P2P Radio as a "Comedy of the Commons":
Mesh networks and the democratization of the radio spectrum

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INTRODUCTION

This paper is based on reflections arising over the course of the seminar on Lawrence Lessig's work *Code: Version 2.0* held at the Universidad Libre y Experimental de Málaga in the first semester of 2009. Actually, instead of "reflections", it is based on interference: the interference that reading the chapter titled "Free Speech" (specifically, the section "The Regulators of Speech: Distribution")[1] provoked in our thinking regarding how to shape the claims related to a commons at the heart of communications networks. I would like to thank Raúl Benítez and especially Gabriel Ochoa for their contributions on the subject.

The general demand for common spaces in this field has existed since the beginning of what have become today's widespread reflections and initiatives related to the (re) conquest of the communicative, creative and intellectual commons, all of which identify themselves as heirs to the philosophy and practice of the successful free software movement. In this sense, special inspiration comes from the metaphor of "layers" that Yochai Benkler borrowed from network architects back in 2000 to frame his commitment to constructing a communicative commons that encompasses all levels of the "information environment":

> As the digitally networked environment matures, regulatory choices abound that implicate whether the network will be one of peer users or one of active producers who serve a menu of prepackaged information goods to consumers whose role is limited to selecting from this menu. These choices occur at all levels of the information environment: the physical infrastructure layer—wires, cable, radio frequency spectrum—the logical infrastructure layer —software—and the content layer. At the physical infrastructure level, we are seeing it in […] the question of open access to cable broadband services, and the stunted availability of license-free spectrum. [2]

This understanding of how the communications system works based on a consideration of three layers was taken up the following year by Lawrence Lessig in *The Future of Ideas*[3] to call for a commons in the area of the physical infrastructure of communications. Thus, the same year the information commons received a fundamental impulse in its "content layer" through the founding of the Creative Commons organization by Lessig (and others), Lessig said:

> ... Second, we should force the government to give up its obscenely wasteful hoarding of spectrum. When radios were stupid and clear channels were necessary, this hoarding made sense. But the government is not using this spectrum with stupid radios. The most advanced work being done in "software-defined radios"—radios that would, like chameleons, change their character to fit the protocol in the context that works best—is being done by the same group that gave us the Internet—the Defense Advanced Research Projects Agency (DARPA). DARPA is researching software-defined radios that share spectrum smartly. It is, in other words, building the Internet in the air.[4]

This approach has recently been adopted closer to home, taking on a larger role given the debate about the use of the "digital dividend" arising from the imminent "analogue black-out" and

the implementation of Digital Terrestrial Television (TDT), whose greater efficacy in its use of the spectrum will free up dissemination frequencies on the UHF and VHF bands that until now were used by conventional analogue television.

