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Wireless Grids or Personal Infrastructure: Policy Implications of an Emergent Open Standard

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Abstract

A wireless grid is characterized by the ad-hoc dynamic sharing of physical and virtual resources among heterogeneous devices. This paper reviews wireless grids standards development, in which the authors are engaged, and draws policy lessons from the emergent phenomenon to consider if they apply more generally for open Internet-driven innovation systems. Implications of wireless grids for open communications policy, whose need has become more obvious with the failure of the 'Network Neutrality' attempted patch to the1996 Telecommunications Act, is discussed briefly in the conclusion to the paper. In addition, new wireless grid product and market concepts – such as edgeware, gridlets and personal infrastructure – or will it become known as personal cyberinfrastructure? – are introduced and their meaning and policy implications explained.

WiGiT (Wireless Grid Innovation Testbed) specifications now under development with support of the National Science Foundation's Partnership for Innovation program (grants # 0917973, #0227879) promise to provide users with a new class of personal infrastructure applications, or edgeware. The WiGiT partnership, led by Syracuse University's Wireless Grid Lab, together with Virginia Tech's Wireless Internet Center for Advanced Technology (WICAT), look to employ an open innovation model to engage more universities, faculty , students, firms and government agencies, in their work. WiGiT partners include government, industry and universities. For example, the Portuguese government's Knowledge Society Agency and the Organization for Economic Cooperation and Development are both founding partners. Recent additions include the Seneca Nation of Indians, and the Syracuse City School District.

Future projections of this nascent specification will be shared in forthcoming publications. For this paper, use cases and scenarios will illustrate some of the capacities, and their benefits and risks, and will make policy recommendations for emergency services, security, privacy, built upon open architecture and open, universal, and flexible access principles for wireless grids.

1. Introduction

In “Virtual Markets in Wireless Grids: Peering Policy Obstacles” presented at the TPRC 30th Research Conference on Communication, Information and Internet Policy by McKnight, Anius, and Uzuner (2002), the world was introduced to the notion of the “wireless computational grid”, and its policy implications were hypothesized. In this paper we look back to learn from where we have gone in the predicted ‘creative destruction’ of markets (Schumpeter, 1942) from this original work, and describe the things expected yet to come from an NSF-supported innovation testbed. It is perhaps unusual to identify a policy conference as a birthplace of a new technology, but stranger things have happened across the Internet. However, what emergent technologies have in common are their distributed, modularized, and smart nature crossed with user’s demand for highly individualized broadband applications, their corresponding devices and the underlying broadband networks (FCC, 2010).

Consequences of emergent technologies are generalizable in the sense that present information and communication policy regimes are challenged, and obsolesced. Equally significant as the technology it is the recognition of the need for standards to govern and facilitate future developments. Specifications for these technologies are now under development, promising to provide users with a new class of personal infrastructure applications, or edgeware. Future projections of this nascent specification are not yet possible, but short use cases and scenarios in this paper will illustrate some of the capacities, their benefits and risks, and provide support for policy recommendations for emergency services, security, privacy, and universal access.

Given the technological development in the recent years towards miniaturization and ubiquitousness of devices and connectivity as well as specialization and modularization of applications (virtualization), critical policy relevant issues arise that have so far not been addressed by academia. We do not know of any study that deals with these issues from a policy point of view. However, the recent technological development has severe implications on people’s private and professional lives. Time has come to address these pressing issues. Thus, in this paper we critique current and explore future regulatory and policy implications of wireless grid technologies. We expect the remote trading of goods and services, enabled by evolving wireless technologies, will become a strategic issue for many organizations in the future. To illustrate these points we describe use cases that are being conducted that involve advanced wireless grids capabilities. These involve; emergency response, academic peer production in field studies, and informal networks for peer production. Through these use cases many information policy questions are raised and explored.

2. Wireless Grid Technologies

Wireless grids are defined as ad-hoc dynamic sharing of physical and virtual resources among heterogeneous devices (McKnight, Howison, and Bradner, 2004). This form of grid computing offers a solution to the challenge of ‘flexible, secure, and coordinated resource sharing among dynamic collections of individuals, institutions and resources’ (Foster, Kesselman, and Tuecke, 2001). The ultimate vision of the grid is that of an adaptive network offering secure, inexpensive, and coordinated real-time access to dynamic, heterogeneous resources (services, application, information, computational power), potentially traversing geographic, political and cultural boundaries but still able to maintain the desirable characteristics of a simple distributed system, such as stability, transparency, scalability and flexibility while maintaining security and integrity.

The grid is an emerging infrastructure that will fundamentally change the way we think about and use computing (McKnight and Kuehn, 2011). A broader understanding of the nature of the opportunities offered by grid computing and the technologies needed to realize those opportunities is required (Fichman and Kemerer, 1997). The concept of a virtual workspace, as a configurable execution environment, can be created and managed by reflecting client requirements (Fichman and Kemerer,1997; Lyytinen and Rose, 2003). Recent relevant and related work regarding wireless grids include works on user and socio-technical perspectives and challenges (McKnight, L., Katz, R.L., and Vaaler, 2001; Dillinger, 2003); coordination of user and device behaviors (McKnight, Howison, and Lehr 2007; Van de Wijngaert, 2004); future internet applications and bridging communicative channels (McKnight and Kuehn, 2011; Jin, 2002; Rogers, 1995). There has been increasing acknowledgement of the nascent growth of wireless grids as a new engineering field of scientific inquiry and innovation.

In the area of radio, wireless distributed computing networks (WDCNs), as wireless grid networks, can transform a group of resource constrained low-cost nodes into a high performance computing/platform. Within each WDCN, the resource requesting node distributes its computing workload to service nodes through wireless link (Chen et al., 2009). These service nodes compute the allocated workload and send it back to the requesting node. Virginia Tech leads the effort to develop gridlets that structure WDCNs over common wireless devices improving efficiency and stability. Areas of application for this work are related to military scenarios, emergency and disaster response, and mobile gaming.

