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PI/PD Name: Jie Wu

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

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Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
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PI/PD Name: Eugene Kwatny

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

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PI/PD Name: Shan Lin

Gender: ☐ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

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PI/PD Name: Chiu C Tan

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

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PI/PD Name: Kapil R Dandekar

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status: (Select one or more)
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- ☐ Visual Impairment
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PI/PD Name: Moshe Kam

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
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- ☐ Black or African American
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- ☒ White

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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1

NSF 11-536 **10/25/11**

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

CNS - COMPUTING RES INFRASTRUCTURE

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				057123192	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

231365971

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

TEMPLE UNIVERSITY OF THE COMMONWEALTH SYSTEM OF HIGHER EDUCATION

AWARDEE ORGANIZATION CODE (IF KNOWN)

6250003097

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

1805 N BROAD ST
PHILADELPHIA, PA 19122-2600

NAME OF PRIMARY PLACE OF PERF

Temple University

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

Temple University

PA ,191226094 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **A Meso-Scale GENI WiMAX Project**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **199,716**	**12** months	**09/01/11**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
CIS

PI/PD FAX NUMBER
215-204-5082

PI/PD POSTAL ADDRESS
1803 N. Broad Street
Wachman Hall - 303 Wachman
PHILADELPHIA, PA 191226099
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Jie Wu**	**PhD**	**1989**	**215-204-8450**	**jiewu@temple.edu**
CO-PI/PD **Eugene Kwatny**	**Ph.D**	**1971**	**215-204-1679**	**gkwatny@temple.edu**
CO-PI/PD **Shan Lin**	**PhD**	**2010**	**215-204-3759**	**shan.lin@temple.edu**
CO-PI/PD **Chiu C Tan**	**PhD**	**2010**	**215-204-6907**	**cctan@temple.edu**
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

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(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1

NSF 11-536 **10/25/11**

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☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Drexel University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0032565000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Drexel University
3201 Arch Street
Philadelphia, PA. 191042737

NAME OF PRIMARY PLACE OF PERF

Drexel University

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

Drexel University
3141 Chestnut St
Philadelphia ,PA ,191042875 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
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☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **A Meso-Scale GENI WiMAX Project**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **100,000**	**12** months	**09/01/11**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
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☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Electrical and Computer Engineering

PI/PD FAX NUMBER
215-895-1695

PI/PD POSTAL ADDRESS
32 and Chestnut Street

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CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

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Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

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A Meso-Scale GENI WiMAX Project

(Project Summary)

The popularity of wireless networks has led to significant investments in next generation wireless technologies such as WiMAX and LTE. These new technologies promise, among other things, better coverage and higher bandwidth rates, than existing WiFi networks. Given the popularity of smartphones together with people's demand for richer mobile content, these new wireless technologies are poised to play an important role in the future of wireless communication.

While researchers have proposed many new techniques and applications to take advantage of the new wireless standards, we still lack sufficient understanding of how such techniques and applications will perform when deployed under real world conditions. This is partly due to the high cost of the wireless equipment (a WiMAX base station can cost up to $\$60,000$ to purchase and install), and partly due to the lack of suitable locations for the install of this equipment. These new wireless technologies have a much longer range compared to existing 802.11 (WiFi) or 802.15 (ZigBee) networks, and a testing area, such as an urban downtown area, will be a more realistic environment than an indoor testbed. *The objective of this project is to build an open, large-scale, outdoor wireless testbed to advance the state of next generation wireless network research in the United States.*

Our proposed testbed will be based on WiMAX, one of the key next generation wireless technologies, and will be jointly administered by Temple University and Drexel University faculty with a wide range of expertise, including wireless networks, sensor applications, and wireless security. The proposed platform has the following unique characteristics: (a) *Open access.* The testbed will be designed to be integrated into the nationwide GENI framework, to facilitate easy access for researchers from other institutions. (b) *Urban location.* The projected coverage area includes a metropolitan downtown area with many tall buildings and competing wireless services (the coverage area will co-exist with commercial WiMAX provider). (c) *Potential for expansion.* At this initial stage, we plan to deploy two WiMAX base stations, one on each institution's main campus. Both Temple and Drexel operate additional buildings in the downtown area that can serve as future sites for expanding the testbed. In addition, the proposed project is a good match for the City of Philadelphia's vision of *"Digital Philadelphia"*, where one of the objectives is to provide gigabit connectivity throughout the City.

The goals of the proposed research are the following. (1) Complete installation and testing of the testbed and the corresponding experimental hardware (smartphones, laptops, sensors, and vehicular devices). (2) Integrate the testbed into the wider GENI framework. (3) Carry out experiments that make extensive use of the testbed. We have proposed 5 projects with wide ranging impact across different research areas which will gain enormous benefit from experiments conducted on the testbed.