Beyond the (limited) repercussions of these discussions in academic circles, we consider of special note two artistic-political projects that, since 2006, have been aiming at encouraging the democratic debate on the electromagnetic spectrum in Spain: "Reclaim the Spectrum"[5] and "The Atlas of Electromagnetic Space"[6], conceived of by Jose Luis de Vicente (the former was a group exhibit at the 2006 Festival Zemos 98, and the latter, an interactive installation in collaboration with Irma Vilà and Bestiario that has been posted on a website which must be visited by those interested in the subject). As Juan Freire explains in "Arte y política alrededor del 'ladrillo digital'"[7], both projects seek to remove the veil of invisibility surrounding the spectrum through a virtuoso graphic presentation of the structure and topology of this "unexplored *terra incognita*"[8], which goes beyond the merely descriptive to fully enter political territory as it makes it possible to "completely, and critically, visualize the political economics of the use of this spectrum"[9].
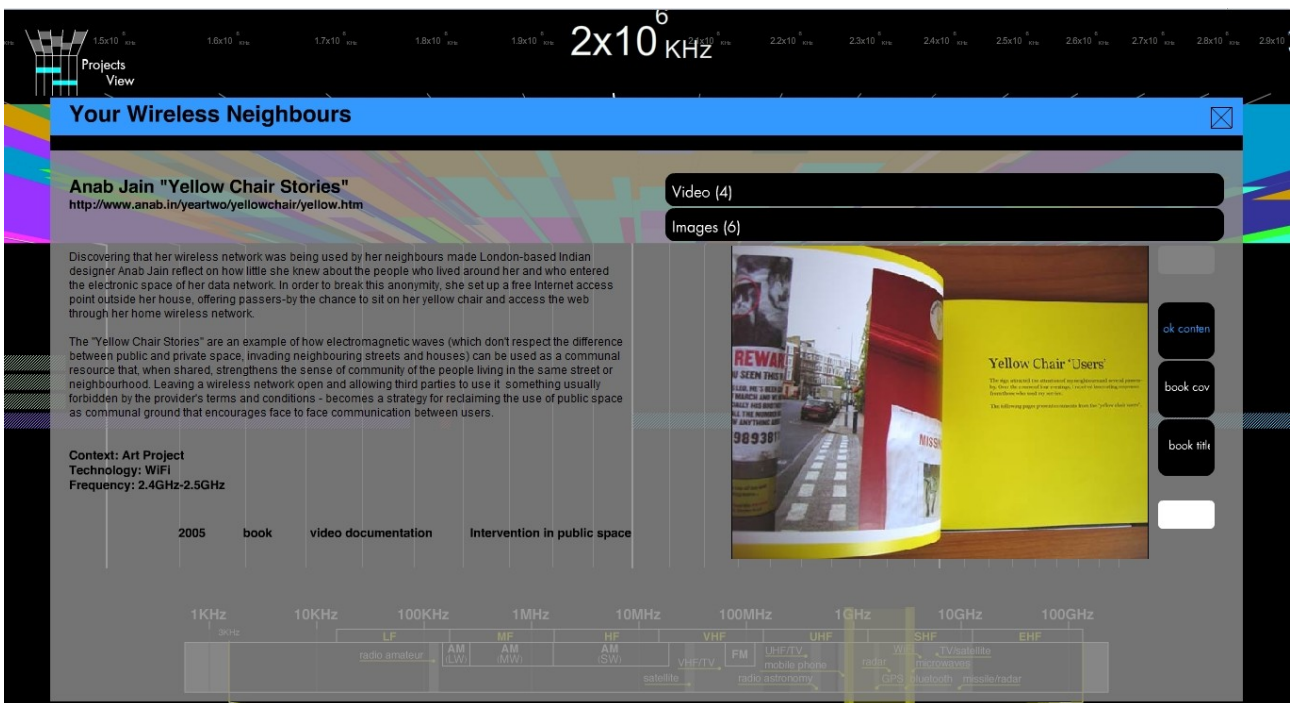
Atlas Project, illustration provided by Jose Luis de Vicente (CC BY-NC 3.0 Spain)
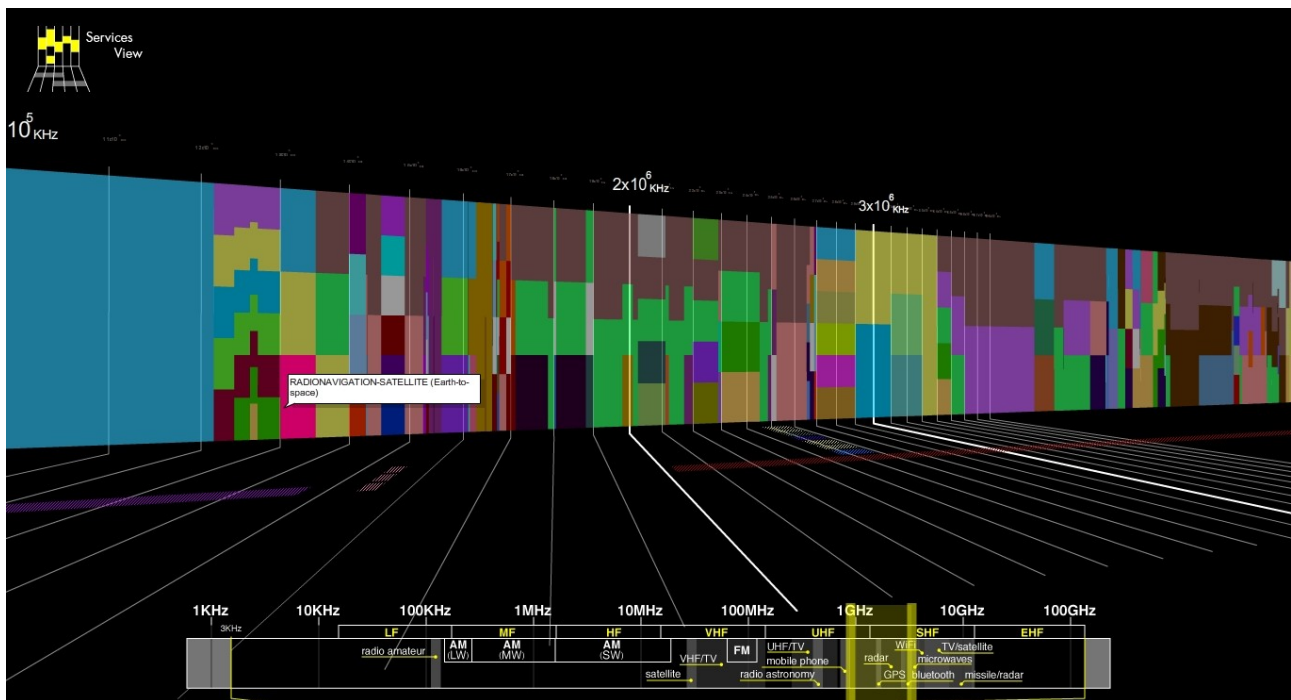
Atlas Services, illustration provided by Jose Luis de Vicente (CC BY-NC 3.0 Spain)