A new class of software, called edgeware, which can enable ad hoc connection of people, devices, software and services in a personal cloud, supported by personal cyber infrastructure, is entering markets and open standards processes (Treglia, Ramnarine-Rieks, and McKnight, 2010). Wireless grid specifications are now under development by the WiGiT (Wireless Grid Innovation Testbed) consortium with support of the National Science Foundation's Partnership for Innovation program (US NSF grants # 0917973, #0227879). The WiGiT consortium, including partners such as the Organization for Economic Cooperation and Development and led by Syracuse University's Wireless Grids Lab, together with Virginia Tech's Wireless Internet Center for Advanced Technology (WICAT), employ an open innovation model to engage universities, faculty, students, firms and government agencies, in their process of standards definition and development. See figure 1 for WiGiT's founding partners.

The development of wireless grids will stimulate a variety of groups to use this technology in ways that are beyond their present understanding. The ultimate goal of the crafters of this new capability are similar to the dream of Mister Geppetto in "Pinocchio" (1883 novel by Carlo Gollodi and 1940 film) that this creation will take on a life of its own going forward.

2.1 Early Work on Wireless Grid Policy Issues

In the McKnight, Anius, and Uzuner (2002) paper the regulatory and policy implications of the wireless grid 'capability in the making' and the market ramifications were explored and expected pressing issues were identified. We look back to see where we have gone from this original work across time to where we are now to the project and posit the things to come. The Internet has shown us without question that technology and advancement of markets wait for no one, not government regulators nor private enterprise consortia. The juggernaut of advances in our ability to communicate and interconnect at greater speeds across devices and platforms cannot be delayed; our best hope is to possibly steer and react in forward thinking ways that are flexible enough to support such a dynamic thing as this phenomena. In this work we provide follow up to some of the ideas that were born in the early works to follow up on where things have gone and are today. Some of the issues that were identified early on have taken on new directions; these are identified here and expanded upon to identify their significance and the market and policy implications that are emerging.

An interesting observation across time has been that disaster is a powerful unifying force in the world. Is it this need to collaborate and make the best use of our human and technological and physical resources in the defense of mankind versus the elements of nature that has been most influential in seeing standards move forward? Several scenarios were described which involved market and economic forces driving and influencing development and adoption of standards. Other forces were identified as well which included interests in sharing intellectual capacity and conducting research to resolve problems and answer questions.

The timing of this research is linked as well the diffusion of innovation model of Rogers (1995). Research (about 5000 studies to date) through a great number of academic disciplines has been conducted regarding the diffusion of innovations (Rogers, 2004). Through this work has evolved a general model of the diffusion of innovation that readily applies to the increasing spread of the Internet or other “enfant de technologie”. According the model it will take several years for the new innovation to enter the market and gain acceptance and traction in the market and society (Rogers, 1995). This dynamic is evidenced here in that the technology of wireless grids has begun to evolve and mature. The interest in and acceptance of the virtual collaborative and shared device environment as well as expectations of the general public, business and government entities is being realized today in some early adoption scenarios.

According to Rogers himself “information-exchange” about the innovation, users sharing notes and experiences which gradually forge meaning regarding the innovation, “is the heart of the diffusion process” (Rogers, 2004). In the most recent works significant factors including; a focus on networks of interpersonal channels as a means for understanding the spread of innovations, and the importance of “re-invention” by the adopters who change the modernism themselves has been included in the model and discussion. This is much in line with the mechanisms in creative destruction whereby the participants and the technology iteratively, if not destructively, remake the new order.

The speed of technological advancement will always outpace the development of policy and regulation in society. Once again it is generally in hindsight that governance and regulatory activities are consummated. The main issues identified in the early work and paper can be categorized into four parts; Architecture and Infrastructure, Virtual Markets, Wireless Grid Infrastructure, Public and International Policy Issues. These are described below:

I) **Architecture and Infrastructure** for the Grid: Ad-hoc dynamic sharing of physical and virtual resources among heterogeneous devices requires an architecture and infrastructure. The main issues with reference to architecture and infrastructure were: *service discovery*; *pricing*; *payment*; *fulfillment* (resource transfer). The Globus Project is one example for global standardization for the field of grid computing. That research project involves developing software infrastructure for distributed computing on the world-wide scale.

II) **Virtual Markets** for the Grid: the market enables the exchange of resources and services. The assurances of *security and privacy* are especially critical to the implementation of a wireless grid. The grid will need to be protected from malicious or malfunctioning devices. *Technology* puts constraints on power sources and limits computational capabilities of mobile devices. Further, technical differences of mobile technologies constitute an obstacle to ad-hoc networks and dynamic sharing of resources. Consumed resources or services have to be compensated, thus *payment* is a core function for wireless grid resources and services. Issues of *intellectual property* and proper compensation of the content producers need to be addressed (who owns what, what is a 'rightful owner', how is value assigned, how is distributed content controlled?).

III) Wireless Grid **Infrastructure**: There is only a limited understanding of how the *quality of services* of end-to-end broadband services might be assured in today's nascent multi-service, multi-provider environment. Further infrastructure related issues are *service discovery*, *guaranteed service, differentiated service*, *performance*, *interoperability*, and *maintenance*.

IV) **Public and International Policy Issues**: The exchange of resources and services occurs across jurisdictional and geographical borders, thus a framework is needed now to address clearly issues on *jurisdiction and geography*.

Having now experienced the eight years between, we might admit that McKnight's 2002 policy concerns were – premature. But still, they serve to provide a foundation for assessing the development that the Internet and in particular wireless grid technologies have undergone to date, and the range of future policy issues likely to emerge with more widespread adoption and diffusion of wireless grids edgeware and gridlets.

2.2 Wireless Grid Standard and Specification Setting Environment

There are several organizations that contribute to standard and specification setting. An overview of such organizations identified in a Wireless Grid Computing survey by Manvi and Birje (2009) is given in table 1.

