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Community Wireless Networking and Open Spectrum Usage:

A Research Agenda to Support Progressive Policy Reform of the Public Airwaves

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The document below is a tale of trinities: facets of an emerging communications revolution that we need both to better understand and to actively support.

Wireless technologies and the public airwaves that are this medium's lifeblood are rapidly being cordoned off, made proprietary, and licensed -- a process being driven by a desire to maximize profit margins, not serve the public good. A refocusing of priorities on "open infrastructures" that better serve the general public is desperately needed. These systems should be predicated on utilizing open spectrum, open source software, and open architecture hardware.

In addition, a major research initiative needs to be conducted to support "open" technological development, progressive policy reforms, and implementation of these new technologies. Thus, this document is both a call to action and a work in progress: over the past half-year, this research agenda has been formulated with the input of scores of the brightest technical geeks, policy wonks, and network implementers, with the goal of collecting information on technical, policy, and social aspects of wireless networking and facilitating far better community networking than is currently the norm. It is clear that a major telecommunications battle is coming -- if we do not prepare, the future of broadband will continue to ignore many communities and marginalize vast constituencies. For those of us who are interested in Community Networking, this is a chance to help mould the future communications systems and information-dissemination processes that will become ubiquitous in the coming decade. Nothing less than the future of social networking -- and the ways in which people relate, affiliate, and communicate -- is at stake.

In August 2004, over 200 wireless developers came together for the first National (US) Summit for Community Wireless Networks. On the last day of the summit, a group of policy experts and Community Wireless Network implementers formulated an outline for supporting progressive spectrum policy reforms. While many other uses for unlicensed spectrum exist, Community Wireless Networks are at the forefront of open spectrum usage and policy reform. In the months following the summit, based upon the initial framework, an international team of wireless developers fleshed out a twelve-point research and inquiry program to support open spectrum policy development around the globe. The research falls into three broad areas (policy, technical, and social); these areas are explained briefly below.

Policy Assessments

1. Identify major research already conducted and the literature being utilized in current regulatory and policy debates.
2. Document in-vivo effects of interference under current spectrum policies.
3. Detail actual and claimed spectrum usage.
4. Ascertain the pros and cons of existing spectrum rules and regulations.
5. Estimate the transnational and international impacts of existing regulatory structures, processes, and regulations of unlicensed and public use spectrum.

Technical Research Areas

1. Test signal propagation characteristics across different frequencies, topologies, and network architectures.
2. Test effects of dynamic transmit power on signal propagation, temperature interference, network architecture, congestion, etc.
3. Gather documentation of Community Wireless Network implementation models, "how-to" resources and guides.
4. Identify security issues and potential technical solutions.

Social Inquiries

1. Conduct an in-depth asset mapping and needs assessment.
2. Analyze and identify major components that maintain and support the digital divide.
3. Carry out an impact assessment of open source software use.

Policy Assessments

Five policy research areas for supporting open spectrum reform were identified.

First, identify major research that has already been conducted and impacted (or been cited) in regulatory/policy debates, as well as the independent research labs that are most active in contemporary spectrum research areas. This assessment would survey the literature that "counts" -- encompassing technical, economic, social, and other domains that should be taken into account and help inform contemporary regulatory/policy debates. This literature could then be used to help set the agenda for future policy debates.

Second, document in-vivo effects of interference -- including actual interference effects and any possible discrepancies between claimed interference and real-world deployments. In non-technical terms -- this would mean

conducting research that would help answer questions such as, "How much interference causes interruption of services?"; "How can we lessen interference within a geographic area?"; "How can multiple devices utilize the same spectrum without interfering with each other (i.e., what interference temperature does not cause degradation of service)?"; etc. For Community Wireless Network users, this research would help network implementers solve interference problems. One problem facing Community Wireless Network deployment is that groups and organizations that do not want to share spectrum claim "interference problems," causing an enormous artificial scarcity for spectrum access. To date, no proper independent analyses of interference problems have been conducted. However, researchers should be able to obtain experimental licenses from the FCC to conduct this type of research. In addition, it would be useful to work to set up mechanisms whereby an outside entity could audit the interference claims of licensees.

Third, document spectrum usage -- both actual and claimed -- paying particular attention to possible differentials among geographic areas (e.g., metropolitan vs. rural communities; developed vs. developing economies). For Community Wireless Networks, this would provide a topology of spectrum usage that would be extremely valuable for laying out new systems and/or avoiding areas where spectrum is congested. It has been suggested that this area of research further focus on two specific areas: bands the FCC (or relevant licensing authority) has already identified as possible for sharing; and bands that the Community Wireless Networking Community wants to see shared based on their physical characteristics. It would be especially interesting to identify significant differences between the frequencies identified by the FCC or other licensing body and Community Wireless Networking allies.

