Peer Production and Innovation in New Media

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ABSTRACT

This review considers how play and contest among subcultures of innovators lead to unexpected innovation in advanced wireless technologies. It concludes that much of the potential for digital media and the Internet to enhance innovation actually echoes much older patterns, as evinced by comparisons to wireless history. While the recent excitement about peer production and user-driven innovation on the Internet emphasizes the newness of these phenomena and explains them as resulting from new technology, this review instead argues that this sort of innovation is not new and not driven by technology. Rather, it exists in a fragile social context. It is possible that this can be damaged by recent changes in intellectual property law.

Peer Production and Innovation in New Media

At age 19, college student Shawn Fanning – nicknamed "Napster" for his messy hair – wrote the popular eponymous music sharing software and demonstrated the viability of a "peer-to-peer" architecture for file sharing. "I was at Northeastern University playing with the idea and getting feedback from my roommates," he has said, "it was really my first Windows application." Two years later, Fanning was on the cover of *Time* Magazine, Napster had 40 million users and Fanning eventually made an estimated $1 million.[1] For Fanning, the situation was unprecedented. He said, "If you're a musician or actor, you know that if you're successful, some level of fame goes along with that. You're prepared. But how often does that happen to a programmer?"

An answer to Shawn might be: "More often, these days." It is true that few programmers other than Fanning have been featured in *Rolling Stone* Magazine, but stories like Fanning's are a staple of popular press coverage about new media technologies. Napster's story is captivating because it contains all of the elements of excellent drama: youth, humble beginnings, success, fame, hubris, failure, and a reversal of fortune (Napster went bankrupt in 2002 after legal challenges by recording artists). But it is also captivating because it seems to teach us about qualities of digital media. The large electronic communication systems that are familiar to everyday life are cable television networks, satellites, telephone systems, and the Internet. These systems and the popular cultural products that they carry (such as films and television shows) usually require millions of dollars in capital investment to produce. If teenagers can create their own infrastructure or popular content at home, out of software, this appears to be a dramatic shift in the ordinary state of things. It may be that digital media allow individual creators more power than ever before.

Napster is software infrastructure—it isn't music but it is a way to distribute music. Beyond Napster, this new power to create is celebrated even more regularly for content than for the infrastructure that carries it. For example, in 1997, Jyoti Mishra (aka "White Town") created the song "Your Woman" in his bedroom with free software and an Atari ST. Within four weeks it was #1 on the UK pop charts. *Wired* magazine, writing about the big business of music that year, wondered hyperbolically "how long they can hold out before cheap technology and the distributive power of the [Internet] take over."[2]

These are not singular examples. There are many exciting stories being told about digital media and innovation, and many posit this shift in power toward new forms of diverse or even distributed creativity. While the Internet was generically reputed to increase anyone's ability to produce their own content, recent examples are more specific and well-documented. To name just a few: Blogs and myspace allow fast and cheap online publishing for anyone. New video game "fan site kits" and level editors allow the players to write portions of mainstream games. New audio software has greatly increased the ability to create digital music, and revitalized the genre of music that is composed entirely of other music, called a "mashup." To reiterate, this trend is not limited to the production of new content. For instance, new techniques to interconnect Web-based applications allow programmers to quickly create a "software mashup" by combining powerful existing Web applications without much new programming labor. Although the celebrated innovators can be any age, much popular attention has focused on the young. Lawrence Lessig, the most prominent advocate of loosening the legal restrictions that encumber this sort of innovation, wrote recently about the application of copyright law to fan-produced Anime Music Videos. He observed "This will be the next big copyright war—whether this form of noncommercial creativity will be allowed."

"When ordinary people hear both sides [of the argument], and more importantly, see the creativity their kids are capable of, 90% will be with us."[3]

This chapter will examine one example of new technology in some detail—wireless communication technologies—and attempt to determine what is really new about the present moment. Have digital media promoted creativity in some new configuration, and shifted power to individuals or the young? (In Fanning's metaphor, are young programmers the new rock stars?)

There are Good Reasons to Expect Transformation

The writing about the power of the Internet and of digital media in the 1990s has been charged and found guilty of hyperbole, utopianism, essentialism, determinism, ethnocentrism, and more. Most of the bombastic claims about the transformative power of new media may indeed have been nothing more than the expression of a somnolent affluence common to that decade, a millennial optimism that was filtered through the academy.[4] Yet, there is good evidence that some things are indeed transformed as the result of digital media, and that there is some reason still to take notice of a transformation with respect to innovation.

The convergence of once-distinct media technologies is the reason that innovation on, in, and with communication systems has special characteristics.[5] Convergence literally means "coming together," but this distracts from the real significance of the phenomenon. The less exciting part of convergence is the idea that a common format or common ownership could allow a converged system to reap substantial economies of scope and scale. Even though this is the less exciting form of the effects of convergence, it is worth reviewing here as it is a foundation for why one would expect a reorganization of media and communication at this historical moment.

Economists use the phrase economies of scope to refer to situations where producing more than one product can be more efficient than producing just one. For instance, if a cable company also offered telephone service (as many US cable providers now do) the same marketing budget can be used to promote both products. Consumers could be offered one bundle including many media services, resulting in one price for a package including telephone calls, Internet service, on-demand movies, television and cable channels – all represented on one bill. This saves the company money when producing these products (e.g., it does not need a separate billing system for each), but it also can attract consumers who see media products as related and value the simplicity of making a single payment to one provider. In this sense, convergence refers to the coming together of media and telecommunications companies into conglomerates that offer products across all media forms.