The urgency of the democratic debate that these projects aim to encourage becomes even more evident at this time, as Spain's Ministry of Industry, Tourism and Trade has announced its project for a Royal Decree that will establish how the bandwidth of frequencies from 790 to 862 MHz will be assigned as of 2015 for, among other things, bandwidths for mobile services[10]. This confirms the questions brought up by the aforementioned Jose Luis de Vicente in his presentation of "Reclaim the Spectrum":

> And yet, we know very little about the spectrum: who owns it, how is it managed, and how its uses are determined. In spite of being a supposedly scarce, precious resource, its regulation is rarely subject to processes of public scrutiny; discussing it is not a political priority. The "masters of the spectrum" (the military, the radio broadcasting industry, and telecommunications operators) have for decades enjoyed the exclusive use of its most useful frequencies, while it is precisely in the insufficient public frequencies open to all where some of the most socially beneficial innovations have taken place, such as wireless Internet access networks. [...] At a time when standard users like third generation mobile telephone companies and wireless users are in conflict, reclaiming the right to decide about the most fertile uses of the spectrum for society has become an urgent priority. Do we really need more TV channels and video messages on our mobile phones? Do we want technologies that allow us to be participatory agents or merely consumers?[11]

That said, this document does not aim to take part in the general debate on the use of the electromagnetic spectrum but rather to focus specifically, along the lines of Lessig's statements quoted above, on matters pertaining to the radio spectrum, that is, the part of the electromagnetic spectrum with frequencies between about 3 Hz and about 300 GHz. This range of radiofrequencies is divided into various sections used for different purposes (from radio broadcasting, television, and telephone communications to radars, WI-FI transmissions, RFID systems for radio frequency identification and so on). Of those, I will address that of *radio broadcasting*.

In addition, it is important to point out that the proposals of Lessig's that I will present succinctly below are not a discussion on the uses that this or any other government assigns to available frequencies on the radio spectrum. They question the role that the government takes on to

justify its control of that assignment. Therefore, let us accept the invitation to a pause for reflection that Lessig and Benkler called for in 1998 in a joint article ("CBS" can be replaced by the media conglomerate of the reader's choice):

> But, before the government proceeds to auction (or to give away) even more spectrum to the few, shouldn't we at least pause to ask where we will be if the promise of spreadspectrum technologies comes true? If spectrum can be shared, does the Constitution really permit the state to silence the many so that CBS can speak?[12]

THE "TRAGEDY OF THE COMMONS" TO THE RESCUE

Liquidating the system of allocating spectrum by the State, or the more recent, lucrative system of allocating property rights to spectrum via an auction to the highest bidder? Sharing the spectrum? Bringing an end to the privileges of the few so that everyone can speak? Many people think of these and other pressing questions as soon as they hear proposals such as those mentioned, that shock us because they undermine basic communicative tenets we believed were based on natural considerations. For hadn't we agreed that the radio spectrum was a "scarce and precious" resource prohibited to the majority for our own good—that is, to prevent a communicative polyphony from collapsing it?

On this point, Lessig draws on his knowledge as an expert in Constitutional Law to challenge such assumptions with the unequivocal demand of the rights guaranteed by the First Amendment to the US Constitution with respect to freedom of speech: "[the] Congress shall make no law [...] that limits the freedom of speech or of the press". According to him, if everyone has a right to speak, then the State must categorically justify that its intervention is essential to foster a wise distribution of the available spectrum and, as a consequence, must persecute those citizens who exercise that right disobeying its centralized assignment. Here is where the allusion to the "tragedy of the commons" appears.