Wireless Grid Standard Setting Organizations
GGF (Global Grid Forum; www.ggf.org) is the primary standards-setting body for the grid. The GGF works with many organizations throughout industry that influence Grid standards and policies, including those for security and virtual organizations.
OASIS (www.oasis-open.org) is a not-for-profit international organization that promotes industry standards for e-business. This includes developing standards such as those related to the

Extensible Markup Language (XML) and the universal description, discovery, and integration (UDDI) service.
W3C (World Wide Web Consortium; www.w3.org) is an international organization initiated in 1994 by Tim Berners-Lee to promote common and interoperable protocols.
DMTF (Distributed Management Task Force; www.dmtf.org) is an industry-based organization founded in 1992 to develop management standards and integration technologies for enterprise and Internet environments.
WS-I (Web Services Interoperability Organization; www.ws-i.org) is an open industry body formed in 2002 to promote the adoption of Web services and interoperability among different Web services implementations its role is to integrate existing standards rather than create new specifications.
Internet2 (www.internet2.edu) was formed in 1996 to develop and deploy advanced network applications and technologies It is a consortium of groups from academia, industry, and government.
peer-to-peer working group (www.p2pwg.org) purpose is to facilitate and accelerate advancement of infrastructure best-practices for peer-to-peer computing.
Liberty Alliance (www.projectliberty.org) is an international alliance of companies, nonprofit groups, and government organizations formed in 2001 to develop an open standard for federated identity management, which addresses technical, business, and policy challenges surrounding identity and Web services.
OGF (Open Grid Forum: www.ogf.org) The OGF is a standards organization for grid computing, or applied distributed computing, with participation from both academia and industry.

Table 1: Wireless Grid Standard Setting Organisation (Manvi and Birje, 2009).

The standards environment for wireless grids remains dynamic. Specifications are not established firmly and the open source community, industry and users and the market will ultimately decide the future. There are presently a number of standards and specifications emerging and established relative to wireless girds. Table 2 lists some of the current specifications architectures, as reported by Manvi and Birji (2009).

Wireless Grids Specifications Architectures
Open Grid Services Architecture (OGSA): Aim is to define a common, standard, and open architecture for Grid-based applications. It was announced at the Global Grid Forum 4 in 2002. An OGSA is a service-oriented architecture that aims to define all fundamental services for e-business or e-science applications(www.globus.org/ogsa/)
Web Services Resource Framework (WSRF): An alternative infrastructure based on unadulterated Web services specifications, also affecting state, created in 2004 by Hewlett-Packard, IBM, Fujitsu, and the Globus Alliance as the WS-Resource Framework (www.globus.org/wsrf).
Grid Security Infrastructure (GSI): The Grid Security Infrastructure is a de facto standard for Grid security using, public key cryptography, X.509 identity and proxy certificates, with a globally unique identifier (globus.org/security/overview.html).

Table 2: Organizations relative to Wireless Grids Specifications Architectures (Manvi and Birje, 2009).

2.3 Open Innovation

The “linear model” of innovation that was accepted by researchers and business practitioners is being abandoned. Although the model provided a simple structure it was not capable of relating the more complex nuances of today's integration and innovation functions. Open innovation, according to the original developer, Chesbrough (2003), refers to a “process, a set of inter-firm relationships and a cognitive paradigm” that uses internal as well as “external ideas and paths to market, as the firms look to advance their technology” (Chesbrough, 2003). This notion is further expanded today to include in the definition the notion of the technology innovation expanding the market itself (Watanabe, et al, 2010). By this understanding we can actively pursue change by putting processes in place that are congruous with a change potential.

Wireless grid specifications are emerging following a decade of support from the National Science Foundation (NSF) Partnerships for Innovation (PFI) program, corporations, foundations, and state government (Treglia, J., McKnight, L.W., Kuehn, A., and Ramnarine-Rieks, 2010). The Syracuse University-Virginia Tech-led Wireless Grid Innovation Testbed (WiGiT) at the heart of the specification process will continue to evolve as WiGiT specifications come into wider use through edgeware applications enabling diverse products and services (Ramnarine-Rieks, A., McKnight, L.W., and Small, R., 2011).

Figure 1: WiGiT Founding Partners. Source: Courtesy of WiGiT, 2010.

2.4 The Wireless Grid Innovation Testbed (WiGiT)

WiGiT is focusing on the technical issues related to the development of open specifications for wireless grids. Among the technical issues to be explored are: wireless grid application performance and optimization, characterization of networks for wireless grid applications, and protocol development. Additionally, user behavior trials, application tests, security models, and trust frameworks for wireless grids will be among the issues explored in the testbed, by faculty, students, and firms (Treglia, Ramnarine-Rieks, and McKnight, 2010).

The initial WiGiT designs will utilize IEEE 802.11 (WiFi) as an air interface. Upper protocol layers (network through application) will be handled the same way as in any other TCP/IP Hybrid model. Software Defined Radio (SDR) is also present at the implementation portion of the testbed and will be used to test additional air interface. SDR is a radio communication system where components that have typically been implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented using software on a personal computer or embedded computing devices (Chen et al., 2009). WiGiT will capitalize on Syracuse University's and Virginia Tech's experience with SDR platforms. In particular the project will make use of VT's "OSSIE" (SCA-Based Open Source Software Defined Radio) and it's Cognitive Radio (CR) Testbed (CORNET) with over 48 radio nodes spanning over 4 floors of the same building (CORNET, 2009). Cognitive radios sense their environment and learn how to adapt their radio transmissions based on policy and efficiency criteria. CR systems are built on top of SDR systems and will be a key component in the design of our Wireless Grid. Figure 2 maps out the relationships among CR components:

