wireless Gateway. For provision, it considers the *Consume* co-op's attempt to build a parallel Internet infrastructure through self-provision in the UK as an alternative to ISPs like *BT OpenWorld*. Consistent with von Hippel (1988); (and see von Hippel & von Krogh, 2003), significant innovation benefits can be produced by users in a co-op setting. This suggests a number of possible strategies for telecommunications policy: co-ops can indeed be superseded by commercial infrastructure as the system develops, or they can be employed as an important adjunct to carriers, providing service in commercially undesirable areas and addressing public goals that other organizational forms could not.

First, this article will consider the role of such cooperative action in the previous literature on communication network development. Secondly, it will introduce Wi-Fi and the Wi-Fi co-op as a topic area. Then, the article will present the three empirical cases of (i) Wi-Fi mapping, (ii) NoCatAuth, and (iii) *Consume* as evidence of cooperative action. Finally, the article will compare the findings from these cases to the literature's treatment of co-ops, propose experimental policy proposals to harness co-ops and a set of research questions to further assess the place of the cooperative form in telecommunications.

1.1. Popularizers and innovators: the role of cooperatives in related literatures

This study will consider several activities from the range of Wi-Fi co-ops. Rather than settle on a single definition and use a dictionary's strictness to choose the cases, this article will instead continue to use "co-op" as it found it—an untidy agglomeration of non-commercial, activist, and amateur components. The literature on large-scale systems of communication has often analyzed co-ops, although sometimes as "independents" or "amateurs." Hughes' (1983) groundbreaking synthesis of the technical, political, economic, and social in the early development of electric utility systems advanced a loosely structured model of four phases: (1) invention and development, (2) transfer, (3) growth in scale, and then (4) the acquisition of momentum. Hughes was explicitly influenced by early systems theory (Parsons, 1951, 1966, 1971), itself an outgrowth of Wiener's (1948) cybernetics. Hughes saw that there was a role for amateur action at the inception of new technologies—as there is initially no profession for an innovation there can be no professionals. In Hughes's invention and development stage, it was the work of entrepreneurs that pushed the technology forward before it was stable enough to attract more organized financial interests. In this conception, co-ops are important at the introduction of a system, but then they fade away as the need for daring and tolerance for disorganization diminishes. This conception is consistent with other theoretical models for infrastructure development (such as the Infrastructure Development Model; Sawhney, 2002). Beyond electricity, the last 20 years have seen a new vigor in the study of sociotechnical systems *of communication*, especially studies employing historical methods (Streeter, 1996a). Inspired by the social constructivist movement in technology studies pioneered in part by Hughes (Bijker, Hughes, & Pinch, 1987; Bijker & Law, 1992; for a philosophical overview and critique, see Hacking, 1999), sometimes called "social shaping" (Williams & Edge, 1996), this study finds evidence that any given large system is special—each is so different that it requires its own analysis (Fischer, 1985; Hughes, 1987). Yet, the frequent occurrence of cooperative action in the literature begs for comparison.

The most direct comparison is the early development of radio. Douglas (1989) refines the concepts of strategy and structure from the history of the corporation (Chandler, 1962, 1977; Noble, 1979) and details how a realistic grassroots challenge to centralization was mounted by amateur enthusiasts and what she terms "the cult of the boy operator" before 1920. Other authors concur that, "by 1914… the largest system of communication by radio in the United States…was an ad hoc, nonprofit network run by…hobbyists" (Streeter, 1996b, p. 65; for a related account, see Smulyan, 1994). While these accounts agree that co-ops were crucial in early radio, they (at least implicitly) support Hughes's notion of an initial emphasis on the system benefits of the co-op.

Beyond radio, wireless co-ops are reminiscent of early telephone co-ops (Fischer, 1987a, b). Fischer's (1992) study of the telephone in the US before 1940 discovers a range of cooperative action during the independent era of telephony. Fischer develops the concept of *user autonomy*: while users are constrained by income, price, vendor action, and regulation, they are (1) relatively resistant to pressure from vendors, (2) not subject to a technological imperative, and (3) work to adapt a technology to their own ends. When telephone companies declined to provide features or even service, users simply formed a co-op and did it themselves. In this can be discerned a second role for co-ops beyond Hughes: they are a vehicle for the frustrated needs of users that cannot find satisfaction in the offerings of existing vendors. Like Hughes, Fischer notes that these offerings are later commodified by successful firms.

1.2. Internet co-ops: community networks and public access centers

Contemporary cooperative action has also appeared frequently in the research literature, often under other names. Some of the wireless co-ops later considered wish to portray themselves as the heirs apparent to the community networking (CN) movement (see Schuler, 1994, 1996). CNs include *PEN* in Santa Monica, CA (see Rogers, Collins-Jarvis, & Schmitz, 1994; Schmitz, Rogers, Phillips, & Paschal, 1995), *Netville*—a "wired suburb" of Toronto, Canada (Hampton & Wellman, 1999, 2000), *Blacksburg Electronic Village* and the *Seattle Community Network* (Silver, 2004). For a review of the research on CNs, see Harrison and Stephen (1999). While some CNs may operate Wi-Fi services, cooperative action in Wi-Fi comes in a number of flavors beyond provision and training, and in this only the Wi-Fi co-ops related to provision and training are comparable to CNs. Also relevant are governmental initiatives at community centers and public libraries aimed at providing access to the Internet. While these attempt to serve many of the same goals as CNs (Straubhaar, LaPastina, Lentz, Main, & Taylor, 2000), aside from the CNs that are run by governments, public access centers are often considered separately by the research literature (for example, Sandvig, 2003; for a collection, see Kahin & Keller, 1995). In the interdisciplinary *social informatics* tradition (Kling, 2000), O'Neil (2002) reviews the research to date on both CNs and public access centers, finding five broad normative themes within which past research has located the consequences of "community" informatics: (1) "strong" democracy, (2) social capital, (3) individual empowerment, (4) sense of community, and (5) opportunities for economic development (pp. 79–82). These categories will be applied below after an examination of co-op activity in the area of Wi-Fi, as this seems to provide a set of motives beyond innovation and popularization that can explain the co-op in telecommunications.

This review anticipates co-ops rising to prominence in the early stages of a large-scale system as a vehicle for experimentation, innovation, diffusion, popularization, and provision of features or services that are not on offer from commercial vendors. Much of the literature implies that the co-op form will later wane in importance, but studies of CNs suggest a five-fold typology of consequences that may also be significant reasons to expect co-ops to continue at any stage in a system's development. Next, 802.11 wireless networking will be introduced before examination of the Wi-Fi case data.

2. An overview of Wi-Fi networking

In industry circles, a medium-range wireless data technology now called "Wi-Fi" was thought to be a means by which individuals could solve small networking problems in their home or office. Wi-Fi employs unlicensed spectrum, and anyone can build a network linking computers within a range of about 150 ft simply by buying the equipment.[1] With the introduction of the Apple AirPort in late 1999, Steve Jobs promised users that, "it's a liberating experience to surf the

[1] Wi-Fi employs the spectrum made available in the FCC's Part 15 rules for unlicensed operation.