Intellectual Merit. The proposed testbed will be an important tool towards advancing the state of wireless network research providing an accessible, outdoor wireless testing environment. The coverage area will create an experimental environment with realistic multipath (from the many tall buildings) and interference (from existing WiFi, cellular, and commercial 4G networks) characteristics. The research projects that will be enabled by this testbed include projects related to *public health*, *next generation networking*, and *public safety* .

Broader Impact. The proposed WiMAX testbed will provide Temple and Drexel, as well as the wider research community, a realistic platform to conduct a wide range of research experiments. In addition, we will incorporate the testbed into the teaching curriculum at both institutions, greatly facilitating the training of undergraduate and graduate students in the field of next generation wireless networking. The testbed is also planned to be used in our outreach activities to local middle and high school students to interest them in the field of science and engineering.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

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A Meso-Scale GENI WiMAX Project

Introduction and Objective

The popularity of wireless networks have led to significant investments in next generation wireless technologies such as WiMAX and LTE. These new technologies promise, among other things, better coverage and higher bandwidth rates, than existing WiFi networks. Given the popularity of smartphones together with people's demand for richer mobile content, these new wireless technologies are poised to play an important role in the future of wireless communication. *The objective of this project is to build an open, large-scale, outdoor wireless testbed to advance the state of next generation wireless network research in the United States.*

While there have been an increasingly number of new techniques and applications [6, 11, 20, 24] proposed to take advantage of the new wireless standards, we still lack sufficient understanding of how these new algorithms, systems, and applications, will actually perform when deployed under real world conditions. There are two reasons for this. First, the deployment costs are high, making it very difficult for many research groups to design practical experiments on their own. A single WiMAX access point (AP), for instance, can cost up to tens of thousands of dollars, and requires a license for access to a slice of spectrum. A moderate sized WiFi testbed consisting of several APs on the other hand, can deployed for several hundred dollars. Second, the location of the experiments will also affect the quality of the outcomes. Experimental results over a rural area will be markedly different from those derived from an urban area. One key advantage of our testbed is that it covers a diverse urban population area with many people, multiple tall buildings, and various types of interference (WiFi, cellular, and commercial 4G networks). This makes experimental results more representative of urban conditions.

Our proposed testbed will be based on WiMAX, one of the key next generation wireless technologies. The project will be jointly administered by Temple University and Drexel University faculty that have a broad range of expertise, including wireless networks, sensor applications, and wireless security. Fig. 1 shows the proposed installation sites and the projected coverage area. The coverage is projected to include parts of the metropolitan downtown area of Philadelphia, one of the most populous downtown areas in the United States. It also includes portions of the main campuses of Temple and Drexel, both large urban universities with approximately $40,000$ and $20,000$ students, respectively. The research platform that we will construct has the following unique characteristics.

1. *Open access.* The testbed will be designed to be integrated into the GENI framework, an ambitions experimental platform for future Internet research. This will facilitate easy access for researchers from other institutions.

2. *Urban location.* The projected coverage area includes a metropolitan downtown area with many tall buildings and competing wireless services (the coverage area will co-exist with commercial WiMAX providers). This type of environment is more representative of urban and densely populated areas as compared to indoor or rural environments.

3. *Potential for expansion.* This grant application seeks to build the first stage of our testbed. For the initial stage, we plan to deploy two WiMAX base stations, as indicated in Fig. 1, on the Main campus of each of the institutions. The second phase of our testbed will be to extend the base stations to enable complete 360 degree coverage around the institutions. The third phase is to identify a City site to deploy a third base station. Both Temple and Drexel operate buildings in the downtown area that can serve as future sites. In addition, the proposed project is a good match for the City of Philadelphia's vision of *"Digital*

Philadelphia", where one of the objectives is to provide broadly available gigabit connectivity across the City.

In this one year grant, we set forth three goals. First, we will complete installation and testing of the testbed infrastructure, as well as the corresponding experimental hardware (smartphones, laptops, sensors, and vehicular devices). This will enable researchers to conduct a wider range of experiments with different hardware. Second, we will integrate the testbed into the wider GENI framework. We have already made contact with the GENI organizers regarding the integration. Finally, we intend to carry out experiments using the testbed based on our proposed research activities, which will be detailed in the next section.

Intellectual Merit. The proposed testbed will be an important tool towards advancing wireless network research. As part of this project, we have proposed 5 projects that will benefit from the testbed. Our proposed research include projects related to *public health* (air quality monitoring sensor networks and wearable sensor based telemedicine), *next generation networking* (mobile content delivery networks), and *public safety* (secure data network for law enforcement and Location base services for tourists).

Broader Impact. The proposed WiMAX testbed will provide Temple and Drexel, as well as the wider research community, a realistic platform to conduct a wide range of research experiments. Once developed, the platform will be incorporated into the teaching curriculum at both institutions, greatly facilitating the training of undergraduate and graduate students in the field of next generation wireless networking. The testbed is also planned to be used in our outreach activities to local middle and high school students to interest them in the field of science and engineering.