Fourth, a policy and regulatory assessment of the pros and cons of existing rules as well as an unlicensed spectrum/public access growth plan has never been conducted for open spectrum. Likewise, with the rise of "Voice Over IP" (VoIP) services and the continuing growth of Community Wireless Networking, an estimate of the service costs and feasibility of universal (broadband) wireless service has yet to be conducted. This research should target areas of regulation that are most amenable and/or useful to change and include both a policy assessment and a technical assessment. This would be an ideal location for discussing alternative economic models (e.g., ones that take the externalities ignored by mainstream models into account); but this is also an area where political blowback might be greatest. In many ways, this inquiry area presents a Faustian bargain -- it could really open up new doors for open spectrum, but one could also seriously harm the movement by creating immense political fallout.

Fifth, estimate the trans- and international impacts as well as the regulatory structures, processes, and regulations of unlicensed and public use spectrum. The International Development Research Centre has already begun this documentation project for the Latin American and Caribbean region, but much more needs to be done to help identify places where public use of the public airwaves is endangered. This analysis would focus both on cross-border/international-agreement issues as well as on non-U.S. practices generally. Wireless communications do not care about borders; thus, the Canadian/US boundary (or other spectrum usage-heavy border) would make for an interesting case study. But also, international regulatory practices are extremely important to many peoples, and decisions in one area of the globe can have dramatic impacts on all other areas. The paper presented at the Telecommunication Policy and Research Conference is a good case in point -- if a single country required that radio manufacturers provide open interfaces to their equipment (which almost none do currently), it would impact open-source wireless development around the globe, allowing for drivers to be programmed and disseminated around the globe. This too is a fairly untapped area -- in that most of the focus has been on impacting US telecomm policy; while potential areas where it might make more sense to target other regimes to affect changes in telecommunications policy.

Technical Research Areas

Four future technical research areas that would support community networking projects were identified.

First, testing signal propagation characteristics in different frequencies, within different topologies and network architectures. In essence, identify vectors for interference and possible solutions -- both existing and areas for future technological development. This is, in many ways related to the policy area focusing on interference issues, but goes straight to the heart of the hardware problems that community wireless network users face. Often, the problem has to do with faulty software -- even the firmware put out by major corporations, the software that runs wireless cards that millions of users buy at their local "big-box" electronics store, have bugs in them that cause problems. In addition, new devices continue to flood the consumer market without any attention to problems of interference and frequency

congestion. A detailed analysis needs to be undertaken before unlicensed spectrum, the lifeblood of Community Wireless Networks, becomes a "junk band."

Second, and in a related vein, a technically focused research area to test the effects of dynamic transmit power on signal propagation, temperature interference, network architecture, congestion, etc. By identifying technological development impacts (e.g., for cognitive radios, smart antennas, etc.), researchers could greatly aid open spectrum implementers and help identify the best hardware options available for building dynamic, robust infrastructures.

Third, the documentation of implementation models (both successful and unsuccessful) and their attendant "how-to" resources and guides is almost entirely non-existent. Open spectrum advocates have identified a need for end-users to have access to more information; and for additional information to be made available to infrastructure implementers. Exemplars that span the gamut from private enterprise to municipal ownership to hybrid public/private partnerships are all needed and best practices need to be collected and disseminated. Paralleling this, open-source/non-proprietary tools for use by community wireless network and software developers need to be identified and their existence made known to the growing number of groups and individuals who are building these systems. Setting up a central library for these resources, where groups can "contribute" as well as find information collected by the research team (and where all participants can update the content) should be a high priority. The Association for Progressive Communications is currently working on a documentation project; however, they have chosen to focus heavily on documentation of proprietary systems -- leaving open-source and non-proprietary knowledge and resources fairly unexamined.

Fourth, documentation of security issues and solutions affecting open source network deployment has been relatively ignored. With all the fear, uncertainty, and doubt surrounding wireless communications, these technical issues also impact the social aspects of the project. Currently, many people have a vague fear of wireless communications (much like people had, and some continue to have, concerning shopping online). The reality is that wireless communications, much like any other mode of communication, are only as secure as end-users make them -- which means that both documenting security issues and educating the public about how to best deal with these issues in incredibly important.

Social Inquiries

Three areas for additional social research concerning open spectrum use were also identified.

First, conducting an in-depth Community Wireless Network asset mapping and needs assessment would help identify particular ways in which available resources could be more effectively utilized among developers, implementers, etc. The goal would be to map the current networking community as well as develop a profile of communities to be targeted for future network deployment.