Internet…while freely moving about your home or classroom.''[2] Echoing Fischer's concept of user autonomy, however, people have had other ideas about where they wanted to freely move.

Wi-Fi installations over the past 4 years have produced a ''cloud'' of Wi-Fi connectivity in many metropolitan areas similar in density to that produced by earlier coordinated commercial data networks such as *Metricom's* Ricochet.[3] This cloud is composed of heterogeneous networks that interoperate by accident as often as by intent. Individuals purchased Wi-Fi devices such as the AirPort to connect a computer in the den to a cable modem in the living room without having to re-wire their house, but the result of many such individual purchases has been that laptop users all over the world are surprised to find that when they open their computer in an unfamiliar place, they have Internet connectivity—through generosity, ignorance, or security failure of some unknown network. At the talks leading to the development of the 802.11 protocols, also called ''Wireless Fidelity'' or ''Wi-Fi'' (see Institute of Electrical and Electronics Engineers, 1999), interoperability was of paramount importance, not security. The result was a default implementation of Wi-Fi products that easily allowed any Wi-Fi device to communicate with any other. Wi-Fi access points (APs) were initially set up by individuals in scenarios that echo Steve Jobs' speech: a homeowner with a cable modem on the first floor and a home office on the second floor who does not want to run wiring to connect them might buy a Wi-Fi AP to bridge this distance. Wi-Fi networks meant to support many users across several APs are also set up by corporations, cafes, and governments.[4] In these functions, Wi-Fi is analogous to Ethernet wiring, although it can be more flexible and convenient. Indeed, an early name for Wi-Fi was ''Wireless Ethernet.''[5] At the same time, larger Wi-Fi ''meta-networks'' function more like a common directory and authentication system that allows sharing across many smaller networks.[6] For instance, early nationwide Wi-Fi providers in the US such as *Wayport*, *Surf and Sip*, and *T-Mobile* deployed hotspots in cafes, hotels and airports. Providers such as *Boingo* and *iPass* attempted to ''federate'' existing APs they did not own by offering centralized subscription, billing, software, and technical support (Bar & Galperin, 2004).[7]

In sum, Wi-Fi developed through individual and collective non-commercial or small-scale commercial action. While the first users were encouraged to use Wi-Fi to ''move freely about their home or office,'' they built an extensive cloud of connectivity that soon had large telecommunications companies entering the Wi-Fi market with a variety of strategies. It is the aim of this study to consider some of the early wireless co-ops

[2] This quote was taken from the Apple Press release archives: (http://www.apple.com/pr/library/1999/jul/21lucent.html).

[3] Ricochet is now defunct as a national system (see Cherry, 2002).

[4] In 802.11 terminology, an extended service set (ESS).

[5] This comparison to Ethernet aptly distinguishes Wi-Fi from other related wireless data technologies like *Bluetooth* (which uses the same spectrum at very short range to form Personal Area Networks), *3-G* (the ''third generation'' of mobile telephony which uses the spectrum assigned for mobile telephony to carry data as well as voice at high speeds). The failed standards *HiperLAN* (Europe) and *HomeRF* (US) provided similar functionality.

[6] No standards exist for true 802.11 roaming. Roaming solutions are proprietary and any roaming that involves nodes from more than one vendor may not work. Technically, macro-networks provide shared authentication—a user is allowed access from one of many ESSs, but may not move across ESS boundaries in real-time.

[7] This ''federated'' approach is particularly relevant to our second case study, which is about co-op developed software that allows non-commercial networks to be federated.

Table 1
Overview of cases and functions

Function	Cooperative	Opposed to
(i) Discovery	Warchalkers/mappers (Zhrodague)	Federated Wi-Fi ISPs (Boingo)
(ii) Authentication	Software developers (NoCatAuth/splash)	Default equipment (3Com Home Gateway)
(iii) Provision	Network operators (Consume)	Broadband ISPs (BT OpenWorld)

and assess their role in the development of Wi-Fi as a system, in light of the earlier research on cooperative action.

2.1. The scope and extent of Wi-Fi co-ops

Wherever there is Wi-Fi there are users cooperating to share it. In most metropolitan areas of the Western world, some of this cooperation has become organized enough to produce a group with a name, Web site and regular meetings. In early 2003, combining multiple directories of Wi-Fi co-ops produced 52 groups in six countries (the US, Canada, the UK, Ireland, New Zealand, Australia) with an extensive online presence in English.[8] Most cities have some kind of Wi-Fi-related cooperative effort: at the very least a traveling Wi-Fi enthusiast might use "International Wi-Fi Meetup Day" (the 2nd Wednesday of every month) to connect with like-minded tinkerers.[9] While CNs are fairly well-justified enterprises from a normative perspective, Wi-Fi co-ops are a much stranger animal. While some co-ops are outgrowths or projects of CNs, many are not. While activists and policymakers working on CN and public access projects take as a central premise that their facilities exist to provide free or subsidized access to underserved populations (the socioeconomically disadvantaged, underserved rural areas, etc.), Wi-Fi co-ops often exist to provide free access to an inexpensive service for the rich—it may take over a thousand dollars of personal equipment to participate in a co-op (laptop/palmtop, wireless card, etc.). In some areas co-ops have been employed to establish point-to-point broadband connections to rural households that are not served by cable modem or DSL services, but the bulk of Wi-Fi co-op activity is occurring in wealthier metropolitan areas.

The point here is not to characterize all cooperative action in Wi-Fi, but instead to strategically sample three contrasting functions that a co-op might serve and compare the operation of the cooperative form in each, then attempt to assess the societal benefits of cooperative action in these different circumstances. This samples for breadth and contrast rather than for generalizability, yet this paper will only consider functional areas that seem likely to be important to the communication system as a whole. Conceptually, a Wi-Fi system requires three things: (i) a mechanism for users to determine where access might be found: network discovery; (ii) a way to allow or deny users access: authentication;[10] and (iii) actual network transport: provision. Table 1

[8] For present purposes, "extensive" usually required a public mailing list archive to allow researchers to read the internal communications of the group.

[9] See: http://wifi.meetup.com/.

[10] It is possible that this function is not so important, and that the most relevant authentication mechanism will eventually be to allow anyone access to everything. This is still a policy of authentication, however, and this paper includes authentication because it is important here even for free or "open" networks, as will be seen in case two.

presents an overview of the three case studies, selected for each functional area. Each case has been listed with an opposition, as co-ops often define themselves in opposition to commercial activity, and these co-ops are no exception. First, the paper will discuss co-ops that produce maps and markings for network discovery: these are substitutes for national or federated Wi-Fi service maps provided by commercial ISPs. Secondly, it will discuss a software project called NoCatAuth that allows authentication services for free, open, or co-op network providers. This is meant as a substitute for the ordinary off-the-shelf gateway software that might be included in a commercial product such as the 3Com Home Gateway or commercial "splash screen" and credit card authorization implemented internally by Wi-Fi network providers that charge for service.[11] Third, it will consider *Consume,* a co-op network operator that attempts to use a cooperative system to provide transport and technical support as an alternative to a commercial broadband ISP like British Telecom's OpenWorld.[12] The following presentation of these three cases was generated by compiling and analyzing public primary source material from these co-ops (what members say to each other and what the co-ops say about themselves), supplemented where noted by secondary sources (what news reports say about these co-ops and what other researchers write about them).[13] The paper now turns to the first case study and the accidental discovery of sharing.

