Collaboration in a Wireless Grid Innovation Testbed by Virtual Consortium

Joseph Treglia, Angela Ramnarine-Rieks, and Lee McKnight

School of Information Studies, Syracuse University, New York , USA
{jvtregli,auramnar,lmknigh}@syr.edu

Abstract. This paper describes the formation of the Wireless Grid Innovation Testbed (WGiT) coordinated by a virtual consortium involving academic and non-academic entities. Syracuse University and Virginia Tech are primary university partners with several other academic, government, and corporate partners. Objectives include: 1) coordinating knowledge sharing, 2) defining key parameters for wireless grids network applications, 3) dynamically connecting wired and wireless devices, content and users, 4) linking to VT-CORNET, Virginia Tech Cognitive Radio Network Testbed, 5) forming ad hoc networks or grids of mobile and fixed devices without a dedicated server, 6) deepening understanding of wireless grid application, device, network, user and market behavior through academic, trade and popular publications including online media, 7) identifying policy that may enable evaluated innovations to enter US and international markets and 8) implementation and evaluation of the international virtual collaborative process.

Keywords: Wireless and satellite networks, E-collaboration, Social and community networks, Infrastructures, Future ICT, Web based technologies, Security and safety.

1 Introduction

Syracuse University (SU) and Virginia Tech (VT) are creating the first Wireless Grid Innovation Testbed (WGiT) with the support of the National Science Foundation (NSF)[1]. It will help refine transformative technologies by bridging the gap between wireless network middleware and grid application layers, thus creating new markets and realigning existing ones. This will serve industry needs 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[2].

The uniqueness of this innovative testbed lies in its combination of new technologies for 'edgeware' for grid computing applications across edge devices, with wireless networking. The potential influence of this combination on current wireless

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[2] Note that views expressed are those of the authors and not necessarily by the respective affiliated institutions.

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connectivity standards will be explored. The project will also investigate the wireless grids' utility to digital communities (including open source technical development communities) in being able to work and collaborate in a distributed, mobile fashion. Businesses, government agencies and private individuals will have new options for interacting and conducting business. The testbed provides students, faculty, firms and government representatives an opportunity to learn from and participate in the growth of this new market. This project will involve participants globally and permits easy access to its main findings and activities, thereby benefiting individuals, researchers as well as companies including media worldwide, in both developed and developing countries, spurring further innovation and economic growth on top of these NSF-derived technologies [1].

The primary goal of WGiT is to bring together unique technical assets from SU and VT, supported by National Science Foundation (NSF) grants, for further evaluation and to establish a baseline set of open or public interfaces, specifications, or standards, for wireless grids. Technical issues that are ripe for further research and analysis as part of this process will be supported by WGiT, including design and manufacturing, application performance and optimization, characterization of networks for wireless grid applications, and protocol development. Evaluation of service engineering simulations, user behavior trials, application tests, security models, and trust frameworks for wireless grids will be among the issues explored through the testbed, by faculty, students, and firms.

Innovaticus, a beta application undergoing testing through a SU campus trial, will be extended to VT and integrated with their own cognitive network testbed. Potentially there will be many more testbed partners within both universities and companies. This is but an early example of the type of products we expect to see more of over time.

A new virtual organization (VO), the Wireless Grid Testbed Consortium, is being created to manage the testbed and set the agenda and lead a globally distributed research effort on wireless grids - spanning the entire value chain from research, design, and manufacturing to consumer usage and policy. The establishment of WGiT promotes extended collaboration with other universities, industry members, and communities to share research and information, and spur innovation and economic growth. The outcome will be a better understanding of the key features of wireless grids (cognitive networks) enabling us to enhance the design, manufacturing and commercialization of the next generation of these information and resource (i.e., hardware, software, content) sharing innovations.

2 Background

The literature around the concept of national innovation systems incorporates a broad range of definitions, the starting point of which includes the "set of institutions whose interaction determine the innovative performance of national firms" [2], [3]. This reflected an important shift in academic understanding; away from linear models of innovation, to one more firmly grounded in policy frameworks. Freeman elaborated on the basic structure five years after Nelson's publication, including the network of institutions in the public/private sectors whose activities and interactions initiate, import, modify and diffuse new technologies [2], [4]. Others [5], [6], [7] expanded understanding of the 'triple helix' of industry-academe-government partnerships, with the latter explaining the interconnections between institutions as a driver of the store and transfer of knowledge, skills, and 'artifacts' that define new technologies. The need has been identified for access to knowledge as a key, critical catalyst for increasing innovative activities [8] [9]. This is placed squarely in the context of national economic development. Modeling tools shared and refined through WGiT may help researchers continuing to work on these challenges.