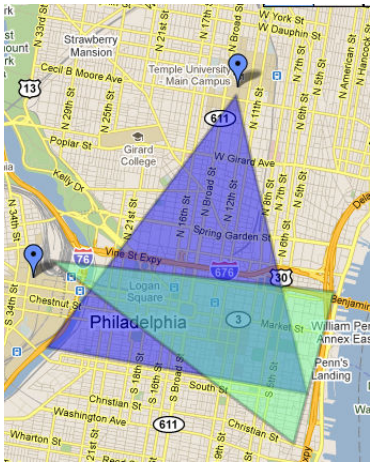

Figure 1: Projected WiMAX testbed coverage. The base stations will be located at Temple University (top) and Drexel University (left). Coverage area includes downtown Philadelphia.

Proposed research activities

Listed below are five research projects that will be enabled by our proposed WiMAX testbed.

Air Quality Sensor Networks for Urban Environmental Monitoring. Particulate matter (PM) emissions present a significant health risk to communities located within dense urban areas. Inhalation of these particles has been shown to result in increases in asthma rates and lead to other detrimental health effects [3, 13–15, 17, 21]. Current Environmental Protection Agency (EPA) methods for monitoring air quality in urban areas make use of monitoring stations that can be separated by very large distances. Furthermore, the equipment that these stations use, and the standards to which the measured data is compared, were developed in a time before the widespread prevalence of wireless networks capable of real-time monitoring.

The motivation for this proposal comes after several years of collaboration with the Philadelphia Clean Air Council through the Drexel University EPICS program. The Philadelphia Clean Air Council is a non-profit organization in Philadelphia that is responsible for environmental advocacy of both air and water quality. Using commercial off the shelf sensors originally intended for indoor air quality monitoring, we have developed and deployed several small scale sensor networks around the Philadelphia region in order to support Clean Air Council initiatives. In this preliminary project, we deployed a working air quality sensor network that (1) integrate commercial sensor packages with ZigBee radios, (2) performed computer modeling of a portion of Center City

Philadelphia to determine desirable sensor placement locations, and (3) deployed a small number of sensors that is able to collect live sensor data to be analyzed by the Philadelphia Clean Air Council. A Google Earth interface has also been developed to present the results of their sensor network deployments in an easy to understand format, with accompanying information on air quality standards that could be used by community partners to assess their local air quality. Fig. 2 shows some of our current deployments.

Figure 2: Illustration of (a) Custom-built sensor packages interfaced with ZigBee radios, (b) Picture of the environment in which air quality simulations and sensor deployment were performed, and (c) Actual deployment of a sensor in the environment.

This proposal advances this preliminary work by replacing the currently used ZigBee radios with WiMAX radios. This will allow for a a sensor network to be deployed that will have much larger spatial coverage. This technology will allow us to deploy larger scale networks for target commercial and industrial air quality monitoring applications. Finally, the greater spatial resolution of the deployed sensor network will allow a wider variety of fusion and networking algorithms to be implemented that will enable research projects in pollutant propagation direction estimation and source localization.

WiMAX Based Data Network for Law Enforcement. Heterogeneous camera and sensor networks have been developed for surveillance in a number of important areas, such as for airports, borders, and military battlefields [12, 16, 22]. For an urban area, surveillance it is also critical for law enforcement and first responders. In order to provide high quality surveillance in such special situations, existing static wired camera network infrastructure is insufficient. Fast, deployable and mobile camera networks can greatly enhance the quality of surveillance over existing systems. This project will explore wireless network requirements for next generation surveillance systems. Our hypothesis is that WiMax/LTE is a key technology to support such systems, compared with WiFi and other technologies.

In this project, we will investigate the following fundamental questions required for the design of next generation surveillance camera networks: (1) how can we integrate WiMax technology with heterogeneous camera networks: (2) how can wireless networks be used to provide fast and robust deployment for emergency response; (3) what is the quality of service required for use in mobile units in a metropolitan area, such as those used by police units (mobile policemen, vehicles, and helicopters); and (4) what are the requirements for remote control and coordination of heterogeneous sensing and camera devices. The research results of this project will help us create effective and efficient system architectures for mobile camera networks. We will also produce a prototype system to benefit the city of Philadelphia and the other academic institutions.

Mobile Content Delivery Networks. The rising popularity of handheld devices, such as smartphones and tablets, have lead to a corresponding increase in mobile data traffic. Given that mobile traffic is projected to continue growing, this will place a greater strain on today's wireless networks, and inevitably result in poorer quality of service and user experiences. One of our goals in examining mobile content delivery network is to explore a new approach towards delivering and sharing content on the mobile devices that carefully combines user mobility [9, 10] and wireless scheduling [4, 5].