3. Case one: "Warchalking" and Wi-Fi mapping as network discovery

Finding Wi-Fi connectivity and contracting for access can be much more confusing than, say, subscribing to telephone service. On the corporate side, companies like *Boingo* address that need, offering the convenience of a national footprint by federating heterogeneous local networks. "Warchalking" is the grassroots equivalent, a decentralized *Boingo*. Directory service seems like a strange choice for decentralized action: telephone books are much preferred over collecting the telephone numbers of a city by word-of-mouth, and yet given that most of the telephone book is useless to any user most of the time, a local approach to a directory service might have some merit.[14]

Warchalking began in London on June 24, 2002 with Matt Jones, a former management consultant who noticed that he could obtain free Wi-Fi at several locations around the city when he stumbled upon "open" APs. He designed three symbols that—when marked on buildings with chalk—would indicate that a Wi-Fi AP was near. He posted these on his personal Web site.[15] This

[11] For instance, the software that matches Wi-Fi users to their billing account when they try to use a Wi-Fi hot spot run by a commercial ISP; typically these use Web redirection and SSL, RADIUS, or PPP-over-Ethernet authentication.

[12] *Consume* does not charge for service, and thus does not implement any billing.

[13] The primary source material for each case is extensive. An average co-op in the researcher's list of 52 might have a mailing list archive spanning 2 years containing 1000 messages, a large wiki (a Web-based collaboration tool), a chat channel, and a public Web site. Material was plentiful for the three cases. For instance, *Consume* (case three) has an archive of nine mailing lists spanning 4 years: at the end of 2003 this contained over 41MB of plain text.

[14] This comparison is not meant to be as fanciful as it may appear: in some post-socialist states the reliable telephone directories of the formerly state-run PTT have stopped appearing and been replaced by word-of-mouth "service" among groups of friends.

[15] The verb coined by Jones to mean the activity of finding and marking Wi-Fi access, "Warchalking," is a reference to "war dialer" software used by hackers (neé crackers) to call all of the telephone numbers in a given set of exchanges looking for the handshaking tones of a modem. The name "war dialer" is itself a reference to the 1983 hacker movie *War Games* starring Matthew Broderick.

Fig. 1. A comparison of discovery symbols.

received worldwide media coverage within a few weeks and spawned "Warchalkers" in most major cities where Wi-Fi exists.[16] Jones was inspired by the diverse lexicon of "hobo signs" prevalent in the depression-era US (see Fig. 1): the Warchalking symbol for a closed node is the same as the hobo sign meaning "nothing to be gained here" (for a review of hobo signs, see Richards & Associates, 1974; Vandertie, 1995).

Warchalking started in London, but it has been reported globally by the press and instances have been documented on the Web in most major cities of the world. Perhaps the most significant Warchalking occurs not with chalk, but with bits. Web-based geographic information systems (GIS) have been employed by "Wi-Fi Mappers" using free open-source tools and public map data.[17] These public connectivity directories allow anyone to type in a post code (or ZIP code) and determine the density of APs in a given geographic area. Individual users are then able to aggregate unaffiliated networks themselves. Instead of consulting a glossy map issued by a commercial service provider to see where Wi-Fi access might be found, a user can consult a free online directory like http://www.wifimaps.com/.

Because these maps promote APs that may be unintentionally public, the practice of Wi-Fi mapping has been surrounded by controversy: governments are considering whether or not unauthorized use of Wi-Fi should be considered theft, and whether or not Warchalking is simply a form of graffiti tagging that criminals use to choose victims. Telecom CEOs have made public statements urging the criminalization of Warchalking on the grounds that unauthorized users decrease performance for the network's owners.

3.1. Mapping databases as directory services

Warchalking symbols and Wi-Fi databases represent a large mass of data that were painfully collected. As Jones accidentally stumbled upon network access in London by opening his laptop in the right place, now these co-op network directory services require an army of network discoverers that will do the same and report back on what they have found through chalk or bits. The people who compile these directories are wireless enthusiasts with laptops or PDAs, a GPS device to plot their location, and a Wi-Fi card. Wi-Fi mapping databases (see Fig. 2) are easily

[16] See for example news coverage such as Hammersley (2002).

[17] See, e.g., NODEDB at http://www.consume.net/, http://www.wifimaps.com/, and http://www.netstumbler.com/.

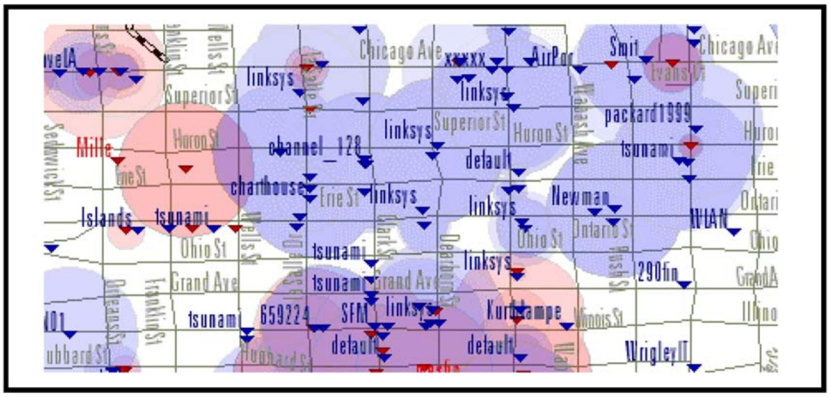

Fig. 2. Sample output from a mapserver: Chicago, IL by Zhrodague.

able to list APs because each has a unique identifier (the MAC) and may also have a human-interpretable name (the SSID—for example, ‘‘keepondriving’’) that can be correlated between reports from many contributors. The database estimates the location of each AP by averaging the GPS data from multiple samples, and it takes note of whether or not the network is open or running a simple form of encryption (WEP) that sometimes indicates whether the network is not available to ‘‘visitors’’ or free riders. The paper will further consider the army that finds these Wi-Fi APs by examining one Wi-Fi mapserver in more detail. In Fig. 2, APs are plotted on top of a public domain Chicago street map (the grid of lines with street names in gray), estimated AP locations are marked by triangles and named by SSID, and estimated coverage areas are marked by circles.

One of the most comprehensive US Wi-Fi mapping databases, http://www.wifimaps.com/, is produced by *Zhrodague*, a Pittsburgh, PA group of computer programmers. Fig. 2 depicts output from this mapserver. *Zhrodague* employed open-source software and census data generated by a University of Minnesota project (funded by NASA), then repurposed these to map Wi-Fi.[18] Maps such as Fig. 2 depend upon the large amount of public domain geodatabase information available from the government, as well as the wealth of free software for manipulating it produced by government-subsidized academic research and open-source developers. For these maps to be filled in with information about Wi-Fi, someone has to drive around the city discovering Wi-Fi networks. Users anywhere on the Internet are encouraged to submit data for the mapserver by a system of reputation ranking. The mapserver keeps an alias for any contributor that submits data and then (in a manner akin to the high score list of a video game) tabulates the number of APs the person has discovered. All of this is facilitated by standardization on a few free software packages that are used to gather and store this data: e.g., *Kismet* and *NetStumbler*. For an overview of the technical details of this mapping, see Byers and Kormann (2003).