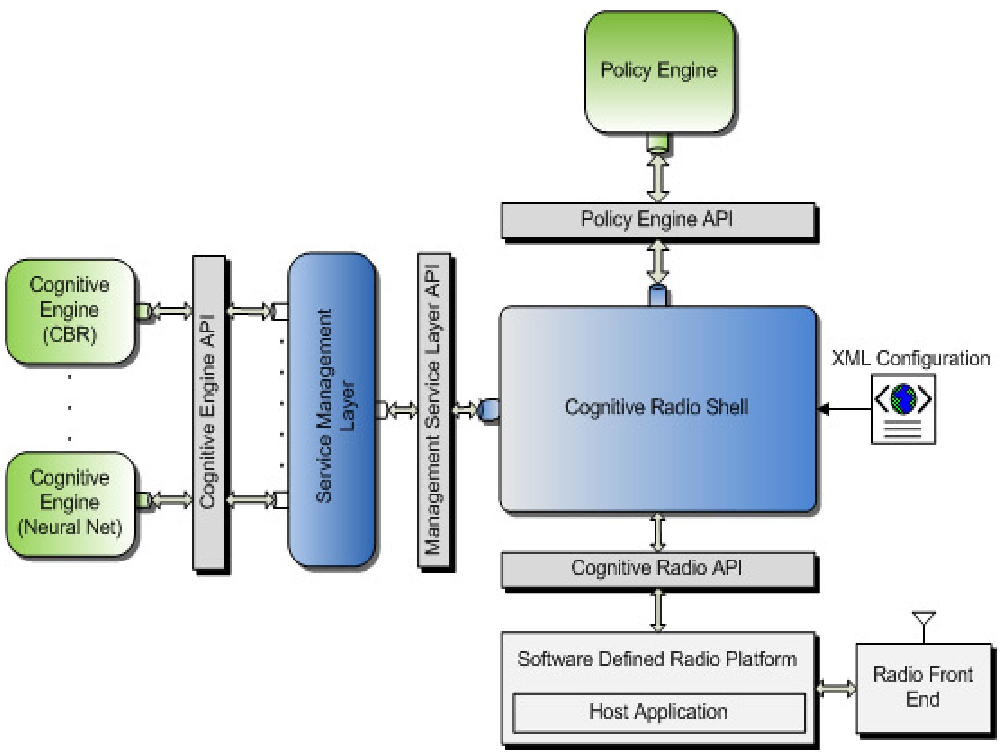

Figure 2: Cognitive Radio Elements for WiGiT. Source: Courtesy of Tamal Bose, Virginia Tech

As mentioned, initial WiGiT open specifications work will use IEEE 802.11 (WiFi) as an air interface and at the link layer. WiGiT research and experiments will serve cameras, printers, screens, switches, sensors, monitoring devices, etc. - connected by a wireless grid.

Software Defined Radio (SDR) systems and cognitive radio networks will be incorporated to enable wireless grid applications over a wide range of wireless technologies. Industry needs these systems for intra-system, or crossover work bridging grid or cloud computing on one platform and wireless Internet on another, contributing to open standards and application programming interfaces for wireless grids. WiGiT will refine transformative technologies to bridge the gap between wireless network middleware and grid application layers, creating new markets and realigning existing ones. WiGiT's open specifications will enable "edgeware" applications over a dynamic wireless (and/or wired) environment. Edgeware applications are a new class of applications that can dynamically make use of content and resources present in devices, phones, PC's. Edgeware will efficiently make use of resources based on environmental and user/application constraints and preferences.

The wireless grids application programming interface (WGAPI) to be developed by WiGiT and its consortium members will provide the capability for establishing wireless grids over heterogeneous wireless devices and involve edgeware applications to make use of the capabilities of wireless devices operating over a wireless network infrastructure and share resources with other edgeware applications in a wireless grid environment. An additional API to integrate wireless grid applications to environments making use of SDR systems in order to operate over a wide variety of wireless technologies will also be developed.

2.5 WiGiT Open Specifications Process

Inspired by Free/Libre Open Source Software development processes, and building upon decades of experience in regulatory and standards-setting for global technologies such as digital TV/HDTV, WiGiT is preparing to issue recommendations for cognitive radio, software radio, and wireless grids. WiGiT team members contribute to the Virtual Organization which will issue initial recommendations by participating in meetings and providing feedback and by contributing beta or alpha software implementations of WiGiT partner's applications to experimentation by WiGiT partners. Through rough consensus of WiGiT meeting/web conference participants, standards will be established and shared.

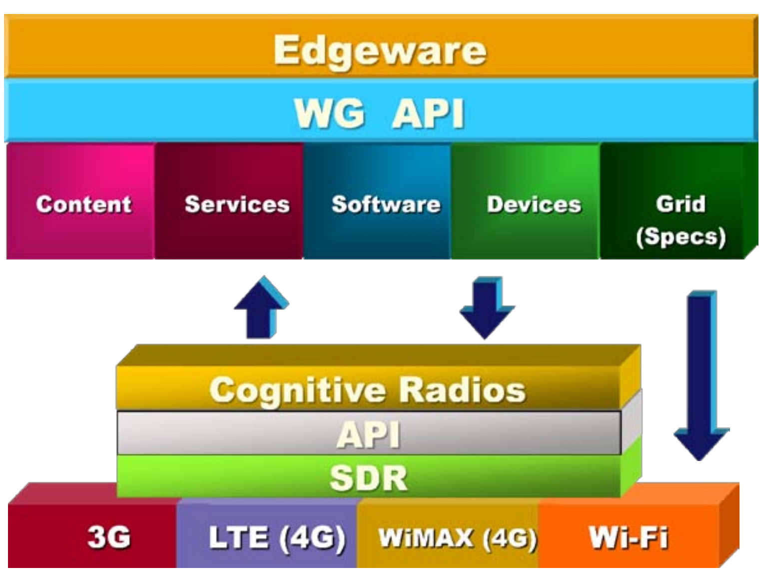

Figure 3: WiGiT Open Specification Layers

WiGiT anticipates defining through iterative and flexible process modular components which can be mixed and matched as partners wish (see figure 3). All participants in WiGiT can contribute their ideas, and/or their software, to the development of open specifications for wireless grids. Community members will determine how the WiGiT process will change, and which partner organizations may join in to contribute to broadening participation in WiGiT processes.