To give a very brief explanation, the term "the tragedy of the commons" comes from the article "The Tragedy of the Commons" published in 1968 by biologist Garrett Hardin in the journal Science. Although an in-depth reading of the text reveals more complex nuances (related to the need, for instance, to monitor dumping of polluted waste into public territory to avoid getting locked into a system of "fouling our own nest"), this article has become widely known as a basic reference to justify the unsustainability of self-regulated management of available resources based on the existence of a commons, as well as to legitimize the regime of private property as the most efficient in this sense. As an illustration, Gardin used the example of a field used in a communal manner by livestock farmers to explain how each of them, in the desire to maximize their benefits by taking as much livestock there to graze as they could, ended up leaving the field barren through applying a logic of individual profit that ruins them all in the end:

> Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons.[13]

It is precisely the assumption of the inevitable tragedy that the commons would lead us to which Lessig uses as the basis of the justification offered by the State in preserving its central role in the allocation of various slices of the radio spectrum, be it directly through licences or indirectly

via auctions. Indeed, if the spectrum were a scarce resource that could be impoverished through widespread use, then the State would have the obligation to restrict its use to a few operators and "to silence the many", who would be reduced to the position of merely receiving broadcasts, always from outside sources. In sum, even though the Constitution grants us all the right to free speech, we should accept the restrictions imposed on us by the State with respect to radio broadcasting given that they are due to the very nature of the spectrum. Lessig says, "Radio waves, in this view, are delicate invisible airplanes, which need careful air traffic controllers to make sure disaster doesn't strike."[14]

But what if the above were untrue? Or to be more precise, what if it were only true given one particular radio broadcasting architecture and not true for others? Would it make sense then to continue using nature as the inexorable guarantee of the State's privilege to give or take away citizens' speech? On this point, Lessig is very clear: "...what most of us think we know about radio is wrong. Radio waves are not butterflies. They don't need the protection of the federal bureaucrats to do their work."[15]

To back up that statement, Lessig begins with a use of the spectrum with which most of us are increasingly familiar: that of Wi-Fi networks. This wireless technology system for network connections is characterized by not using any licences or deeds of ownership to organize the use of a small fraction of the spectrum (mainly frequencies of 2'4/5 GHz), opting to share it via a distributed regulation based on IEEE 802.11 standards. Without ignoring the clear limitations of this example, Lessig uses it to knock down the cliché that any use of the radio spectrum not controlled by State intervention will lead inevitably to collapse, underlining the fact that no computer connected to a Wi-Fi network needs those "careful air traffic controllers" to tell it when it can and cannot broadcast.

Following this line of reasoning, Lessig invites us (as he does throughout the remainder of *Code: Version 2.0*) to avoid the dead ends built on so-called "natural" fallacies that only lead to powerless inertia and instead, to begin to reason in terms of design and architecture. In terms of code, in fact: a code that is truly malleable given that it is determined by human decisions. In this sense, and with respect to the threat of a "tragedy of the commons" applied to the ether of the radio spectrum, the founder of Creative Commons unequivocally points to alternative designs to optimize its use:

> Congestion is certainly a possible consequence of spectrum usage. But the critical point to recognize […] is that the possibility congestion depends upon the design. WiFi networks can certainly become congested. But a different architecture for "sharing" spectrum need not.[16]

"THE COMEDY OF THE COMMONS": P2P RADIO AND MESH NETWORKS

How then can one conceive of a different architecture for "sharing" spectrum that does not inevitably lead to congestion as it gains an increasing number of users? On this point, Lessig once again fosters a radical shift in our outlook in proposing a new metaphor that is familiar to us all, that of P2P (peer to peer) file-sharing networks, which illustrates quite well how it is possible to make the transition from the former tragic versions to the true promise of "a *comedy of the commons*":

> Just as peer-to-peer technologies such as BitTorrent harness the bandwidth of users to

share the cost of distributing content, users within a certain mesh-network architecture for spectrum could actually increase the spectrum capacity of the network. Under this design, then, the more who use the spectrum, the more spectrum there is for others to use—producing not a tragedy of the commons, but a comedy of the commons.[17]