[18]The mapserver is a very prominent one—it contains over 100,000 nodes and receives submissions from Warchalkers far beyond Pittsburgh: e.g., the screen shown is not for Pittsburgh, but for Chicago.

3.2. Motivations for mapping and the "army of cool"

While a commercial concern like *Boingo* might use field representatives to discover Wi-Fi networks and affiliate them, *Zhrodague* and wifimaps.com uses strangers and this system of reputation ranking. By also providing a bulletin board system, contributors can discuss technique, preferred equipment, and brag about their finds. Some of the reputation systems proposed by *Zhrodague* are very sophisticated. Although not implemented at the time of writing, one proposed way of filling blank areas of the map was to add a weight (or "bounty") to the reputation ranking of APs discovered in the blank area. In this manner, contributors could rise up the rankings even faster if they discovered networks in areas where no discoveries had yet been made, as these discoveries would have more reputation value. Contributors are sometimes referred to as an invisible "army." This is an army of enthusiasts who never meet, passing time compiling maps and uploading them to a co-op database that directs them on their errands.

Just as some of Fischer's early telephone co-ops did not provide very good service, considered skeptically, Warchalking does not seem to be a particularly effective directory system.[19] Bad weather might wash away a chalk mark,[20] the presence of a chalk mark alerts the network's owner that someone is sharing their service, the marks themselves are not particularly easy to see—if they are drawn on one side of a building and the user approaches from the other side, the directory service is wholly ineffectual. Furthermore, the mark for a closed network ("nothing to be gained here" in the hobo lexicon) makes the least sense, as it takes effort to make and maintain the mark, but it conveys no useful information to the wandering Wi-Fi user except "don't open your laptop here." If Warchalking were an effective directory service, the user would not be tempted to open his or her laptop while wandering the streets in any case, and so the mark is a wasted effort.

Logically, the more primitive Warchalking appears to be a precursor to the more practical GIS-driven Wi-Fi map databases like wifimaps.com, but databases like the *NetStumbler* mapserver were in operation before Warchalking was conceived. Warchalking received a large amount of media attention, and it may be that it is entirely a media phenomenon—a clever idea and a good story that gained wide circulation even though it was not actually happening in the manner that it was described. While many instances of Warchalking are recorded on personal Web sites (and in some central repositories like http://www.warchalking.org/), these are often instances of bragging where the user owns the Wi-Fi AP that was warchalked. Warchalking is then a way to affiliate with a subcultural community rather than a practical directory service, as predicted by two of O'Neil's consequences. First, Warchalking promotes *individual empowerment* by providing an excuse and a group practice around which to organize learning about wireless Internet technology, and it also promotes a *sense of community* by providing a means of affiliation.

[19] The material in this section comes from a mailing list challenge made by the author in November, 2002 to find people who actually used Warchalking as a meaningful directory service. The author wishes to thank the many correspondents that answered this challenge. Although none were able to provide a case of Warchalking as a meaningful directory service, their insights were very helpful. The challenge eventually evolved into a bounty (of $1) for an example —the bounty remains unpaid. Special thanks go particularly to Jeremy Hunsinger and Ben Partridge for their assistance in this effort. The bounty is chronicled at: http://www.niftyc.org/bet/.

[20] The traditional chalk marks used on the walls of Oxford colleges to denote rowing victories are often made on walls that are unprotected from the elements, and these chalk marks can last for 6–12 years.

GIS-based Wi-Fi databases appear to be more useful than Warchalking, and there are even reports that commercial providers attempt to "suck" the content of some co-op databases through repeated automated queries. However, it is remarkable how little discussion on mapserver bulletin boards is related to *using* the directory rather than *providing* it. Most of the talk centers on equipment, node discovery, and the technical and aesthetic problems of mapping. A frequent feature of personal Web pages, mailing lists, and discussion boards devoted to these directories is the exchange of maps, each more beautiful than the last, with a running commentary describing how the author achieved a glowing, gauzy purple cloud (representing Wi-Fi coverage), superimposed over an aerial photograph. It is the common practice of all of these directories to significantly overestimate Wi-Fi coverage by assuming a very large radius of coverage from the estimated center of each AP. Little comment is given to these fudges, and if the mapservers were regularly used by people trying to find Wi-Fi access, more discussion of this sort of design choice would be expected. When finding Wi-Fi service is mentioned in these fora, word-of-mouth and personal experience trump the mapserver's database, since the picture drawn by the mapserver is likely to exaggerate the available coverage.[21] This author conjectures that these beautiful maps serve as the poetry of the Wi-Fi army. Lured by reputation ranking into spending their time finding Wi-Fi APs, foot soldiers work to refine and trade their maps to demonstrate their exploits, not to provide a practical directory service for users. Next, the paper will consider the second case, the authentication function of network, and will turn to a software package that might be used by a Wi-Fi provider discovered by these mappers and listed in wifimaps.com.

4. Case two: NoCatAuth as an authentication service

Thinking about mapping and "borrowing" Wi-Fi prompts a consideration of selfishness and altruism: a central concern for all of social science. In the world of Wi-Fi, a Californian wireless co-op called *NoCat* is attempting to fix a solution to human selfishness in software code. Named after a famous Albert Einstein quote explaining the operation of radio,[22] NoCat is a Wi-Fi co-op active in the provision of service in Sonoma County. However, in their experience providing connectivity, the members of the co-op realized that there were coordination needs beyond provision that could be realized by cooperative action. As Rob Flickenger, a leader of the project, explained:

> While some node owners are perfectly happy opening their networks to whomever happens to be in range, most of us hesitate at the thought of paying for our neighbors to use our bandwidth. After all, apart from using up resources that we're paying for, anonymous users could potentially abuse other networks and have their shenanigans traced back to our network! If we want to provide responsible wireless access, we need a way of securely identifying users

[21] Scatter of Wi-Fi signals is quite significant and the actual picture of a Wi-Fi Access point would never be represented by a circle, as it is represented in a Wi-Fi mapserver.

[22] "You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is *no cat*."