Second, analyze and identify major components that impact the digital divide (e.g., access to hardware, access to connectivity, system administration expertise, lack of translated information) with the goal of empirically accounting for a majority of the digital divide variance. Identify community wireless network usage characteristics (e.g., demographics, structural constraints). This inquiry area includes components that do not appear, at first glance, to go together -- analyzing the economic barriers to deployment as well as conducting user case studies; but they are, in many ways, two sides of the same coin. This analysis would focus not just on economic barriers, regulatory barriers, fear of technology barriers, gender barriers, etc. but also on the multi-faceted, global digital divide. Current thinking assumes which aspects are most important to attend to (e.g., access to computers, technical training); but there is little in the way of empirically driven answers to the question of "What are the most important mediators and moderators for the divide?"

Third, and finally, a thorough impact assessment of open source software use needs to be conducted. These analyses would ideally include social, economic, and networking capital generated by these systems. Especially important is the inclusion of aspects that are often excluded from mainstream economic impact studies (e.g., include a detailed externalities assessment).

Taken together, these twelve policy, technical, and social research areas provide a comprehensive (though certainly not exhaustive) list of research areas that would help us understand and support open spectrum at the local, national, and international levels.

Appendix A

PLEASE FORWARD

FOR IMMEDIATE RELEASE

February 1, 2005

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CUWiN ANNOUNCES PUBLIC RELEASE OF FREE OPEN SOURCE WIRELESS NETWORKING
SOFTWARE:

Imagine a free wireless networking system that any municipality, company, or group of neighbors could easily set up themselves. Over the past half-decade, the Champaign-Urbana Community Wireless Network (CUWiN) has been developing an open source, turnkey wireless networking solution that exceeds the functionality of many proprietary systems. CUWiN's vision is ubiquitous, extremely high-speed, low-cost networking for every community and constituency. Following in the footsteps of Linux and Firefox, CUWiN has focused on creating a low-cost, non-proprietary, user-friendly system. CUWiN's software will share connectivity across the network, allowing users to buy bandwidth in bulk and benefit from the cost savings. CUWiN networks are self-configuring and self-healing -- so adding new wireless nodes is hassle-free, and the system automatically adapts to the loss of an existing node. And, because CUWiN networks are completely ad-hoc, there's no need for expensive central servers or specialized administration equipment.

To set up a network, all end-users need to do is burn a CD with CUWiN's software (which will be available for free at http://www.cuwireless.net), put the CD into an old desktop computer equipped with a supported wireless card, and turn the computer on. Once the computer boots from the CD, the rest of the setup is completely automated: from loading the networking operating system and software, sending out beacons to nearby nodes, negotiating network connectivity, and assimilating into the network -- all the complicated technical setup is taken care of automatically. Unlike most broadband systems, CUWiN's software builds a local intranet as well as providing for Internet-connectivity -- thus, a town that uses CUWiN's system is also creating a community-wide local area network over which streaming audio and video, voice services, etc. can all be sent.

CUWiN is a cutting edge research and development initiative. CUWiN has pioneered the first open source implementation of Hazy Sighted Link State routing protocol (first developed by BBN Technologies); thus

CUWiN's software creates a highly robust, scalable ad-hoc wireless networks. CUWiN's route prioritization metric is based on research conducted at MIT and will automatically adapt to any network topology and local geography.

CUWiN's software is, and always will be, available for free. CUWiN is a non-profit organization supported by grants and donations. CUWiN's software provides one of the world's most advanced networking solutions available today; and we are now making our software available to the general public to use, test, and help develop. We know that there are features and improvements that people will want to see in future releases -- as an open source project, we are counting on the feedback and input from people around the globe.

More information on setting up your own CUWiN network is available online now at: http://www.cuwireless.net/documentation

The latest version (0.5.5) of the CUWiN software will be available for public download by the end of the week at: http://www.cuwireless.net/downloads

A brief article on the background, history, and ethos of the CUWiN project is available at: www.comtechreview.org/article.php?article_id=259

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About CUWiN:

The Champaign-Urbana Community Wireless Network (CUWiN) has built a communications system using wireless networking equipment. This is essentially the same "WiFi" equipment used in homes and offices, but we put it on rooftops to connect neighbors and form a high-speed community network.

CUWiN's three-part mission is to: connect more people to Internet and broadband services; develop open-source hardware and software for use by wireless projects world-wide; and, build and support community-owned, not-for-profit broadband networks in cities and towns around the globe.

CUWiN gives communities a new choice for their communications infrastructure by building a house-to-house wireless "mesh." CUWiN makes it possible for neighbors to share broadband Internet access and services including Voice over IP as an alternative to traditional phone service, and alternatives to radio and cable -- such as live broadcasts from grassroots media-makers from Independent Media Centers and "Internet radio stations" in subscribers' homes.