Without daring to go into detail, I will attempt to give a simple explanation of what mesh network architecture consists of and how its application to wireless mesh networks is conceived. Mesh network topology defines a way of assigning a route for data transmission via a structure in which each node of the network is connected to the rest of the nodes, acting as both broadcaster and receiver. In this way, mesh topology guarantees the reliability and robustness of the network because it not only avoids jammed points inherent to mass dissemination schemes based on a central node, but also adds redundancy to the transmission, so that the fall of one does not affect the network as a whole, which is able to find alternative routes by *hopping* from node to node until the data reaches its destination.
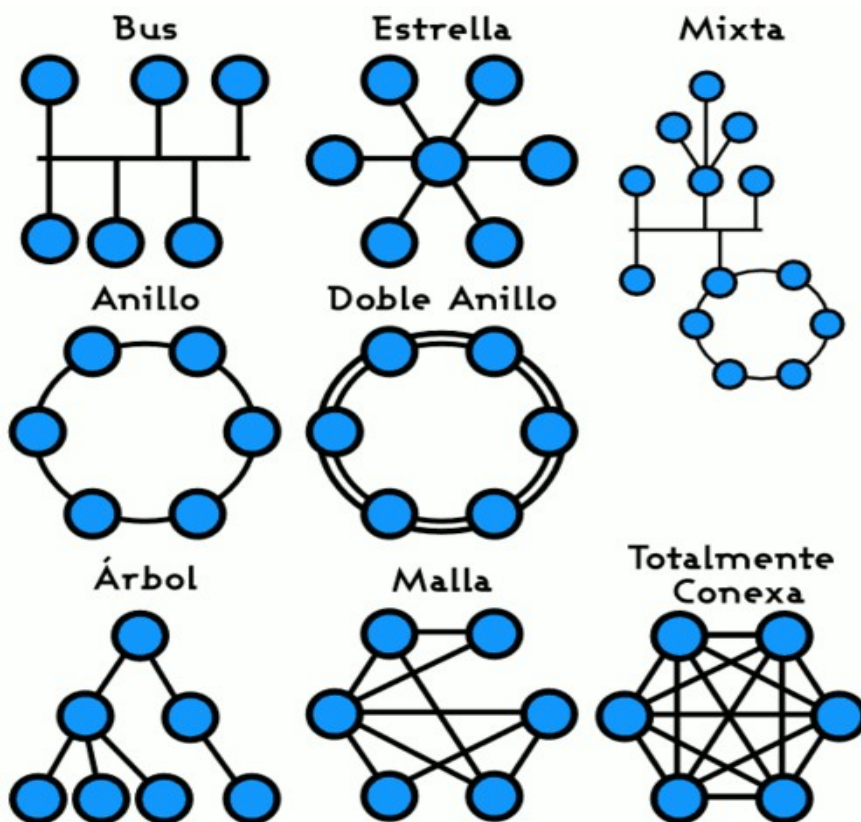
Comparative graph of network topologies taken from the blog Crónicas para el futuro (CC BY-SA 3.0 Spain)[18]

The implementation of this topology to decentralized wireless networks is defined by IEEE Standard 802.11s (still in draft form[19]) and it makes it possible to conceive of the creation of a network of connected radios such that their capacity increases by adding new nodes to the mesh. This is similar to what happens in P2P networks when the increase of sources (users) rebounds in the availability of a bigger bandwidth and consequently in elevating the exchange speed. In this sense, Lessig specifically mentions the MIT research project "Collaborative (Viral) Wireless Networks" that aims to propose viral mesh network schemes whose capacity is directly proportional to the number of connected nodes:

Cooperation could lead to substantial total (network) transmission power savings or increased spectral efficiency [...] under certain conditions and the goal of this research is

to provide distributed and adaptive cooperation algorithms that could be applied in practice.[20]

In sum, the reference to how P2P networks function illustrates Lessig's call for a radical democratization and optimization of the radio spectrum via a mesh network architecture where each node is intercommunicated with all the other nodes in the network and combines reception and transmissions operations, acting as a router for sending packages by the most efficient route (that which avoids potential breakdowns in nodes without blocking the entire network and takes the most direct route to its destination). In such a set-up, just like file-sharing networks, it is understood that there are no grounds for sustaining the tragic reconvening of those (tele) communications outlooks that sanction the privileges of prevailing expression, stubbornly clinging to claims of the threat posed by opening the spectrum to *dumb receivers*.