> when they connect, and then only allocate the resources that the node owner is willing to contribute.[23]

(NoCat is also profiled briefly in print by Flickenger himself; see Flickenger, 2003.) NoCatAuth turns a computer running Linux/BSD into an AP and authentication gateway, granting the ability to provide any visitor with a welcome screen, terms of service page, and/or an authentication screen. In a manner virtually identical to what happens in a commercial Wi-Fi hotspot, when Wi-Fi visitors attempt to connect to a network provided from a NoCatAuth server they may see a splash page inviting them to login. This software functions both as a prioritization service and an authentication service—NoCatAuth allows ''free riders'' while removing the cloak of anonymity from free ridership, but at the same time NoCatAuth allows the owner of the connectivity to assign priority to their own use, or to prohibit free riders from doing some things with Wi-Fi that the owners are allowed to do. In technical terms, NoCatAuth intercepts outgoing Web requests and redirects them to an authentication server. If the visitor is authenticated, the authentication server provides a cryptographically signed reply. The visitors are then redirected to their original Web request and subsequent requests pass through the NoCatAuth gateway (for more technical detail, see Kershaw, 2003).[24]

The significance of the NoCatAuth project is two-fold. The first and more obvious goal is allowing authentication on ''open'' networks. While NoCatAuth allows a local Wi-Fi network to implement any authentication service that they like (e.g., NoCatAuth could even be used to authenticate paying users in a commercial network) the NoCat group has greater ambitions. They also operate a free centralized authentication database (auth.nocat.net) with the aim of hosting authentication for anyone who would like to participate. As the README file says, ''We hope NoCatAuth helps you provide unlimited bandwidth everywhere for free.'' This is the second and more profound goal of the NoCatAuth project. Despite appearances, the NoCat group does not really aim to allow any Wi-Fi provider to authenticate their own users; in the documentation for NoCatAuth they suggest that running your own authentication services are time-consuming and costly. Instead, they recommend that Wi-Fi providers affiliate with an umbrella authentication organization. This is NoCatAuth's larger aim: to build a global authentication framework wherein any user of a free network can be authenticated centrally.

4.1. The problem with strangers

These goals may seem quite paradoxical. Why would the providers of *free* networks work so hard to develop a system of *authentication*? It seems nonsensical—even sinister—that so much effort would be expended by free wireless activists to build a global framework for centrally certifying user logins. In some way the NoCatAuth effort is a response to law—or the idea of law. It is an attempt to reconcile a new technology with old ideas of private property, and the discussions about NoCatAuth's development are also discussions that treat anew the problem of what, exactly, is meant by ''theft.''

Wireless activism generally has been dogged by a stigma arising from free ridership. As briefly highlighted in case one, the wireless activist mantra has been that connectivity should be as free as

[23] Taken from Rob Flickenger's introduction to NoCat at: http://nocat.net/wiki/index.cgi?AuthIntro.

[24] NoCatSplash is at the time of this writing simply a faster version of NoCatAuth with fewer features.

the air (jokingly epitomized by one activist with the slogan, "Peace, Love, and Wi-Fi"). The problem has been that Wi-Fi, unlike air, is already understood as private property. The boom in Wi-Fi hot spots and the mushrooming of free APs described in the last section was the result not of a conscious altruism, it was the triumph of unreflective accidents. The consumer equipment (the AP) that an individual user purchased for his or her own use came direct from the factory with no security enabled. Taking an AP out of the box and turning it on would result in the accidental provision of an "open" Wi-Fi hot spot. In this way, the bulk of open Wi-Fi coverage is open by default and not by design. The concept of altruism in Wi-Fi (as in anything) has a saintly air, yet users of these accidentally open hot spots are not taking something that has been freely given. Just as the Warchalkers were accused of being thieves, the open wireless co-ops like NoCat had to demonstrate that they were interested in taking only what was freely given. NoCatAuth was a way to show that they were not taking but trading—cooperating to create a system that benefited all. If the open wireless community could convince users to run NoCatAuth, it would be convincing them to make a sharing decision explicit, meaning that free wireless users could always defeat the charge that they were simple thieves. In this manner, NoCatAuth uses computer software to facilitate an electronic manifestation of gift-giving.

Nobody knows how many of the accidental sharers would continue to give away connectivity if the decision to do so was made explicit. Activists rightly fear that the ingrained respect for private property and the ownership implied by paying the backhaul bill every month (for DSL or a cable modem) would lead AP buyers to exclude free riders. If the question is phrased as, "Will you share your water or power with strangers?" the answer seems likely to be "no." However, if the offered calculus could be changed so that by giving access away the "altruistic" sharer does not lose anything, who could refuse? Proponents of NoCatAuth needed to redefine the sharing as something that would occur at no noticeable cost.[25] NoCatAuth thus evolved with a design goal that the owner should be able to obtain an absolute priority over free riders. As long as AP owners used a flat-rate monthly broadband Internet service for backhaul, they do not pay for any usage in addition to their own, and any costs are passed along to their Internet Service Provider. This idea of eliminating any cost to owners is likely to have resulted (at least in part) from the Wi-Fi activists' ongoing attempts at lay jurisprudence. The mailing lists of the Wi-Fi community are littered with the postings of intelligent engineers and technologists who seek to puzzle out the legality of what they are doing via the lay interpretation of black-letter law. One of the most interesting of these is a lengthy review by a non-lawyer (Pozar, 2002) that has achieved wide circulation. It attempts to cover all conceivable law and FCC regulation that might impact Wi-Fi co-ops. Despite some of their slogans, these Wi-Fi "rebels" are quite often middle-class technical experts with a healthy respect for the law and the last thing they wish for is the label, "thief."

4.2. Selling the air vs. giving it away

In an important parallel, Streeter (1996b, introduced above) analyzed the development of spectrum management in US television broadcasting as a property relation. He demonstrated that

[25] A parallel might be made with the trade-off in peer-to-peer file sharing software between bandwidth allocated to uploads vs. downloads. However, on the file sharing systems in use today, altruism *can* affect your own use and cost you slower downloads.

the ether was commodified as something that could be bought and sold because of the dominance of an ideology of *corporate liberalism* among business and government elites. In this way of thinking, proper stewardship of a scarce public resource demanded rules so similar to private ownership that they were effectively private ownership.[26] The case of NoCatAuth is quite different, in that it demonstrates that property relations can arise "from below" as much as from above. The idea of wireless connectivity that is "free as the air" appears subversive to property relations, yet this freedom was implemented in such a way that the intangible of Internet connectivity is, in the end, something that is agreed by all to be owned. In their (perhaps unconscious) fear of the law, technologists realized a system of rules in software that paralleled property relations. They found a nebulously defined practice (wireless Internet) where any claim of ownership was questionable and solidified it by defining their actions as providing gifts of well-defined property. They envisioned giving away this gift as the privilege of an owner, and in the process helped to create wireless Internet as something that could be owned.[27]

This conception of gifting remains problematic, however, as Internet service is conceptualized by ISPs as a service and not as a good. ISPs usually have prohibitions in their subscriber agreements that preclude resale or connection sharing, the latter being the chief occupation of the co-ops that might use NoCatAuth. ISPs see broadband Internet as a gift only they can give, and they resist the notion that home users have purchased property by claiming that whatever property exists remains theirs. NoCatAuth is a move in a larger game where ISPs have tried to use private law as an instrument to stop those that would give away their bandwidth. This has not been particularly successful to date: chasing individual altruists has proven to be terrible public relations, and the terms of service used by many ISPs are filled with ridiculous provisions that effectively state that the user cannot do anything the ISP does not like at any time. Many overbroad penalty clauses are likely to be unenforceable.