The conversion of media technologies into related digital formats also promises substantial economies of scale, a phrase that refers to situations where producing a larger number of units of the same product allows the cost of making each one to drop. This is familiar to most people as the rationale behind mass production. If convergence led to more sales, this could straightforwardly lower costs at a converged company. But in a slightly more subtle scenario, within a converged company that provided content for film, television and the Internet, content developed for one media system could be slightly repackaged and transmitted over another, creating new efficiencies in production and duplication. In effect, what had been related but fundamentally different products (film, television) might become essentially the same product.

To illustrate this situation, consider "DTS." Since 1993 some films have been distributed using an audio standard called the Digital Theater System, and in the last ten years, motion pictures have been marked "in dts" or "dts digital entertainment" [lowercase *sic*] on theater

marquees to promote their high-quality sound. Motion pictures distributed to theaters using DTS are shipped with a CD-ROM containing the soundtrack. During playback, this CD-ROM is synced with the film projector by a dedicated computer. However, a version of DTS was later produced for consumers, and DTS sound began to routinely appear on DVDs sold to the public, and it appeared as a setting on home entertainment equipment (along with the also-popular Dolby Digital format). While the transition from one format to another used to always require rerecording, DTS illustrates how this may no longer be necessary. A DTS soundtrack for a film is now essentially the same across two markets: public exhibition in theaters and home exhibition on DVDs.[6] It is this sort of efficiency gain that has excited some commentators on media convergence.

It is worth pointing out that this situation in media is not new. The telegraph and related technologies sparked just this sort of excitement about synergies with newspapers in the media convergence dreams of the 19th century (though this was not then known by the word "convergence").[7] New developments in telegraph technology such as the printing telegraph (invented in 1846) and new "online" media formats like the stock ticker or ticker tape machine (invented in 1857) convinced some newspaper companies that the future of media would be converged, integrated companies providing content simultaneously for multiple formats. This didn't come to pass for a number of reasons, but chief among them was that the new formats still required a large amount of effort to interconnect and demanded different sorts of expertise. This may be a cautionary note for the enthusiasms of today.

New Access to the Means of Production

While "convergence," meaning a coming together of producers for economies of scope or scale (or to produce the same content in related formats) is an old situation for

communication technology, part of the recent excitement about convergence is different. The preceding section identified itself as the less exciting dynamics of convergence for our purpose here. The significance of the more exciting aspect of convergence for this chapter's purposes relates to the properties of digital information. Once-distinct analog media like film, music, telephone calls, and television have been digitized and can share a common structure of binary code. Profoundly, this means that the means of reception in communications have also become the means of production and the means of distribution—all are now computers.

The simplest route to demonstrate this is by example. In 2005, if the owner of a relatively cheap personal computer installs the free software package *Asterisk*, the computer becomes a telephone exchange. If the user installs *Photoshop*, the computer becomes a photographic studio. *Audacity* or *Garage Band* produce an audio recording studio. *MythTV* or *Linux4.TV* produce a personal video recorder or a cable set-top box. That the means for media production and reproduction are so cheap and readily available is a new phenomenon, and excepting the telephone handset, it is remarkable that one common device may act as receiver, editor, and transmitter for a variety of products. In addition, as the products are themselves digital data files, reproducing and manipulating them need not degrade their quality, require additional materials, or impose additional expense.

Most discussions of convergence until very recently treated these benefits as though they would only accrue to large corporations seeking efficiency gains in their operations. While it was clear to many scholars of digital media and telecommunications that a single platform – the computer – would change the production of cultural products, it was not clear until very recently that these benefits might extend to the general population of computer users. Although commentators linked computers and the emancipation of information and production as early as the 1970s, this was a minority view.[8]

In the previous examples given of personal computer applications like *Garage Band* and *Asterisk*, note that the malleability of computing resources and its implication extends far beyond content to include the networks that distribute content. Before digital convergence, communication systems and their configuration consisted of relatively fixed arrangements of electro-mechanical components that were difficult to change. In fancier language, the logical architecture of the network and its physical architecture were the same.[9] Earlier, change involved building (or at least moving around) heavy and expensive wires and switches. With computerization, while manipulating these systems may not be trivial, at least it often involves the comparatively easier task of changing the digital instructions for how to do things. Significant changes in infrastructure may now be a *conceptual* rewiring like Shawn Fanning's peer-to-peer software. Napster only changes the instructions for how to transfer information, whereas with networks before convergence this sort of change could require an *actual* rewiring, with screwdrivers.

There is then some basis to believe that developments in digital media might actually prefigure new abilities to manipulate and reconfigure any of the systems of communication in society. The chance to reunite the traditional producers of communication (the people) and the means of production for communication is a heady possibility well worth investigating. Claims that digital media allow or cause new forms of creativity and production are part of the hyperbole surrounding the Internet in the 1990s, it is true, but careful empirical scholarship has found that tools like the Internet have new potential to enable innovation and experimentation in ways that were formerly impossible (or at least very difficult).[10] After convergence, software and media can potentially be easily combined, reworked, and shared, and the results are important new artifacts and organizational forms such as open source software.[11]

Despite this optimism, it is important to keep in mind that one major problem with earlier writing about digital media has been that technology was portrayed as an exogenous force outside history, politics, and culture. To be fair in assessing technological change, a skeptical eye is required. To demonstrate that anything is different about the present moment should require detailed and earnest consideration of the past as a point of comparison. At the same time, any investigation must remember that technology is built by people who spend money and time to shape its development to serve their own interest, not to simply facilitate the expression of a technology's innate potential. If digital media assists in a shift of any significance, there should also be signs of inertia and resistance. Finally, small particularities in the details of practices surrounding the development of digital media may be the key to determining important changes in its trajectory and consequence.