As an example of the virtual partnership it is quite simple to join WiGiT, although membership privileges vary by the degree of contribution, whether technical, financial, or user feedback, is offered in return. WiGiT rights also come with responsibilities, since the grid is by its nature a trusted environment, and WiGiT partners must earn the trust of partners, or others will not share resources with them. Further WiGiT partners are themselves essentially volunteer test subjects, with appropriate privacy and user safeguards as set forth by Syracuse University (and partner universities Institutional Review Boards and federal requirements for experiments on human subjects. WiGiT disseminates results through publications of participants, from its website, via social media, and via its partners.

Prior publications have spoken of WiGiT's open specifications, which are to be announced fall 2010. But we fully expect WiGiT to continue to grow as an alternative, open and participatory, specification process. WiGiT may feed into or complement existing standards organizations and processes, but it is too soon to say how this intra-organizational aspect of wireless grids standardization will unfold over time. The standardization activities within WiGiT is described in the following architecture model (figure 4).

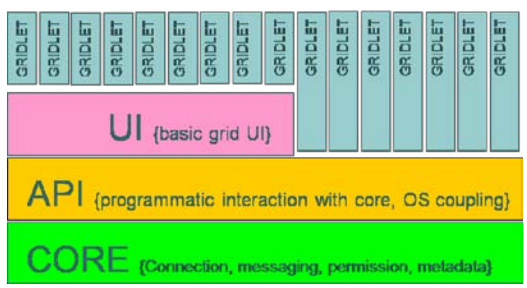

Figure 4: Wireless Grid Architecture Model. Source: Courtesy of WGC.

3. Current WiGIT Work Areas

In 2010 wireless grids took its first steps out of the laboratory into the real world, coordinating distributed resources in the entertainment and biomass energy systems. These are but just two examples that allow for ad hoc sharing of resources (such as screen, signal and microphone) on edge devices (such as PDA's, laptops and mobile phones). The many possibilities of user applications are still unknown. However, the success of this new technology to a large extent depends on the degree to which it actually matches user needs and fits the context in which customers must use the specific functionalities (Van de Wijngaert, 2004). Below are described some of the applications and use cases that will be focused upon over the next year. Beyond that, security, accessibility, and telemedicine working groups are also in formation.

3.1 Cyberlearning with Wireless Grids

Distributed and collaborative learning allow students and instructors to participate in learning activities anytime and anywhere. While distributed learning provides an environment where resources can be shared and dispersed students may participate in learning, collaborative learning puts more emphasis on providing a shared workplace for students to interact and learn through cooperation. Learning technologies can offer a platform not only for traditional students to conduct additional learning activities outside of the classroom, but also for working adults or other nontraditional students to learn according to their own schedules.

A major problem in the research and development of distance learning systems is how to provide organized effective support for communication, interaction, and collaboration in networked virtual learning environments (Jin, 2002). We will investigate the software and hardware requirements for sharing wireless sensor networks for remote experiments under the wireless grid environment focusing on the development of localization and power management strategies. Additionally, an interdisciplinary wireless grid capstone course in Information Management and Electrical Engineering will be offered by Syracuse University, Virginia Tech and Tufts University focused on the use, design, development, and evaluation of wireless grid applications.

3.2 Emergency Response and Neighborhood Notification System

The ad-hoc networking capabilities of nodes that participate in a wireless grid make these grids suitable to provide communication services and resources in emergency/security scenarios. WiGiT will work on an emergency notification system aimed at economically-poor urban neighborhood areas. Persons in a notification list would receive data alerts about emergencies on multiple devices, including cell phones and laptops. The list of persons to be notified would be managed through a web-based management interface; this interface would also allow authorized users to prioritize notifications over other uses of the wireless infrastructure without disrupting such uses. The goal being to enable community, private and public entities in problem resolution.

The system here involves using edgeware and a Software Defined Radio (SDR) front-end together with a wireless WiFi infrastructure for emergency notification purposes (Chen et al., 2010). A SDR is a radio communication system having computer based components that manage modulation, amplification, detection and other functions that were previously handled by dedicated hardware components.

Those on the list for notification by this system would receive data alerts on multiple devices, including of course laptops, cell phones and other devices. The list of persons to be notified would be managed through a web-based management interface; this interface would also allow authorized users to prioritize notifications over other uses of the wireless infrastructure without disrupting such uses. The notifications will not be using the frequency bands assigned to public safety agencies. The wireless infrastructure in development on the south side will use 5+ GHz backhaul devices with Wi-Fi for the distribution. The plan being to expand communication channel options between citizens, service providers, government and other supports.

Having the capability to create ad-hoc networks at incident sites that incorporate voice, messaging, graphics, and video means command and control personnel will have much richer information resources to use for decision making and coordination. (Carver and Turoff, 2007).

The atmosphere required to provide Information and Communication Technology (ICT) based support for improvisation is one that facilitates emergent interoperability: "a structured approach to real-time mixing and matching of diverse ICTs to support individuals and organizations in undertaking response activities" (Mendonça, Jefferson, and Harrald, 2007). Common devices such as cell phones also provide information processing support as many integrate text and multimedia capabilities. These platform dependent technologies can be integrated with more sophisticated technologies, such as sensor networks or other devices through edgeware services such as the wireless grid.

3.3 Distributed Computing

Wireless distributed computing networks (WDCNs) can transform a group of resource constrained low-cost nodes into a high performance computing/platform. Within each WDCN, the resource requesting node distributes its computing workload to service nodes through wireless link. These service nodes compute the allocated workload and send it back to the requesting node. Virginia Tech will lead the effort to develop gridlets that can structure WDCNs over common wireless devices improving efficiency and stability. Some areas of application already envisioned for this work are related to military scenarios, emergency and disaster response, and mobile gaming.