Here can be seen cooperative action that goes directly against the expectations of the literature. The co-op behind NoCatAuth does not seem to be engaged in innovation or experimentation: if anything, the basic features of NoCatAuth as an authentication system were first realized for commercial ISPs and then borrowed by the co-op, and the technology of NoCatAuth uses readily available building blocks. Similarly, the co-op has not invested in popularization. O'Neil's *sense of community* consequence of CNs explains this co-op quite thinly. The NoCatAuth mailing lists are much more practically oriented than the discussion fora of the Warchalkers and Wi-Fi mappers. Like other successful software development communities, they want to build a "product" that works. NoCatAuth also seems to be more effective in terms of its own stated goals than Warchalking. While Warchalking claims to be a directory service but actually does not function (much) as one, NoCatAuth realizes the authentication system that it attempts. Some explanation for all this can be found in Fischer's notion of co-ops as a way of implementing desired features that vendors do not provide, but here the desire is not for a technical feature but for control of the authentication system itself. Users of NoCatAuth want their own system of affiliation, and they want to achieve a system that protects them from the legal epithet "thief." In this, they have been

[26] Spectrum allocation in US law has specifically precluded ownership since the Communications Act of 1934.

[27] This interpretation is consistent with the scholarship on "interpretive flexibility" in the sociology of technology (Bijker et al., 1997) and the notion of the "gift economy" found in anthropology. While gift economies are typically considered as subversive to capitalism, they are not necessarily so.

successful, but on a small scale. Next, this paper will move from authentication to provision and examine the kind of co-op that might employ NoCatAuth—a co-op dedicated to providing Internet service using Wi-Fi.[28]

5. Case three: *Consume* and Internet provision

The *Consume* project was founded in London, UK in 1999 as a "collaborative strategy for the self-provision of broadband telecommunications infrastructure."[29] *Consume* began with discussions between wireless enthusiasts who later assembled a diverse group that shared a passionate anti-corporate feeling and a talent for aphorisms.[30] The *Consume* slogan is, "Trip the loop, make your switch, consume the net"! and (as in this last phrase) the name *Consume* most often evokes the meaning of "eat"—meaning literal consumption. *Consume* means to subsume the Internet, to internalize it, rather than to purchase it. *Consume* refused any financial support from members, accepting only in-kind contributions of provision, expertise, or equipment. In addition, *Consume*'s organization belies the word. Although founded in the UK, it admits no boundaries and lives on the Internet. From the discussions on its mailing lists, it appears to be a very loose confederation of individuals that pursue whatever projects they wish to pursue. Perhaps the least organized of the cooperatives examined so far, *Consume* acts as an information hub whose chief assets are its mailing lists and Web site. *Consume* also operates *NodeDB*, a directory of members that also functions as a GIS-driven Wi-Fi map similar to wifimaps.com (considered above as case study one). To "join" *Consume* you nominate yourself as a node, list your node in *NodeDB*, and are presented with a list of nodes that are near you (if any).[31] You are then encouraged by the FAQ to contact nodes near you and arrange some way to interconnect. This is a vision of a mass of people throughout the UK throwing Ethernet cables over back fences: if enough people follow this set of steps, an alternative network to the Internet will have been created by cooperative, volunteer action at very low cost.[32]

Unusually for provision co-ops, the members of *Consume* have devoted a large amount of energy to tackling the legal arrangements required to run a cooperative network infrastructure. Specifically, they realize that to be useful their network will have to interconnect with the existing Internet, and so they watch carefully for ISP reaction to connection sharing (introduced earlier in this paper). The *Consume* membership also put a significant amount of effort into legally defining the peering arrangements to be used between *Consume* nodes, culminating in a formal agreement called "PicoPeering" that defines the relationship.[33] Members have also expended considerable

[28] While statistics on this are not kept, it is likely that some of *Consume's* many members have installed or experimented with *NoCatAuth* to produce splash pages.

[29] Taken from the Consume GeneralFAQ at http://consume.net/twiki/bin/view/Main/GeneralFAQ.

[30] Unless otherwise noted the material in this section comes from the Consume mailing list archives at: http://lists.consume.net/mailman/listinfo and from the Consume wiki at: http://consume.net/.

[31] This section is based on the author's experiences joining Consume, constructing a node called "SpeakersCorner", and using low-cost commercial equipment to provide Wi-Fi coverage to Speaker's Corner in Hyde Park.

[32] Admittedly, if this scenario were to come true, the routing difficulties would be daunting.

[33] See: http://www.picopeer.net/PPA-english.html. Development of the Picopeering agreement has stalled at the time of writing.

effort in understanding how connectivity to the Internet might flow between *Consume* nodes. The usual practice is simply that Internet connectivity is shared with any Wi-Fi user that is within range, or that the *Consume* members (illegally) enlist neighbors as users of their broadband connection. However, *Consume* members have pondered how to use strategic peering relationships with ISP to provide backhaul for an envisioned large network of nodes with no backhaul of their own.

Consume and co-ops like it also function as a kind of *Consumer Reports* for Wi-Fi equipment, as members subject commercial equipment to a series of tests and much discussion is devoted to the best equipment (what to use, how to build it, where to buy it). *Consume* is also partly responsible for a number of spin-off projects. In addition to PicoPeering, above, it has provided a general starting point for a number of more focused, local network provision projects such as *Arwain* (http://www.arwain.com/), a Welsh provision co-op based in Cardiff.

5.1. "Death to telco monopolies"! while peering with them

In terms of motivation, *Consume's* public face does not present a particularly well-justified endeavor. In a way, *Consume's* general mission might be seen as attempting to cooperatively build a new, second Internet without the financing or expertise of the telecommunications companies of the first Internet. Not only is a volunteer-run, donated Internet infrastructure a very difficult challenge to set oneself, it does not have any of the immediacy of a need. Most of *Consume's* activity occurs in areas (such as London) that are already well-served, and so the creation of a second Internet takes on the fanciful air of Don Quixote's quests. A thread that runs through many discussions is the idea that commercial network services are presently overpriced, but when compared to the trouble and difficulty of becoming your own network service provider, participation in a project like *Consume* is not likely to save any money for the average participant, or to be an effective price protest. In the face of direct questioning about motivation, the public documents of *Consume* dissimulate. The *Consume* GeneralFAQ denies having a motivation, claiming that "[t] here is no single set of reasons why we should want to do this: one of *Consume*'s strengths is that it is many different things to many different people." In another section of the FAQ the response is an ironic and self-effacing dissembling. In answer to the question of why *Consume* should be founded to pursue these goals when so many other co-op organizations already exist to pursue them (see also CNs, above), the FAQ replies, "Death to the communications monopolies! May ten thousand autonomous systems bloom!" Yet as discussed above, *Consume* depends upon these hated monopolies for backhaul service, and hopes to partner with ISPs in the future.