Wireless grids are defined as ad-hoc dynamic sharing of physical and virtual resources among heterogeneous devices. Recent relevant and related work regarding wireless grids include works on user and socio-technical perspectives and challenges [11], [12]; coordination of user and device behaviors [13]; future internet applications and bridging communicative channels [10], [14], [15]. There has been increasing acknowledgement of the nascent growth of wireless grids as a new engineering field of scientific inquiry and innovation [16]. The grid is an emerging infrastructure that will fundamentally change the way we think about and use computing [10]. A broader understanding of the nature of the opportunities offered by grid computing and the technologies needed to realize those opportunities is required [17]. The concept of a virtual workspace, as a configurable execution environment can be created and managed by reflecting client requirements [17], [18]. The development of WGiT will stimulate a variety of groups to use this technology in ways that are beyond their present understanding.

3 Project Description

WGiT seeks to evaluate specifications for possible standards in order to scale and integrate the 'transformative innovation' of wireless grids developed in a prior Partnerships for Innovation (PFI), together with specifications and protocols developed through the NSF I/UCRC Wireless Internet Center for Advanced Technology (WICAT), meshed with technologies and ideas from students, faculty, and companies worldwide. At SU, WGiT will test 'edgeware' or software that resides beyond the cloud, across edge network devices, both wired and wireless. At Virginia Tech, WGiT will also evaluate how such applications might perform on a recently established wireless cognitive radio network testbed (VT-CORNET). Technical standards and open application programming interfaces may be needed to enable this desired growth, and will be explored by the testbed, and discussed with project partners. Equally critical will be end-user feedback and systems and user evaluation.

3.1 Technical Development

This project continues efforts initiated by Tufts University, SU's Wireless Grids Lab, and spin-out firm Wireless Grids Corporation (WGC) under the prior PFI, to develop a technology that fills the need for better personal network usability, and standards for user-defined experience. The WGiT research agenda seeks to determine the extent to which wireless grid computing may successfully augment and enhance communication networks and standards such as the Internet, Bluetooth, WiFi, WiMAX and mobile WiMAX for data transmission, communication and collaboration. The wireless grid will enable shared resources among dynamic groups or social networks of computing and communication devices. Grids are comprised of objects and resources with individual profiles that are assigned a specific status relative to similar objects and resources. Services include multimedia recording; photo, printer, screen, connection and audio sharing; home monitoring, data storage and recovery, and integrated sensors and nanotechnology based devices.

3.2 Innovative Outcomes

There are many kinds of devices that can be shared, for example, mobile phones, mobile Internet devices, printers, displays, remote sensing devices, local weather sensors, wireless sensor networks, etc. Initially, investigation will focus on the software and hardware requirements for sharing wireless sensor networks for remote experiments under the wireless grid environment. Localization in a wireless ad hoc network is an important issue. There is no central control unit to identify the location of a node in a wireless ad hoc network. Location of a node can only be identified relatively to a node or nodes whose location is/are known. We have done localization research using signal strength to identify the node location. Power conservation is another important issue in mobile wireless network. A routing protocol for wireless network with power constraint has been developed. The signal strength of a transmission depends on the power of the transmitter. These two issues can be naturally considered and tied together in a wireless grid environment.

An interdisciplinary Electrical Engineering and Information Management senior capstone project will be developed using wireless grids for spring semester 2010 and will be taught jointly among SU, VT and Tufts University. We will teach a group of students how to use the wireless grid (at Syracuse) and a cognitive radio network testbed (at VT) to run a variety of applications for the wireless grid. Students from each of the campuses will be able to remotely deploy experiments on the network at the other campus. Each project group will consist of students from all of the three campuses. Participation from Portugal's Instituto Superior Tecnico, and a Portuguese next generation network testbed operated by UMIC may be integrated by the following year. They will implement a web based user interface capable of acquiring data from wireless sensor networks. Wireless sensor network data will be acquired through an Ethernet based base station and Java code will be used to parse collected information and display them. To do this project, students will learn TinyOS, Java, sensor network and wireless grid topology. Once familiar with the sensor network topology, they will design a program that will be capable of reconfiguring a wireless sensor network. This is done through writing new code instructions to the wireless sensors, i.e. reprogramming wireless sensors. Therefore they will write a program that can inject commands into a sensor network via the WGiT and we will run the localization application on the sensor network.

To allow students to share devices some preliminary solutions before the course will be explored and solutions will be articulated. At SU students in a variety of courses and through work at the associated labs will be provided with hands-on experience in the use of the wireless grid beta applications as they become available. The expectation is that in time, students will be able to easily develop their own wireless grid applications, building upon the platform provided. Through the testbed, students at participating institutions including high schools in participating communities will interact directly with each other and with engineers at the participating firms, as they design and use a variety of wireless grid applications as they are introduced, whether as proof of concept or prototype.