Locating Production and Innovation in Digital Media

Garage, dorm, and bedroom producers of new digital media projects make for exciting headlines, but the excitement about their existence begs the question: where would one reasonably expect new innovation to come from? It may be that the garage, dorm, and bedroom are not such unusual places for technological production.

Like any claim, the claim that digital media allow new sorts of creativity and innovation from new or unusual sources tells as much about the preconceptions for where innovation ought to come from as it does about the purportedly novel situation today. The story of garage innovation echoes many historical stories of invention that have been viewed skeptically by the scholarly literature on science and technology. While today's inventor-heroes usurp or bypass existing industries, older stories of invention portray inventors who tinker in the garage and accidentally discover the foundation for a major industry. The birth of the personal computer,

for example, is often told this way.[12] Whether David or Goliath comes first, both versions are very much in circulation. Noticing press accounts of younger people discovering things in garages does not yet demonstrate that innovation in digital media differs in a fundamental way from the innovation that came before.

Although professionalized research and development is an endeavor that has flourished in the developed world only in the latter half of the 20th century, it has a strong hold on consumer consciousness, and on the thinking in some branches of economics. Consumers might be likely to imagine that new media-related products originate at laboratories or product development facilities dedicated to that purpose by the same companies that normally supply them with these products. Indeed, "user" or "consumer" has been opposed to "producer" in most writing about media and computer technology.[13] However, the definitive work on this question, Eric Von Hippel's *Sources of Innovation,* convincingly demonstrates that in some fields, users develop most or even all of the innovations.[14] Consumers, after all, are the ones with the most intimate knowledge of the uses for a technology or product. They are the ones frustrated by missing features or services that could be commodified—omissions that to them are obvious.

In the area of cultural products, user-driven innovation seems almost obvious. This comes into focus by turning away from conduit for a moment and focusing on content. In the culture industries, it is readily accepted that stars were fans first, they were likely "users" of older instances of a media genre before contributing their own innovation. Rather than the "R&D" of the consumer products world, media firms have evolved strategies like "A&R" (artist and repertoire departments) and independent film festivals to scout for new products rather than developing them in house. With cultural products, consumption can easily blur into production. One could argue that most truly committed music fans also play an instrument, and they might even learn to do so by playing their favorite song from the radio.

This may seem a far cry from infrastructure and technology innovation. After all, we are told that performers are artists and that they (presumably) have talent, while programming is a skill that can be taught. Yet since computing's early days programmers have been "derided for their adherence to artisanal practices,"[15] and they have been compared to artists and surgeons as often as to coders.[16] The professionalization of programmers has been as incomplete as the professionalization of musicians and artists. (You can get a degree in computer science, in music, and in multimedia production, but the successful figures in every one of those fields agree that the superstars can be self-taught.) Detailed studies of programming labor have found that it is creative and performative, with some programming languages providing an infinite number of ways to resolve a single task of any complexity, just as there are an infinite number of ways to write a novel.[17]

Programmers are not being compared to artists here in order to congratulate them. By reminding ourselves that programming is an activity that may not require formal training and can be advanced by virtuosos, examples like Fanning seem less unusual. The advent of the Internet has produced a pantheon of programming virtuosos (the rock stars of new media) from Tim Berners-Lee to Bram Cohen.[18] These innovators are often used to embody a "bottom up" or nontraditional path to innovation that lies outside the traditions of corporate R&D, but the situation is more complex than this.

It is true that while some of these "rock stars" had formal educations in computer science, they often pursued ground-breaking work well outside a traditional research and development context. While some held jobs in computing, these jobs were often not particularly related to the innovations they produced. Berners-Lee proposed the World Wide Web while working at a particle physics laboratory (*Organisation Européen pour la Recherche Nucléaire*), not while working in the R&D lab of an Internet company. While Craig Newmark

was trained in computer science, he developed the Web Application *Craig's List* as a hobby and (like Berners-Lee) because he wanted to use something like his innovation.

The distinction that is important here is not commercialization: Newmark would later commercialize *Craig's List* and incorporate as a for-profit company, but when he originally conceived of the project it was as a user of the Internet, not as someone whose job was devoted to developing new applications. *Craig's List* started as a hobby. These user-driven innovations (to use Von Hippel's term) can be distinguished from the entrepreneurial path espoused during the dot-com boom of the late 1990s in trade press books about start-up companies.[19] The celebrated entrepreneurial path in digital media involves start ups and venture capital funding and a desire to get rich, but this is quite different from hobbyists or college students who yearn to *use* the technology they are inventing.

That is, programmers like Bram Cohen (designer of the peer-to-peer file sharing system *BitTorrent*) can be distinguished from Fanning and Newmark by their exact position of production—Cohen worked at a series of related start-up companies that were trying to commercialize peer-to-peer file sharing software before starting his own. Fanning and Newmark developed new applications as a creative experiment, and only later realized that their innovations had value. Innovation is digital media is often portrayed as David vs. Goliath, meaning start ups vs. corporate R&D. But both of these positions are Goliath if one is interested in the more novel innovation position of the user-innovator.