In another light, the motivation of a Wireless provision co-op like *Consume* is obvious—to provide service to users. It is strange, then, that there is little evidence on the mailing lists of widespread use of *Consume* services by non-members. Sometimes this realization comes as a disappointment, as one mailing list post lamented in June 2003:

> Editing my dhcpd.conf file—I noticed it was exactly one year old. In that time I've not had one single connection from outside this house. Most recently my box was up for 34 days without a reboot—so it's not because I'm never online. And this is urban inner city North London—okay it's just an internal antenna... Very sad[34]

[34] From: http://lists.consume.net/pipermail/consume-thenet/2003-June/008275.html.

It is certainly not true that no *Consume* service providers have users—some at least post tales of bandwidth sharing with neighbors. However, the appearance of this comment highlights the true essence of *Consume* as a network service provider—the resources of *Consume* exist for the use of members. *Consume* is not particularly interested in recruiting novice users as this means more work for their scarce volunteer energy. Public place provision might be some exception, as users in public places may be transient to the degree that they are never in the area long enough to figure out who they might contact for technical support. The jargon-filled mailing lists and confusing Web site are an intimidating place for the novice, but attract the hobbyist who have some technical skill and an urge to learn more.

5.2. A public place for a private purpose

What, then, to make of *Consume*? It could be judged a success as a hub that spawned a number of more focused projects, but by its own stated goal of collaboratively self-providing broadband it has not succeeded. Similar to the present analysis of Wi-Fi mapping databases as network discovery services, the functional benefits of *Consume*'s activity can be considered as a community independent of the larger system and found useful. *Consume* as a social group may (like Warchalking or Wi-Fi mapping) promote technical knowledge and a sense of community. Considering *Consume* in any larger context, however, leaves the author struggling for a justification. Hughes's "stage one" activity is apparent: experimentation in ways that would otherwise be considered pointless or too risky. Overall the effort seems still to be best explained as a social club for technical elites. The idea of a voluntary cooperative alternative Internet might yield significant societal benefits as a testbed used to pioneer alternative technologies and methods, but *Consume* appears far from realizing such a testbed. Its members are too dispersed to peer, and uninterested in peering anyway. The average person is unlikely to join, given the amount of expertise required to even understand what it is that might be joined. And beyond all of this, *Consume* has not articulated a compelling need or service—the frustration that drove rural farm co-ops into self-provision of electricity and telephones does not exist in most of the areas where *Consume* is active. Although some of the discussion in *Consume* fora is stridently anti-corporate, this opposition does not manifest itself as concern for the socioeconomically disadvantaged or an organized resistance to specific corporate practices that are seen as negative. The mailing lists of *Consume* are filled with examples that evoke Fischer's dictum that users adapt technology to their own ends and introduce new features and services. *Consume* members were serving public places (see the "description" field of *Consume's* node database) at a time when no commercial public hotspots were available, and they spoke of balconies, patios, streets, and public squares before wireless commercial ISPs in Britain. It is not possible to determine how often these public place nodes are used from the data available, but postings on the mailing list generally support the idea that they were constructed by and for a single *Consume* member—service in public places was deployed because it suited the AP owner, and if others stumbled across it that would be an added benefit. Whether this public place provision remains useful if commercial provision becomes widespread is another matter, one that returns this inquiry to larger questions about all three cases and the lessons from this research.

6. Assessing cooperative action in Wi-Fi networking

How are these cooperatives valuable to the development of the communication system as a whole, or to society? From this evidence, those who hope that these co-ops represent the next wave of a popular movement will need to readjust their expectations. The chief problem for the success of any popularization of cooperative self-provision in this area is technical knowledge. The technical hurdles to realize *Consume*'s populist uprising and *NoCatAuth*'s vision of universal cooperative affiliation and voluntary sharing are profound and striking. While off-the-shelf equipment is usable in some cases, to be a member of *Consume*, to operate a NoCatAuth gateway, or to hunt for Wi-Fi networks requires considerable expertise.

O'Neil's five-fold typology of consequences of CNs is now telling. While CN consequences include (1) "strong" democracy, (2) social capital, (3) individual empowerment, (4) sense of community, and (5) opportunities for economic development, the cooperative action considered here seems to focus little on democracy, social capital, and opportunities for economic development. These co-ops function (as any community does) to generate social ties for members, it is true, and they promote technical knowledge and community in the same way that any voluntary association devoted to an educational purpose might. Overall, the Wi-Fi co-ops examined here are inward-looking: they emulate Douglas's "cult of the boy operator" in radio before 1920 more than they provide an outward-looking CN that builds its own internal community through an explicit mission of helping those outside the group that are disadvantaged. This is not to be seen as a surprising finding, however, as cooperatives have often been vehicles for self-interest.

6.1. "Don't cancel your ISP account just yet"

The literature reviewed above posited that each different functional role (discovery, authentication, provision) might trigger related weaknesses (disorganization, unreliability, lack of expertise) and strengths (flexibility, heightened awareness of public-interest concerns, low cost) of the cooperative form of organization. Interestingly, Wi-Fi mappers managed to surmount the traditional co-op weakness of disorganization by centralizing a Web-based system of automated reputation ranking to direct their activities. All co-ops examined here showed great evidence of building expertise among those already possessing some expertise. While co-ops are often thought of as lacking expertise when compared to their professional commercial counterparts, the discussion boards of these co-ops demonstrate much more expertise than the technical support personnel of the commercial ISPs with which they interact. Indeed, co-ops are in some cases so expert that this makes it impossible to imagine their success as a populist movement. Unreliability was also not the problem one might have expected. While the co-op mapservers are sometimes unexpectedly unavailable, there are multiple mapservers. While it is difficult to depend on a volunteer organization, NoCatAuth produces software code that runs. And while the individual nodes of *Consume* may not be reliable sources of connectivity, *Consume* is implemented as a redundant system, a second Internet. Members are expected to have another source of Internet connectivity (in the words of GeneralFAQ, "Don't cancel your ISP account just yet.")

Similarly, while the literature anticipated the cooperative organizational form as more flexible, sensitive to public-interest concerns, and low in cost than non-co-op counterparts, the results of this inquiry are mixed. As demonstrated by the above assessment of O'Neil's typology, these co-ops were not particularly sensitive to public-interest concerns in practice, although in their stated goals they often claimed to be.[35] *Consume* did demonstrate considerable flexibility but it did so by having undefined goals and no internal organization. The data concerning *NoCatAuth* examined here did not provide a robust test of flexibility as compared to a commercial system. In terms of cost, NoCatAuth and the Wi-Fi mappers provided substitutes for goods that are available in the marketplace. NoCatAuth replaces an authenticating captive portal that would otherwise have to be purchased or programmed, while Wi-Fi mapservers very imperfectly replace the directory service provided by national or federated ISPs. Both co-ops provide these services for free. *Consume* is a harder case, providing some network access to users for free but costing its members a great deal of effort and equipment. These findings are pessimistic only for those who expected Wi-Fi to be an emancipatory technology empowering everyone to operate their own telecommunications carrier. If the implications for public policy are considered, promising avenues for action remain open.