3.4 Entrepreneurial Ecosystems (SEED/iBox)

With support, encouragement and inspiration from Syracuse University Chancellor Nancy Cantor's vision of 'Scholarship in Action,' and support from a Chancellor's Leadership Project grant, augmented by support from the Kauffman Foundation for Entrepreneurship and the Syracuse Center of Excellence in energy and Environmental Systems, in concert with SEED partner's participation in the National Science Foundation Partnerships for Innovation project awarded SEED co-PI Lee McKnight $600,000 for the Wireless Grid Innovation Testbed (WiGiT) project in 2009. WiGiT leverages the Syracuse University-Near West Side - Syracuse Center of Excellence in Energy and Environmental Systems nexus of SEED as a local experimental testbed for new green ideas, products, technologies and standards. The new WiGiT resource sharing grid can be fully integrated in the Urban/Farm Greenhouse concept under development, as well as within the community. The other innovations of SEED may also be shared across wireless grids, encouraging job creation and entrepreneurship within Syracuse and well beyond. WiGiT open specification development is attracting wide interest in this area.

Similarly, the interactions with Chancellor's Leadership Project (CLP) interdisciplinary faculty, student colleagues, and diverse community residents, has been of great value to Summerhill Biomass Systems and its refinement of applications for its unique clean technology biomass burners and grinders. For example, greenhouses are an ideal setting, for evaluating this technology since they also produce waste biomass, which Summerhill's process turns into powder fuel. Both firms have been attracting substantial industry attention, thanks in part to the visibility of their participation in this Project. Both firms as they expand remain grounded in New York, potentially creating new opportunities for many other entrepreneurs. Syracuse University students have been valuable researchers and at times interns assisting these firms bring their technology to market, as well as studying both firms in various class projects of CLP.

In addition to the success of the CLP in inspiring dozens of students, as well as new standards, platform technologies, and companies focused on changing energy and communication practices towards sustainability, more than half a dozen journal articles, conference papers, and book chapters by participating faculty and graduate students have been published or are in press, with more to come.

4. Setting the Next Agenda for Wireless Grid Technologies

The prior paper on policy implications addressed many issues that are still important today, and will be more important tomorrow. In the meantime, several issues have been addressed; however, the wireless grid world has become more complex, even if its emergence is still nascent. Now, a more comprehensive approach is needed to understand the implication wireless technologies have that go far beyond the general questions of virtual markets and wireless gird infrastructure. From today's point of view, we might admit that McKnight's 2002 policy concerns were premature. But, they did address relevant issues. As the world has moved forward, a new emergent field of issues has arisen, but only a few of the previous issues can be considered as solved and the research enterprise continues.

4.1 Open Issues

4.1.1 Infrastructure

Next Generation Infrastructure and Technology - Next generation infrastructures for the private and public sector are evolving. Such an infrastructure provides a range of generic functionalities which other systems can build on and which are used by a large number of users. (Janssen, Chun, and Gil-Garcia, 2009). During the financial crisis in the years 2007 to 2010 significant investment into technology was enacted to stabilize tumbling national economies. (Roberts, 2009; Guellec and Wunsch-Vincent, 2009). Wireless grid technologies will be an essential as part of the next generation of infrastructure and as such benefit from the recovery investments in the economy. In the United States, significant investments directly address the further development of wired and wireless broadband technology, further a series of research initiatives address innovative national endeavors, such as a nationwide interoperable public safety broadband wireless network (FCC, 2010). Based on these national initiatives, other related areas will benefit, i.e. the emergence of 4G networks based on the support for further extension of 3G networks. With the rollout of new network capacity and the demand for new applications and devices, the rollout of IPv6 is further pushed ahead by the pure business potential of seamless connectivity and greater accountability.

Devices - The bulk of the change in interest being in the area of handheld and distributed device sharing. The widespread deployment of hand held phones for communication lead to the need for other services to be provided through these devices. The market has no tolerance for devices not being able to be shared or managed; users are separated from designers and do not care to understand standards or hardware design differences but instead simply expect that market forces and the increased ability of our scientists and programmers will create ever more intuitive, and powerful systems that work as we want them to regardless of the environment or regulatory environment (Gartner, 2010). Consumers will drive for what they want over what they need. Forrester research recently found that consumers are also quite willing to be "co-creators" of products that they expect to eventually buy (Melanson, 2010),

4.1.2 Resource Allocation and Prioritization

Resource Allocation - The new economy of the wireless grid has the capacity to assign resources based on constraints of availability, capability and costs. The present state of the internet is still struggling with this need for assessing and assigning costs to transactions and activities in a distributed environment. A technologically mature and evolved wireless grid has within it the capability to enjoin user and resources and to assign costs and allocate resources based on best case dynamically. As indicated previously it may be impossible to correctly assign users and devices across the globe and across grids. Within any given network it has been the case that an administrator assigns users and resources and access based on given criteria. In this distributed environment it is impossible for any administrator to know all of the users or to have knowledge of the status and conditions for use of federated devices of other network grids. There must be a better way to allow for access and service provision. One protocol involved owners of devices allowing for use in a case by case basis, which requires a great deal of overhead and complexity. A more futuristic way is to allow for proxies where profiles and circumstances determine users access and use of systems and resources and this determination is still left to the owners of the networks, grids or devices. The system looks for a way to vouch for a user or group of users based on other contacts or information that is available without having to individually vet the contact with an original source. Such a system is based on extended trust and verification. Fortunately the new wireless grid environment is also better equipped to verify authenticity of users and devices to support this.