Geolocation, From Big Government to Small Subculture

In order to look more closely at this elusive notion of innovation in digital media, where innovation starts, and where innovation leads, it is essential to spend time with the gritty detail of examples of new media technologies and ideas about them. This section will do this via a

discussion of some little-known developments from wireless communication technology, starting first with geolocation. This particular example is useful because geolocation is a significant new technological ability and the story of much of its development has not been written. (This relative obscurity will help avoid the distraction of hype and enthusiasm, as this technological area is obscure enough that it has little popular awareness and no popular inventor-heroes.) Yet, today's wireless innovation makes an interesting case study because "new developments" in wireless is an old topic with a long history, studied extensively by generations of historians and media scholars, thus providing a useful point of comparison.[20]

For our purposes, this story begins in 1993, when the US Air Force launched the last Navstar satellite required to complete the Global Positioning System (GPS). GPS technology precisely locates moving people and objects on the Earth's surface, and in 1993 this was firmly a government effort. The same GPS devices that today produce driving directions for the affluent originally cost twelve billion tax dollars to build. GPS was developed by the US Department of Defense and Raytheon, and they intended it as a means to guide intercontinental ballistic missiles to their target. GPS fits all of the criteria that have been proposed to define a "large technological project," a term of art defining that special sort of undertaking that includes "big science" and "big military" projects representing an expensive and complex societal effort.[21] These large projects (like Boston's "big dig" or the Apollo Program) address objectives that are thought to be impossible to achieve without a massive financial investment and a centrally-managed sociotechnical system to control it. Large public projects like these are sometimes contrasted to networks and private systems that begin as small, isolated parts and then become large (like the railroads or the telephone systems) through interconnection, consolidation, or some form of agglomeration. Unlike projects that can start small, by this logic, geolocation and landing on the moon both require a gigantic investment in infrastructure before the desired

results can be achieved even once. While GPS has its stories of individual inventors and pioneers, the "S" for "system" in GPS required multiple satellites to be launched before anyone would know where they were.

GPS, in other words, is a system that was as far as possible from the decentralized, participatory ethos of digital media that now excites some commentators. But just a decade later in 2003, when the "next-generation" of geolocation technology was advanced by the Skyhook Wireless corporation to improve upon performance of GPS, the new version was built on the backs of disaffected teenage digital media hackers. Without much fanfare, the innovative infrastructure for geopositioning had shifted from a network of military satellites to a network of emergent media practices—from big government to small subculture.

Generically called "software-only positioning," Skyhook's new replacement for (or supplement to) GPS takes advantage of the prevalence of wireless Internet consumer products in cities. After 1999, short-ranged wireless Internet access devices became a fantastically successful information technology product across the developed world, both in homes and in businesses of many types. The most popular type of wireless Internet, called "Wi-Fi" (a term coined by a naming consultancy that does not stand for anything), allows high-speed communication without a cable between computers at a range of about 150 feet. These devices were often purchased by broadband subscribers who wanted to connect a cable modem or DSL line to their home office without the trouble of running new wiring.

Anyone who bought a $70 Wi-Fi access point for their house after 1999 has been steadily transmitting a unique number from it as long as it has been turned on. This number is part of the protocol that allows these devices to interconnect with your computer, and each other. In a massive survey, Skyhook inventoried these numbers across the 25 largest cities in the US, and compiled a database that identified exactly where each unique number had been found.

When a user of Skyhook's software-only positioning system opens their laptop in a moving car, the laptop's now-commonplace wireless Internet chip listens for these numbers, and then Skyhook's database correlates them with locations from their earlier inventory. As long as most Wi-Fi users haven't turned off their access points (or moved, or bought new ones), Skyhook delivers an address more reliably than the Pentagon, and with more precision.[22]

This is a significant advance. In the urban canyons of cities, the line of sight from a GPS receiver to Navstar satellites is likely to be blocked or limited, causing the GPS system's notoriously poor performance in urban applications. But the denser the city, the more Wi-Fi signals there are, making the place where GPS is least accurate to be the most accurate for software-only positioning. GPS usually requires a specialized receiver (or at least a chip) and this provides a measurement of location that is accurate to within about 20 feet 95% of the time. In contrast, the promotional literature for software-only positioning claims accuracy rates within one foot.[23]

Wireless Play and Accidental Infrastructure

To say that all this came from disaffected teenagers isn't meant to imply inspiration or provenance, but to be taken literally. Skyhook's survey of Wi-Fi networks and its correlation of addresses originated in the folk practice of "wardriving," a quasi-legal hobby invented by computer enthusiasts.[24] As Drew explains in the underground instructional video "Responsible War Driving," wardrivers discover wireless signals by driving around the city with modified computers that "show us exactly where [people] are." All this is fun, Drew says, because of "the interesting maps you can create and explore."[25]

While driving around, a wardriver brings along a laptop or palmtop computer connected to a GPS receiver. Software like *Netstumbler* or *Kismet* logs the Wi-Fi networks that

the computer has discovered along with the latitude and longitude where they were found. The results can be visualized using free mapping software like *GPSMap* or *JiGLE/DiGLE*.