This then would be the technological materialization (albeit wireless) of the transition "from consumers to users" that Benkler called for in 2000. In this transition, restrictions expressly arising from licences and property rights to the spectrum would be fully delegitimized given that, as stated by Lessig, except for certain technical specifications that could be set by the State (certifying devices, establishing power limits on transmitters, and so on), "Once the protocol is agreed on, no further regulation is required."[21]

In sum, I consider that the technological exploration discussed by Lessig in *Code: Version 2.0* with a view to fostering the sharing of the radio spectrum through mesh networks is fully included in the inspiring claim by Benkler (that he reclaimed subsequently) to a communicative commons that encompasses the liberation of each of the "levels of the information environment", in the concrete case of what is called the "physical layer". These and other proposals have been collected recently in movements such as the Catalan Guifi.net (whose worldwide pioneering work I suggest be evaluated with maximum attention)[22] and the U.S. Open Spectrum[23], who work for dissemination and claims that are becoming increasingly significant due to the inevitable urgency of the aforementioned question posed by Lessig and Benkler over ten years ago. I will close this text with that question as testimony that the interference that was present at its origin has at least given me the certainty that we are presented here with a decisive debate for the future of the commons: "If the spectrum can be shared, does the Constitution really permit the state to silence the many so that CBS can speak?"

NOTES

[1]1 Lawrence Lessig, El Código 2.0, Madrid, Traficantes de Sueños, 2009, pp. 430-437.

[2] Yochai Benkler, "From Consumers to Users: Shifting the Deeper Structures of Regulation", in Federal Communications Law Journal, 52, 2000, p. 562. Available at: www.law.indiana.edu/fclj/pubs/v52/no3/benkler1.pdf (last retrieved: 1 July 2009).

[3] Lawrence Lessig, The Future of Ideas. The fate of the commons in a connected world, New York, Random House, 2001, pp. 23-25 and 240-245.

[4] Ibid., p. 242.

[5] http://www.zemos98.com/reclaimthespectrum (last retrieved: 1 July 2009).

[6] http://spectrumatlas.org/spectrum/ (last retrieved: 1 July 2009).

[7] Juan Freire, "Arte y política alrededor del 'ladrillo digital'", in soitu.es, 27 March 2008. Available at: http://www.soitu.es/soitu/2008/03/25/pieldigital/1206460679_324219.html (last retrieved: 1 July 2009).

[8] Presentation of the NOW Project, whose April 2008 issue contained the presentation of the Atlas del Espectro Electromagnético: http://www.cccb.org/now/es/projecte (last retrieved: 1 July 2009).

[9] J. Freire, op. cit.

[10] Ministerio de Industria, Turismo y Comercio, "El Gobierno regula el uso del 'dividendo digital'" (press release), 2 June 2009. Available at: http://www.mityc.es/es-ES/GabinetePrensa/NotasPrensa/Paginas/dividendodigital020609.aspx (last retrieved: 1 July 2009).

[11] http://www.zemos98.org/festivales/zemos988/reclaim/intro.htm (last retrieved: 1 July 2009).

[12] Yochai Benkler and Lawrence Lessig, "Net Gains", in The New Republic, 14 December 1998. Available at: http://www.thadk.net/ideas/lessigcopyright.html (last retrieved: 1 July 2009).

[13] Garrett Hardin, "The Tragedy of the Commons", in Science, vol. 162. no. 3859, 13 December 1968, p. 1244.
    Available at: http://www.sciencemag.org/cgi/content/full/162/3859/1243 (last retrieved: 1 July 2009).

[14] L. Lessig, El Código 2.0, p. 433.

[15] Idem.

[16] Ibid., p. 435.

[17] Idem. (Italics are mine).

[18] Graphics taken from the article "Las redes de malla; más que una ventaja, una revolución", published on 21 December 2007 on the blog Crónicas para el futuro. Available at: http://cronicas-futuro.blogspot.com/2007/12/como-casi-todos-sabemos-las-redes-son.html (last retrieved: 1 July 2009).

[19] See: http://grouper.ieee.org/groups/802/11/Reports/tgs_update.htm (last retrieved: 1 July 2009).

[20] Aggelos Bletsas, "Collaborative (Viral) Wireless Networks", September 2004. Available at: http://web.media.mit.edu/~aggelos/viral.html (last retrieved: 1 July 2009).

[21] L. Lessig, El Código 2.0, p. 436.

[22] See http://www.guifi.net

[23] For more information on Open Spectrum, I recommend the list of Frequently Asked Questions available at: http://www.greaterdemocracy.org/OpenSpectrumFAQ. For much more detailed and precise explanations of the technologies used in the demand for an "open spectrum" (including not only mesh networks, but also solutions based on "software-defined radio" and "broadened spectrum"), see Robert J. Berger, "Open Spectrum: A Path to Ubiquitous Connectivity", in Queue, vol. 1, number 3, May 2003. Available at: http://queue.acm.org/detail.cfm?id=864028 (last retrieved: 1 July 2009).