Resource Prioritization - The notion of being able to prioritize requests and resources for use in the wireless grid was recognized early on as an important issue. What has come about from that early work is an even more acute appreciation of the need for an expansion of the early notion of access and priority to account for very large scale demand for scarce resources in time of crisis or system limitations. The case of a natural disaster brings this point to light. In the case of a disaster there becomes a flood of users on the network. Were traffic is undifferentiated it would be impossible for those responsible to manage the situation to obtain resources and connect with others whom they must connect and contact. The wireless grid must be robust enough to allow for a definable hierarchy of users who have priority over all others and are recognized by the systems, disparate systems and grids, as necessary. When hundreds of thousands of users are vying for connectivity and use of resources it must recognize and empower those who need to communicate over others. This is perhaps one of the greatest aspects of the mature wireless grid. The evolution of this type of created resource prioritization hierarchy for access control is now moving to the next stage.

4.1.2 Security, Trust, Control and Privacy

Protecting information and information systems from any unauthorized use, access disclosure, modification, disruption or destruction involves consideration of components including: confidentiality, integrity and availability and are necessary for advancement and adoption (Chandra and Khan, 2010). Privacy and security considerations must be addressed in this dynamic and distributed environment as well as social or personal issues and others that we discuss in the following.

Trust - Trust must be established among parties that use wireless grid technologies for the purpose of sharing resources or information. Lack of trust may hamper information sharing on a collaborative system in an institutional setting (Karahannas and Jones, 1999), but this may be applied analogously in individual settings where future wireless grid technologies also will play significant role. Social and personnel issues that involve trust and security concerns may hinder the effective sharing of resources and information across one's own organizational or individual borders. A transparent design of systems, devices, and applications may lower the level of required trust to engage in sharing of resources. By all means, unauthorized access, modification or disruption must be avoided to maintain the necessary level of trust. Without guaranteeing classic information security characteristics – confidentiality, integrity, and availability –providers of resources and information in wireless grid networks will be reluctant to share. As a prerequisite for trust, control of the information flow is important; systems must be capable of monitoring and tracking of information dissemination. (Powner, 2008). Otherwise, institutions and users may not be willing to use or adopt those technologies, i.e., in the critical context of emergency response (Tierney and Sutton, 2005).

Identity - Identity will no longer be a static process. Users are identified by personal descriptors as well as by their behavior and verified activities. Intelligent systems will verify that an alleged user is possibly who they claim or not. New systems will be based on use patterns as well as things such as passwords or responding to queries from memory. Accountability will stem from being able to flag logical inconsistencies such as one user logging in from two different physical locations. This is becoming vital as the number of potential users grows into the billions the likely hood that basic profiles will be repeated is almost a guarantee in some cases. Dynamic intelligent identification regarding users and transactions is critical, and possible. This knowledge and degree of dynamic accountability is a part of the wireless grid environment.

Authentication - The issue of user authentication is combined now with the need for device identification and vetting for access and accountability across this distributed and dynamic environment that is being created as a wireless grid.

Access - The problem of controlling authentication and access privileges in such a distributed environment is understood to be an overwhelming issue as we consider that networks interact directly with network grids creating exponentially large and complex systems of users and resources all needing identification, authentication, authorization and policy management and control. Add to this that users of today are on the move. It is not enough to have a one-time authorization and vetting but we must account for the user in a mobile and wireless environment dynamically changing and needing to be vetted across their connections and means. This is true as well for the devices themselves as one of the primary benefits of the wireless grid environment comes from the economic and utility advantages of making use of the most efficient resources available. The configuration of devices engaged by any one user or group of users in a session will also be dynamic and changing. Devices are encumbered as resources as needed and in accordance with the best identifiable schema for power and computing savings and utility. Economically it may also be that engagement of devices is done according to their transaction costs; in some cases resources may be utilized as a barter system, for free or for fee, with the system determining the best way to get the device and computing and communications resources needed in accordance with the capital or means available based on the users themselves.

Context aware - There are evolving schemas for access and control in context-aware systems such as the described wireless grid environment. Device awareness of the context for its use allows for a seamless use of available technology. One of the goals of context-aware systems is to gather information on the particular context of a device so that it may provide services that are appropriate to the users, place, time, and action (Hong, Suh and Kim, 2009). The grid systems aim to provide context-aware access to data, communications, computation and other resources.

4.2 Emerging Policy Issues: What will happen in the Future?

As Nobel laureate Nils Bohr once said, prediction is very difficult, especially if it's about the future. This applies in particular here. Now we have over ten years of experiences and know the principal requirements for wireless grid technologies. In the same time, the environment has changed and the requirements have consequently become more complex. Just to mention a few of the emerging trends of the recent past years which encompass: social media and social networks, higher bandwidths and ubiquitous connectivity and the more recent discussion on net neutrality. What we can note is a merging of technologies and different fields of regulation and policy; the convergence of technologies now follows the convergence of policies, regulations and societal or market influence. For the future, the environment has to be taken much more into consideration than has been done before. The following scenarios from different areas illustrate the use and implications of wireless grid technologies in various environments. The use cases described here and previously in this paper, will further help to identify emerging policy issues and social impacts of this capability.

Spectrum Policy – With the rise of wireless communication and data exchange, need for spectrum has constantly reason. This is not only caused by human-to-human and human-to-computer communication but by a steady increase of wireless machine-to-machine communication (i.e. the Internet of Things). Today, in metropolitan areas wireless data congestions can be experienced, leading to a sensitive delay or even hindrance of wireless data communication. Consequently, more frequency spectrum is needed to allow efficient wireless data communication. According to experts, until 2020 800 MHz to 1720 MHz of additional spectrum is needed (FCC, 2010). This can be achieved by reallocating existing spectrum (spectrum auctions, spectrum markets) and technological advancements (dynamic frequency selection, detect-and-avoid-algorithms, cognitive radio techniques, software defined radio techniques). The issues on spectrum are of high importance not only for wireless grid technologies but for wireless broadband in general. Not for nothing is stated in the U.S. national broadband plan "spectrum policy must be a key pillar of U.S. economic policy" (FCC, 2010).