Some of the pleasure in wardriving obviously comes from being privy to information that other people don't have, even if it is simply knowing where to find invisible signals. Typically, wardrivers don't use the Wi-Fi they find for any purpose other than to map it. Wardrivers like to trade stories about interesting Wi-Fi access point identifiers they have found ("im_watching_you" "garyisgay" "nojohnissupergay").[26] The fact that driving slowly and systematically down every street in a neighborhood is a suspicious activity adds excitement, and some wardriving sites refer to trips as "adventures." As one "tips and tricks" site advises: "Do not draw unwanted attention to yourself…do not be nervous of [sic] police officers."

Is difficult to get a clear picture of the average wardriver. Information on any small subculture is hard to come by (the most prominent Web service devoted to wardriving had 54,768 users in 2006), but wardrivers generally prefer anonymity or pseudonymity because of the uncertain legal status of their hobby.[27] They need to be old enough to have access to a car, but at least some are not much older than that. This younger group is joined by an older cohort that has previous experience in amateur radio. They appear to be predominantly male. Some of them are technically sophisticated when compared to the general population. Postings to Web forums that betray personal information say things like: "I have my rig running when I'm delivering pizza." "I wardrive between home and school." "I need to do some college hw [homework]." "My gf [girlfriend] isn't into wardriving." "I've been a radio hobbyist all my life, a ham in the 80's."

Wardriving became more of a group activity, and more like a sport, with the introduction of opportunities for coordination, teamwork, and competition. Early efforts included "group" wardriving dates discussed on message boards in 2001-2002, attempts to

wardrive at the same time in different places (and compare notes) like the "World Wide Wardrive" in 2002, and attempts to cultivate a WarDriving Meetup at meetup.com.[28] Artists attempted to collaboratively produce Wi-Fi maps with volunteer wardrivers [FIND CITE], while groups like NZ Wireless pioneered a way to organize treasure hunts using wardriving equipment (the treasure is a set of specific unique identifying numbers for Wi-Fi access points).[29] At this time, articles appeared in "serious" publications pointing out that wardriving might have useful applications.[30]

A major shift in the utility and character of wardriving as an activity arrived when Web services became popular that allowed pseudonymous hobbyists to pool their efforts into one shared dataset. That is, a shared dataset that allowed them to both cooperate and compete in a systematic way. Drew (introduced earlier) created the Internet site wifimaps.com while Arkasha, Bobzilla, and others (these are online pseudonyms) created "WiGLE"—the Wireless Geographic Logging Engine. These services allow wardrivers to submit their results over the Internet and aggregate them. By 2005, thousands of young wardriving hobbyists using WiGLE had cooperatively mapped 5 million Wi-Fi networks.

Evoking open source software production, these sites allowed individual hobbyists with no connection to each other to collaborate on producing a result that was much greater than each individual part: a global map of Wi-Fi.[31] But just as crucially, the sites defined a venue in which avid enthusiasts could compete against each other, creating a new incentive for the discovery of more networks. An example posting to the blog chroniclesofawardriver.org is illustrative. It reads: "Congratulations go out to mark571 for claiming 2nd rank earlier this morning…Mark571 is currently 11,248 above my ranking and doesn't appear to be slowing down any – watch out 1st!"[32]

None of this was supposed to lead to geolocation. However, when entrepreneurs conceived of the possibility of geolocation and wanted to test its viability on a large scale, they found that wardriving enthusiasts were the ones in possession of the largest datasets locating Wi-Fi. Arkasha and Bobzilla of WiGLE sold their aggregated Wi-Fi database to Microsoft, creating a minor controversy among the wardriving community that was less about the hobby's commodification than it was about the sharing of the spoils. (One wardriver, mc_sikes, posted on the WiGLE forum asking "Now that wigle sold the data to Microsoft, are wardrivers going to get paid?") In this way, some of the same bits of data produced by the hobby have made their way into prototypes and even commercial software-only positioning products by Navizon, ekahau, Skyhook, and Microsoft.

General Prerequisites for Unexpected Innovation in Digital Media

From one perspective, the story of software-only positioning links terribly disparate actors, events, and technologies in a web of happenstance that is difficult to believe. To recap: A hypothetical middle-class urbanite in Pennsylvania buys a Wi-Fi access point to connect their cable modem in the living room to their computer in the upstairs den. Some time later, an anonymous hobbyist drives by (perhaps it was "SignalSeeker") hoping to collect the device's ID number as part of a treasure hunt. In Chicago, Bobzilla and Arkasha like to play with maps and computers, and so in their spare time they build a system to share this hobbyist data online and rank SignalSeeker against "Psychic Amish Stumbler" and other players. Later, they sell SingalSeeker's early results to Microsoft Research. Back in Pennsylvania, this turns out to help a passing motorist in a rented SUV to find their hotel. The SUV's on-board navigation system uses software-only positioning, but this works especially well when it is combined with a guidance system for ICBMs (the GPS).