3.3 Entrepreneurship and Economic Impact by Design

The testbed itself is a new model for innovation and entrepreneurship to support economic growth. By fostering its "entrepreneurial ecosystem" around a VO supported by cyber infrastructure, we expect to refine technologies and standards to propagate wireless grid innovations across geographic locations, businesses and academic institutions. Interested government agencies and public-private partnerships at local, national, international and global scale, will contribute feedback.

Anticipated impacts to partnering firms include expansion and growth as markets emerge, first among partners and then more broadly across various vertical markets as students, faculty, firms – and governments – derive more strategic and precise applications of wireless grids that may fit their particular needs and interests. The testbed will support training and courses related to innovation, wireless grids technologies and business/social impacts opportunities, such as technology entrepreneurship offerings across campus.

From an enterprise perspective, our research and applications will potentially have the following impacts on businesses: 1) lowering transaction costs of internal knowledge and resource management, 2) lowering transaction costs of interaction with their customer base by enhancing and advancing how they communicate and offer their services, 3) increasing ROI by giving new capabilities to existing digital devices and networks, and 4) reducing total cost of ownership by enhancing remote service features.

3.4 Evaluation Methods and Outcomes

WGiT partners will integrate qualitative and quantitative feedback to monitor progress. For example we will achieve broader impact through information gathering around the core priority areas for the development community that we convene around the testbed as well as collect potential users' opinions regarding their needs.

Systematic evaluation and assessment as well as opportunities for unstructured feedback are essential for such projects to be useful and sustainable. Tufts and SU have been cooperating for several years in licensing the wireless grid innovations stemming from NSF PFI award 0227879. Pre-tests with SU's institutional review board (IRB) approval have been acquired, assessing data from an ongoing campus trial of wireless grid network, application, and user behavior. Pre-tests done in 2008 yielded valuable feedback from an initial user population on the SU campus. WGiT would expand this test across the Syracuse campus and into the community, and on to VT's campus.

VT's cognitive radio network testbed can be combined with the application and user layer data generated at Syracuse, yielding new insights into networks and applications from wireless grid specifications and future products. We propose using an epidemic model to evaluate the use and acceptance of Innovaticus and overcome barriers to acceptance that is limited by lack of information available about the new technology, how to use it, and what the technology does. Formalizing this diffusion process may enable firms to grow target markets within the wireless grid. Impacts of this work will be worldwide, as wireless grid products meeting specifications derived from the WGiT innovation testbed and integrating technologies from multiple partner organizations come to market. Immediate impacts will be observed in regional innovation networks and entrepreneurial ecosystems to both locally and internationally.

4 Collaborations and Partnerships

SU has joined forces with seven public and private universities in the New York State Grid project, a new venture to provide researchers access to high performance computing resources through the New York State Grid.

This PFI project involves an expansion of the wireless grid innovation testbed coordinated by SU and VT in partnership with several other academic, government and corporate partners. This will spur the growth of new companies and innovative services through the use of transformative developments in grid computing capabilities. The testbed will extend beyond small collaborations and individual departments in New York and Virginia to encompass wide-ranging and geographically dispersed activities and groups. The testbed aims at facilitating people-to-people, people-to-resources, and people-to-facilities interactions. This project will bring in Virginia Tech's College Engineering, and specifically the NSF IUCRC Wireless Internet Center for Advanced Technology (WICAT) to build upon the strong technical, industrial and institutional relationships built up over time, to manage the proposed WGiT. WICAT@VT is a subset of the world-renowned wireless center called Wireless@VT, which will bring in expertise in cognitive radios, wireless networking and other communications technologies.

A consortium will be created out of our partnerships and collaborations that will operate as an independent VO, with a paid membership of qualified universities and firms and led by both SU and VT Affiliated public agencies and community organizations and individuals will participate through local nodes of activity, namely the testbeds and beta trials in Virginia and New York, and the Instituto Superior Tecnico – Lisbon's research on the UMIC (Portuguese government) and EU-funded Next Generation Network community testbeds and modeling tools project.

The goal of promoting Wireless Grids is to see this functionality reach a much wider mass of people who do not have this level of technical knowledge. As technological innovation becomes centered on intuitive, easy access to the content, applications and devices [19], [20], [21], [22]; platform usage, user behaviors, user responses, and old/new applications will be monitored and analyzed by the Wireless Grids Research Lab and its WGiT partners.

5 Conclusion

Better assessment of wireless grids protocols and applications will inform design, manufacturing and commercialization of these next generation information and resource sharing innovations. The testbed will support training and courses related to innovation, wireless grids technologies and business/social impacts opportunities. The broader impact of the WGiT comes from the benefits foreseen from novel wireless connectivity standards and specifications; the wireless grids' utility to diverse digital communities (including the open source community) in being able to collaborate in a distributed fashion without network overload. Firms and government partners can help wireless grid innovations stemming from WGiT achieve national global impact. Ultimately, it will be up to its users and application developers, if WGiT is to achieve its intended broad impact on future education, technology, virtual collaboration and employment.

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