Taxation and Financial Accountability – Emerging from those early roots are issues of taxation and financial accountability for transactions across a distributed wireless grid. There has been a great deal of progress and work in the area of provenance and accountability in networked environments (FCC, 2010). Assignment of costs and ownership regarding elements of a transaction continue to be important things to consider and from the time of the original article additional standards and options for this have come about. Current issues in the area of taxation and accountability include determination of whether Internet-based business activities rise to the level of a taxable presence in a particular jurisdiction, and determining the geographic "source" of income from Internet-based transactions is an important factor for governments. State based institutions play a role in the activity of the internet and related networks that cross sovereign boundaries. The United Nations (U.N.) and the Organization for Economic Cooperation and Development (OECD) are but some of the influential parties here. States or countries individually are also necessary participants and stakeholders in commerce across the internet. Internationally, there are a number of non-state based organizations who contribute to the discussion and policy in this area as well. Multinational businesses are in this category of operators as well, with varying impact based on revenue, size and geographic presence (Ring, 2010).

User Demand and Emerging Markets - As for markets, the original paper did not go far enough to recognize the trend towards internationalization and the emergence of economies and markets such as China, the Middle and Far East as influential players and stakeholders. According to Gartner (2010) "by 2014, over 3 billion of the world's adult population will be able to transact electronically via mobile or Internet technology". Emerging economies will see rapidly rising mobile and Internet adoption will also rise in emerging economies while at the same time, advances in mobile payment, commerce and banking make it easier to transact via mobile or PC. The combination of these trends leads us to a state where a significant majority of the world population is able to transact electronically in the very near future.

Governance - The owners and stakeholders of the infrastructure now are at the heart of any of this movement. Will they be a force, influential to governments, or will they be subservient and reactive to consortia or regulatory bodies that are in place or coming into being. Some examples ICANN internet governance committee and International Telecommunications Union. At the 2009 World Telecommunication Policy Forum (WTPF), hosted by the International Telecommunication Union (ITU); there were 850 delegates, representing 118 governments and other organizations participating (Epstein, 2009). They were to set the agenda for future ITU discussions and the Plenipotentiary Conference. The results from these forums (known as the Lisbon consensus) are non-binding but influential to participants and standards setting entities.

Societal Implications - More and greater is clearly what is going on as predicted. What remains unclear is the influence and impact of individual users relative to the corporate or business users and government users. All of these interests are growing. The market result is yet to be fully understood. Is the focus to be on business to business or individual to individual or business to individual? Which will be the controlling force is a question well worth consideration. It is for sure that this activity will be a diving force towards standardization and policy change.

4.3 Governance Framework to Identify Emerging Policy Issues

To allow future oriented research Dawes (2009) developed a governance framework that identifies six areas of influential factors. Each group represents a common central idea or dimension that can be applied accordingly to the wireless grid environment. For future research, this governance framework enables to identify likely implications and future policy areas that need to be addressed. The six dimensions that describe a dynamic open socio-technical system are briefly outlined as following.

- **The purpose and role of government:** What will or should be the purpose and role of our government? Capabilities of civil service, efficiency and effectiveness of processes and diversity of governmental organizations are frequent themes in government.
- **Societal trends:** Trends in humanity at large will have changing influence on the future of society. Demographic tendencies, age distribution, birth rates, and mobility, blended with globalization, multi-culturalism, privatization, and institutional change are powerful forces apart from the control of government systems among many others that can be identified.
- **Changing technologies:** Technologies that do not rely on a specific place or tool were notable in the science findings, among them mobile phones and other mobile instruments, and ubiquitous sensors capable of automatic information collection and monitoring. Intelligent agents, logic, interfaces, and forensics could assist users and analysts. New architectures, shared services, safety, authentication, and reusable code could mark the cornerstone of a dynamic cyberinfrastructure. Social networking software, visualization, and virtualization may offer the mechanism to explore, or take advantage of, fresh communities and relationships.
- **Information management:** This cluster comprises a broad variety of anxieties, notions, devices, and practices. This area also pertains to devices for access to, use of, investigation into, and preservation activities relative to information such as searching, ontologies, information administration, and forensics.
- **Human elements:** Human factors, beyond human–computer interaction, relative to integrity, identity, autonomy, choice, privacy, trust, individual capacity, and degree of acceptance of change are considerations regardless of the technology. Where ICTs become involved, additional factors must be accounted for such as individual capability and access to information, management of information overload, and the design and interface of systems that are used.
- **Cross-boundary interaction and complexity**: This cluster encompasses elements representing challenges that cross technical, organizational, institutional and human boundaries. These include: multi-channel access to information and services, interoperability, distributed and multi-agent systems, collaboration schemas, cooperation, or competition. Other factors include risk management and an ability to discern, understand, and respond to unanticipated dynamics or circumstances.

Overall, each cluster represents a set of trends, developments or actions within a system which interact variously to render anticipated or unique results. The technological aspects identified become enmeshed in a more organic and interactive notion of governance.

5. Conclusion

We might admit that McKnight's 2002 policy concerns were premature. It becomes clear that almost 10 years after a new age is coming that it requires new paradigms. These paradigms have been heralded in the previous five years and have been silently introduced in the information society. Those paradigms encompass the enablement of users in a shifting role as "prosumer." Further, the always on metaphor in the advanced early days of the Internet age has turned into ubiquitous connectivity on high bandwidths. Not only these developments have implications on Public and International Policy, but also new approaches in the leadership and management of this field is required. Leadership in this new environment looks more like the unified actions of a flock of birds. There is purpose and combination of resources but there is no solitary source that can be recognized as the overall leader or change agent. At different times different elements combine to sway the group and move in a direction. For every change or next occurrence there are different leaders or agents of change. From the outside and at a distance it all looks well orchestrated and unified in purpose. That is the environment of wireless grids and of the internet and the telecommunications environment that we operate in.

Last but not least, after the convergence of technologies we can observe a convergence of regulation and policy. The increased complexity of the wireless grid environment and in general the ICT sector requires a close and diligent alignment of all factors of influence, in particular of technology, regulations, and policy – subset of the governance model for a digital age.

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