While the details of this particular story are little-known, parts of the broad sketch might seem familiar. The Internet, as its history is sometimes told, was invented as a Cold War communication system designed to survive nuclear attack. It was then transformed by computer geeks who wanted to summarize old Star Trek episodes and share pornography.[33] In another version, supercomputing exists because of the military need for complex simulations of nuclear weapons, but the National Center for Supercomputing Applications was the birthplace of the first graphical World Wide Web browser, written by a part-time college student and now used by everyone. There are many other narratives like these.[34] Wi-Fi and software-only positioning's juxtaposition of military technology, play, and production may seem particularly novel, but it is just this combination of purposes that Timothy Lenoir has highlighted with the brilliant phrase "the military-entertainment complex."[35]

The basic ingredients that unite geopositioning, the Internet, and the graphical Web browser are a large-scale institutional or government investment refined or repurposed by upstart users. The pleasant surprise in these tales is the unexpected outcome: a technology has dramatically shifted function. These accounts of innovation invite the listener to celebrate the romantic notion of the individual, the "expressive, exploring, transfiguring idea of the individual" rather than the calculating utilitarian.[36] Horkheimer and Adorno's classic rule that in the enlightenment "whatever does not conform to the rule of computation and utility is suspect," has been observed in part by finding new value and utility in media and software play and exploration. This play is linked with the young, as play is so often linked.

Is this sort of innovation a new feature of digital media? Software-only positioning leveraged a number of other existing digital infrastructures to produce a new and unexpected resource. That is, the large technological project of the GPS first provided a centralized geolocation system that could be bootstrapped into a better decentralized one (software-only

positioning requires GPS). The large technological project of the Internet provided a converged digital communication infrastructure that could be employed to transmit and coordinate a variety of media, from e-mail to a wardriver's log files or mapserver. The large installed base of cheap consumer Wi-Fi access points accidentally provided the signaling mechanism that in the GPS would have required a satellite. The large installed base of Wi-Fi chips in laptop computers (and, more recently, cell phones) provided the antenna that in the GPS would have required a specialized handheld receiver. "Playing with maps" and mapservers on the Internet is an acceptable and encouraged pastime for programmers thanks to the many popular examples of hobbyist programming provided by the open source software movement. "Playing with Wi-Fi" and wardriving developed as a small but coherent subculture that provided its adherents an interesting pastime and an identity. Seen this way, the innovation of software-only positioning was a logical combination of these building blocks.

Speaking more abstractly, requirements for this innovation that could be applied to other examples could include that: (1) rich sets of information are freely available to be played with and repurposed, (2) information resides in a digital format that aids in its ready duplication, transfer, and manipulation, (3) cheap or free communication via the Internet allows the coordination of disparate, distant actors, (4) important features of existing digital systems are documented and programmable so that they can be easily reconfigured by those who have the skill, and (5) a subculture exists or can be created that provides incentives to participate.

Stated in this more abstract manner, many of the new media technologies employed by youth subcultures also fit this general template, as do the interesting software recombination projects mentioned earlier called "software mashups." Social networking services like myspace and Friendster have promoted themselves as a youth fad and induced individuals to produce a whole (e.g., a network) that is much more interesting than any single person's profile. The

photo sharing service Flickr does much the same, relying on the extensive existing infrastructure of digital cameras. If the five-part template introduced above represents a real departure from previous innovation, 2005 could be the edge of a digital media renaissance, where form, tool, genre, and infrastructure are newly amenable to change and recombination. But this conclusion is premature. Before generalizing about the "new" present, we should look for the Bobzillas and SignalSeekers of the past. Analog wireless play, after all, was pioneered by young boys and this led to what we now think of as radio.[37]

"New Wonders with 'Wireless'—And by a Boy!"

To those who have read the history of wireless innovation 100 years ago, the parallels to the Wi-Fi experimenters of today are uncanny. The argument here is not that parallels can be found in history for the current situation – history is a large domain, and so it is almost always true that some sort of historical parallel can be found for any situation. The argument here is instead that wireless history offers exactly the same sorts of roles, behaviors, and activities: not a roughly comparable situation but an almost identical one. In the first days of Wi-Fi, much was made of the "Pringles Cantenna:" a Wi-Fi antenna produced by enthusiasts who modified a potato chip can. A hundred years ago, the phenomenon was exactly the same, but the can used was Quaker Oats.

In the exemplary *Inventing American Broadcasting,* Susan Douglas coined the phrase "the cult of the boy operator" to describe the culture of radio amaterism and the press coverage that promoted it in the early years of the 20th century.[38] As a point of departure, she refers to a 1907 article from the *New York Times Magazine* headlined "New Wonders with 'Wireless'—And by a Boy!" The star of this feature was 26-year-old Walter J. Willenborg, an ordinary student with a facility for manipulating wireless equipment. A subsequent article in 1908 emphasized that

"even today there are young folks who make [a] mistake in thinking that all great things that are worth doing have been done; all the great discoveries made; all the grand inventions finished."[39] Willenborg was an example of the white middle class boys who were advancing the grand inventions of wireless. They did this by participating "in contests of strength, power, and territory," (p. 191) and by eavesdropping on otherwise inaccessible signals.

Douglas asserts that for the amateur operators of 1908, technical prowess in wireless was an important new way to be a man. The middle-class masculinity of the day was dominated by physical and natural contest. As formal education increased in popularity and duration and everyday life became more urban for most people, there had to be some way to reclaim "a sense of mastery" using other means: technology.[40] Boy operators could still "triumph over nature if they controlled the right kind of machine" (p. 191).