6.2. Co-op policy experiments: the blank spot bounty

This paper's initial literature review asserts a need for greater telecommunications policy attention to co-ops. Hughes, Douglas, McChesney, Streeter, and others all implicitly or explicitly suggest that amateur action in the early moments of a technological system has been an engine for experimentation, innovation, popularization, and provision of features or service that are not available from commercial vendors. To be clear: if these case studies have demonstrated anything it is *not* that co-ops are ineffectual. Quite the opposite—these groups appear to be extremely capable: while NoCatAuth is largely a replication of what already exists in commercial systems, nonetheless it works and it is free. Similarly, the extensive mapping databases produced by groups like *Zhrodague* and *Consume's* repository of user information are professionally produced, technically sophisticated and effective in their own terms—*Zhrodague* makes beautiful maps. These maps do not work as a directory service because they were never really intended to, these maps are an aesthetic project and a community-building hobby. Similarly, *Consume's* members deploy Wi-Fi hotspots that work, but they often deploy them in places where they are unnecessary. The issue is not whether or not these groups are capable, it is how to align the talents of this skilled population with society's needs.

In Wi-Fi, this mismatch between cooperative action and societal goals can be addressed by public policy. Attempting to mobilize cooperatives is a relatively low-risk, low-cost policy option—these groups have shown a great willingness to invest large sums of their own effort and equipment. It appears that co-ops genuinely want to help: beyond *Consume's* catchy but argumentative slogans, the mission statements of most cooperatives include goals directly tied to public service. Consider this assortment of statements made in public documents: *BARWN* exists to build a research testbed, *Bristol Wireless* will "reduce the digital divide," *CUWiN* intends to

[35] In mission statements, statements of goals, and Web pages about these organizations.

promote content production by "grassroots media-makers," *DFW Wireless* promotes the use of wireless technologies, *RotterdamWireless* is dedicated to "access for all," *NoVAWireless* hopes to bring Internet access to underserved areas, *NYCWireless* will promote research and development, *Personal Telco* plans to build community empowerment by linking public places, *RAWUG* will educate users, *SF Wireless* pledges bandwidth "to those who need it," *TCwireless* will document access locations to promote economic development, *TCWUG* charges its members to make resource sharing easier, *TWCN* hosts a forum for communication between users and service providers, *WSCIC* builds wireless services in "DSL deserts."[36]

Like most areas of public policy, telecommunications have a relatively small, well-known set of central problems. The present situation in the Wi-Fi cooperatives considered here suggests a program of targeted subsidy that would rein in the enthusiasms of these amateurs to the problems of telecommunication policy. Two longstanding societal goals are innovation in new telecommunication services and access in underserved areas. In the US, the federal programs that currently exist to support these goals will never mobilize Wi-Fi co-ops unless changes are made. Specifically, the US Commerce Department's Technology Opportunities Program (TOP) exists to support experimentation in services by non-profit organizations. This might seem a useful channel to promote grassroots Wi-Fi innovation. (In the 2004 funding round of $12.9 million, TOP declared a special interest in Wi-Fi.) However, these groups may be organized enough to produce hardware and software solutions to telecommunications problems, but not organized enough to demonstrate eligibility for these funds through the Byzantine application process. Moreover, the average TOP grant far exceeds the scale of most co-ops. Turning to the second goal, access in underserved areas, at the time of writing both the US and UK are currently perceived to be lagging in the deployment of broadband.[37] The dominant policy approach to increasing deployment in underserved areas has relied upon cross-subsidy to providers ($5.3 billion in the US in 2002[38]), yet it would be very difficult for a Wi-Fi co-op to receive these funds even if they provided effective service. While the co-ops consider themselves providers, public policy considers them to be users, and ineligible.

It is straightforward to imagine an inexpensive policy instrument that would succeed. Continuing the example of access in underserved areas, policymakers can borrow a trick from the Wi-Fi mappers and assign a bounty to blank areas on the map. In "DSL deserts," rather than waiting for telecommunications carriers to act,[39] public policy can take Fischer's autonomous users to heart and encourage the underserved to provide their own service. This would entail a policy strategy emphasizing education (e.g., a clearinghouse of instructions for self-provision) and interconnection guarantees (e.g., a clarification of the Wi-Fi co-op's status when obtaining backhaul). Additionally, cross-subsidy mechanisms could be modified so that cooperating groups of "users" would be more easily recognized as providers eligible for universal service support. Almost all co-ops

[36] Jolene White contributed essential research assistance in gathering these statements.

[37] This does not mean to imply that the common practice of conceptualizing the deployment of advanced telecommunications services as a race between competing nations is analytically useful.

[38] This figure refers to disbursements from the US Universal Service Administrative Company.

[39] In the US, the Section 706 Advanced Services Inquiry is the home of this waiting game.

interested in provision also experiment with IP telephony. This presents the possibility that experimental co-ops could self-provide both high-cost rural local loop service and advanced broadband service using unlicensed wireless.

6.3. Directions for future research

This study has presented only a first look at cooperative action in Wi-Fi. This research was conducted in 2003 in an area that changes quickly and this begs a second look with complementary research methods better able to assess the scope of these co-ops. At the conclusion of this study, the prospects for cooperative action in Wi-Fi remain murky. At the least, this work suggests some revision of how co-ops are considered as an organizational form in telecommunications. The assumption that co-ops are flexible but inexpert public-interest minded altruists is more stereotype than substance. These co-ops are varied, and might even be characterized as inflexible, self-interested, inward-looking, and expert. (However, if the category "cooperative" fails us in cohesive meaning, it does no worse than the equally broad term "commercial.") Two of the co-ops considered here served several non-obvious purposes that were not their stated goals. Wi-Fi mappers seemed uninterested in the actual directory service, while *Consume* served a diverse variety of purposes, but the main effect was not the widespread self-provision of broadband. Further research should more directly address the possibility of co-ops as an important symbiote to other infrastructure, providing service in commercially undesirable areas. As an urban organization *Consume* was a poor test case to choose for the study of provision if this symbiotic relationship were the chief issue. A valuable future comparison would consider an urban provision co-op alongside a rural co-op where wireless provides the only viable broadband infrastructure.[40] The provision function, particularly, requires further study before a firm conclusion can be reached about the value of cooperative provision. While these cases were selected to inform theoretical understandings of cooperative action in telecommunications, a pragmatic next step would be to determine how many provision co-ops are actually building infrastructure and serving users. Finally, consistent with Hughes, there may be occasions where a co-op's actions could be more important than that of commercial organizations for reasons of innovation. These co-ops did evince widespread experimentation, but this study found no evidence of significant innovation (and stumbling upon it in such a small sample would be unlikely). Claims of innovation and experimentation benefits from cooperative action call for a study of the most innovative Wi-Fi co-ops.

This initial assessment then concludes with further questions, as any first look should. On cooperative action more generally, Henry David Thoreau famously believed that "the only cooperation which is commonly possible is exceedingly partial and superficial." In contrast, Franklin D. Roosevelt said in an early campaign speech that, "competition has been shown to be useful up to a certain point and no further, but cooperation…begins where competition leaves off." In the area of Wi-Fi, this assessment ends with ambivalence, somewhere between Thoreau

[40] For example, the Didcot Ring: http://www.didcotring.uk.net/.

and Roosevelt, but with the prospect that innovative public policy action can shift cooperation toward a more recognizably useful future.

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