Scholars of media technology have given these boys enormous credit for shaping the development of radio as a system. The introduction of the inexpensive crystal set provided the means for amateurs to affordably experiment with radio, and the amateur audience that they developed foreshadowed the use of radio as a mass medium for entertainment. By many accounts, the most societally significant innovation in early radio was not a characteristic of the receiver or transmitter, but the idea of mass broadcasting itself. With radio, "it is not only that the supply of broadcasting facilities preceded the demand; it is that the means of communication preceded their content."[41] Radio companies of the time were focused on taking business away from cable and telegraph operators, and were reeling from the collapse of a speculation-related bubble in the stock market. In later developments in the regulation of radio, the significance of amateur operators would sharply decline, but in developing a very early audience of hundreds of thousands of users and uses for radio, amateurs demonstrated the viability of a system of mass broadcasting that would later be commercialized as "the media."

The point, then, is that a specific group of nonprofessionals in the past contributed valuable innovations to the social organization and the technological system of radio. If their greatest contribution was the idea of broadcasting (they were the first to transmit music over the radio), this was only one of many other contributions. As they had limited resources, their contributions often emphasized overcoming these constraints. For instance, the American Radio Relay League managed the first transatlantic transmission by shortwave in 1921 – a feat that without shortwaves required giant industrial machinery consuming large amounts of power.

Some of the rules and games of wireless play are identical, even across 90 years. NZ Wireless's Wi-Fi treasure hunts, mentioned earlier, are the same sort of organized seeking for particular signals that early radio amateurs pursued under a variety of names.[42] Much like the wardrivers of the 21st century, the early 20th century pioneers often organized themselves while at play, and some activities took the form of a contest. Starting in 1916 the US amateurs began to organize large scale radio relays that would convey messages across the country (in 1916 a message from Iowa reached both coasts in about an hour).[43] These relays emphasized different characteristics of wireless technology at different times (e.g., some were speed contests, some experiments with reliability checks). The organizational vehicle for these relays, called the American Radio Relay League, became the dominant membership association for amateur radio.

Bobzilla and Arkasha's creation of WiGLE (the Wireless Geographic Logging Engine) on the Internet to organize wardrivers was then a newer version of an old sort of effort. Bobzilla and Arkasha used a dedicated Web server and computer programming expertise to harness the latest geographic information systems (GIS) and technologies. In 1916, W. H. Kirwan bought "a

large map of the United States and a pair of compasses," and when he wanted to communicate with amateur stations, he produced mailings of one thousand letters.[44]

The Prerequisites Revisited: What's Different Now?

Earlier, this chapter posited five general prerequisites for unexpected innovation in digital media. Summarized again concisely, they were: (1) rich sets of data, (2) digital formats, (3) cheap communication, (4) open, documented interfaces, and (5) a subculture of innovators. After a short detour to the history of wireless play and radio amateurism 90 years ago, it should now be clearer that surprising things can also be accomplished with poor sets of data, expensive communication, and analog formats. While the fifth prerequisite (a subculture of innovators) has garnered a lot of attention recently, the young inventor-hero and the subculture of innovation is not a new phenomenon by any means (as Walter Willenborg would agree, if he were still living).

It may be that there has been no revolutionary shift in innovation, but instead an altering of scale that is significant enough in itself. If the Shawn Fannings of the world are not a new phenomenon, it may still be that there are more chances to innovate in this manner now. Von Hippel depicts an acceleration of user-driven innovation across society in just this way: not as a wholesale transformation, but as a change in scale. "[R]apid technological advances in computer hardware and software and networking technologies have made it much easier to create and sustain a communal development style on ever-larger scales," he writes, due in part to "prepackaged infrastructural support" for subcultures of innovators.[45]

However, this leaves one prerequisite unaddressed: the need for open, documented interfaces to be able to experiment with and modify the technology in question. It is clear from the discussion so far that both the Wi-Fi amateurs of 2003 and the radio amateurs of 1916

seemed to have sufficient access to the technologies they were experimenting with. Yet, the present situation is often thought to be special in that there is a new and increased role for intellectual property law in regulating (some would say restricting) innovation.

It has been noted that recent changes in copyright and patent law are potentially disastrous for small experimenters or innovators. This combines with the more general and often heard argument that the society is being juridified or legalized, or becoming more litigious. It may be that innovation is different now because of an encroaching legal culture that restricts aspiring innovators. As a report of the National Research Council noted in 2000, the increasing use of software patenting is dangerous to the creativity of the computer software and Internet industries because "the need for access to cross-licensing agreements and the legal protection of large corporations" may mean that "developing and deploying software and systems may cease to be a cottage industry."[46] Similarly, recent legal restrictions on reverse engineering are portrayed as harmful to new entrants with limited resources.[47]

It is essential to recognize that intellectual property played a central role in wireless innovation of the distant past. (The narrative of early radio technology could be organized solely by its patents, and patent disputes.) But still, there is some evidence that intellectual property is now looming larger than ever before among subcultures of amateur innovators like those in wireless, software, and digital media.

For instance, the London-based wireless Internet cooperative CONSUME was founded to experiment with alternative wireless infrastructures in 2000. CONSUME was a volunteer project, organized in meetings at pubs after work. It took the membership just ten months to realize that it had to split its general-purpose online mailing list into two lists. One would focus only on the legal implications of the enterprise, while the second list would focus on all other aspects of the project. Others have written about the pivotal role that licensing agreements have

played in the development of alternative forms of production such as open source software, and in the very large amount of time spent by the open source software community discussing details of licensing. This is a difficult situation to assess now, as the benefits of the Internet and digital convergence for innovation may be encouraging innovation at the same time that relatively new legal developments like the software patent and the Digital Millennium Copyright Act are discouraging it.

One clear conclusion, however, is that the characteristics and organizational dynamics of a motivated group of amateur experimenters has remained relatively stable. Unlike recent writing about innovation and social production, in the wireless domain the same sort of people are organizing themselves in the same sort of ways to try the same sort of things. This is not to disparage the value of these endeavors. Indeed, if, as argued earlier in this chapter, early wireless amateurs provided important technological innovations to society, is it possible to determine how this sort of benefit can be created in the future? An ideal national policy on science and innovation should take all routes to innovation into account, including Shawn Fanning and Walter Willenborg.

One beginning avenue for further inquiry is the unusual status of the radio amateur in wireless regulation. Although Wi-Fi enthusiasts (as users of an unlicensed technology) are not licensed, tradition radio amateurs (or "hams") are certified by the FCC. This is less the result of a foresighted innovation policy as it is the response to the early chaos in wireless communication that resulted in federal intervention in the first place. However, it is worth noting that the amateur license has proven to be a remarkable source of group identity and cohesion, and that the goal of advancing radio as a technology is written into the mission of the amateur groups and public policy discussions of amateur licensing. Amateurs ostensibly needed licenses because the scarce frequencies of the electromagnetic spectrum were subject to

their malicious interference, and licensing provided both a certification of education and a form of accountability. However, in hindsight it might just as easily be said that amateur access to the spectrum was required for the experimentation that was so beneficial to be allowed to continue. In a similar manner, a future research agenda could address what prerequisites would be required for an "amateur experimenter's corps" to be allowed access to the open interfaces and interface documentation – in other words, the intellectual property – required for innovation in digital media.

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Notes

[1] For a popular history of Napster, see Menn (2003).

[2] See Pemberton (1997).

[3] This quote is from Lessig's blog (Lessig, 2006) but see also Lessig (2005).

[4] This argument has been advanced by Carey (2006).

[5] See Mueller (1999) for a review.

[6] The compression characteristics of consumer DTS and the DTS CD-ROM used in theaters differ slightly.

[7] Winseck (1999).

[8] e.g., Theodore H. Nelson's famous quote, "The purpose of computers is human freedom." See Nelson (1974) and http://xanadu.com.au/ted/TN/WRITINGS/TCOMPARADIGM/tedCompOneLiners.html. For a review, see Turner (2006).

[9] This language is expanded upon in Bar & Sandvig (2000, p. 22).

[10] See Weber (2004), for instance.

[11] For many examples, see Lessig (2004).

[12] For an analysis, see Pfaffenberger (1988).

[13] See Miller, Slater, & Suchman (2004) for a review of this divide.

[14] See Von Hippel (1988).

[15] as Nathan Ensminger dryly puts it (Ensmenger, 2003, p. 154). See also Ensmenger (2001).

[16] See Brooks (1995).

[17] For example, see Turkle (1985).

[18] Tim Berners-Lee is credited with inventing the World Wide Web. Bram Cohen designed BitTorrent, the peer-to-peer file sharing system optimized to handle large files.

[19] Examples of fiction in this genre include Bronson (1997), while trade press nonfiction summaries include Kaplan (2000).

[20] e.g., Barnouw (1966), Desoto (1985), Douglas (1989, 2004), McChesney (1995), and others.

[21] For a definition, see Joerges (1988). For other examples, see Hughes (2000).

[22] Several products combine GPS and software-only positioning. Ventures include Skyhook Wireless, ekahau, Navizon, and Microsoft Research's WiFi Positioning.

[23] It is likely that this is not true, still software-only positioning offers more precision than GPS in urban areas.

[24] See Sandvig (2003).

[25] See http://tv.seattlewireless.net/november/november2003.html

[26] See "best SSIDs you have seen" at http://www.broadbandreports.com/forum/remark,12349735~mode=flat

[27] WiGLE.

[28] See http://www.worldwidewardrive.org/ and http://wardriving.meetup.com/about/

[29] See "Treasure Hunt Wi-Fi Style in Aukland" at http://nzwireless.org/content-3.html and "Use Wi-Fi to Play Access Point Games" at http://www.extremetech.com/article2/0,1697,1746269,00.asp

[30] e.g., Byers & Kormann (2003).

[31] Or perhaps a "global" map – these maps have holes where wardrivers do not go.

[32] See http://www.chroniclesofawardriver.org/?p=285

[33] For a more nuanced treatment, see Abbate (1999) and Hughes (1998, 1999).

[34] For more, see Edwards (1996).

[35] See Lenoir (2000, 2003).

[36] Streeter (1999).

[37] See Marvin (1988), Douglas (1989).

[38] for other discussions of radio amateurism and alternative radio, see Desoto (1985) and Walker (2004).

[39] quoted in Douglas (1989), p. 189.

[40] This only alludes to the large literature in feminist technology studies and anthropology linking the "technical" to the masculine.

[41] Williams (1975), p. 18-19.

[42] Radio amateurs, for instance, collect specific signals by gathering QSL cards (a paper version of the code QSL, meaning, "I confirm receipt of your transmission"). For more detail, see Gregory & Sahre (2003).

[43] see Kirwan (1916).

[44] Kirwan (1916), p. 24.

[45] Von Hippel (2005), p. 99.

[46] e.g., see National Research Council (2000, p. 192).

[47] for an overview, see Samuelson & Scotchmer (2002).

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