We envision a new type of architecture which we term *mobile multi-content-sharing hybrid networks (MMCHNs)*. In a MMCHN, content will first be pushed from a base station to some of the mobile devices. Then, we take advantage of the mobility of these devices to help spread the content to other interested users. In this way, a user has an additional source of content delivery, from the base station, and from other users. As a preliminary step for this project, we have begun to explore an analytical foundation for exploiting both the wireless broadcast and user mobility for content distribution networks, as well as develop robust algorithms, protocols, and heuristics for content sharing that considers various network conditions.

The proposed testbed allows us to conduct large scale experiments to determine the performance of different aspects of this delivery, such as handoff and energy management algorithms. The range of the WiMAX base station will allow realistic experiments that incorporates imperfect channel conditions (due to multipath and other interferences from existing campus wireless systems), as well as large scale user mobility.

Sensor Based Telemedicine. We believe that 24×7 continuous medical care will benefit all human beings. Enhancements in sensor and network technologies have enabled new medical care and monitoring systems such as bodynets [7, 18, 23]. We project that in the next 10-20 years, the medical sensing and nano technologies, such as EEG monitoring, will become very sophisticated and operate with low cost. The medical monitoring devices built upon these technologies can be attached to the human body or to clothes. These devices will continuously generate large volumes of physiological data. Collecting these data in real-time requires two-way high bandwidth data transmission between the individual humans to the medical data centers. Since WiMax is a standard new technology for researching next generation high bandwidth wireless communication, we will focus on addressing the fundamental communication challenges in this interdisciplinary domain.

The next generation cell phones that support WiMax/LTE will have higher communication capacity. It is our goal to investigate how to fully utilize and enhance intelligent phones of the future: (1) for continuous 24×7 medical monitoring, (2) as an important communication link in an overall technological solution, and (3) in providing cognitive assistance. It is obvious that the cell phone can provide video and audio transmission between user and doctor, issue reminders, allow access to real-time medical data, make suggestions on exercises and social activities, and share information with local medical care givers. The questions we are investigating include how to best exploit all these features, what data processing algorithms shall be integrated into cell phones, what communication algorithms shall be developed to transmit data from sensors to cell phones and then to medical data centers in order to provide cognitive assistance, and what limitations do current cell phones have with respect to cognitive assistance so that other solutions are required.

Location Based Services for Tourists. Philadelphia attracts an estimated 36 million tourists per year [1]. The downtown area, which is covered by our testbed, is home to many attractions, including the Liberty Bell and the Philadelphia Art Museum. Researchers have proposed leveraging the advance functionalities found in modern smartphones, such as digital compass, accelerators, and GPS sensors, to improve the tourist experience [2, 8, 19].

Our focus is on designing algorithms targeted at tourism based location services that balances user privacy, service fidelity, as well as energy efficiency. As part of our preliminary work, we have begun exploring a new category of location privacy attacks based on friendship information. In this category of attacks, the adversary will combine the trace information from a set of users with known friendship relationships to better estimate the location of individual users. We have achieved some preliminary results based on trace simulations. The WiMAX testbed will allow use to test our system on a realistic scale. This project is one of two projects that the City of Philadelphia has expressed interest.

Plan, Budget, and Broader Impact

Personal: The research team consists of 7 PIs (Wu, Kwatny, Lin, Tan, and Yoo at Temple University; Dandekar and Kam at Drexel University). The PIs from each university will be responsible for the base station deployment on their respective campus site. The air quality monitoring research project will be conducted by PIs Dandekar and Kam from Drexel, and the remainder of the projects will be conducted by the PIs from Temple. The overall project will be led by PI Wu from Temple University.

Work Plan: The proposed project is intended to last for one year (September 2011 - August 2012). The task for the first half of the year is to deploy and test the WiMAX base stations at both campus, and to connect with the nationwide GENI network. We have already started preliminary identification and assessment of potential deployment sites on different campus properties. The task for the second half of the year will focus on the proposed research projects that will make extensive use of the testbed. The projects on air quality monitoring and law enforcement data network will be the first to be carried out, followed by projects on mobile content delivery and sensor based telemedicine, and finally the tourist application project. The tasks for each half of the year will take approximately 50% of effort.

Coordination Plan: Temple and Drexel are in close proximity to each other, which greatly facilitates interaction between the PIs from the respective institutions. Across institutions, the PIs will schedule conference calls at least once a month to exchange ideas and experience from operating the testbed. The PIs within each institution will hold group meetings at least once a week. In order to encourage wider participation from researchers from other universities, we have allocated funds to attend GENI Engineering Conferences which are held three times a year to bring together researchers and industry representatives. PI Lin has attended the latest GENI Engineering Conference to gain a deeper understanding of the requirements need to integrate the testbed into the GENI framework.

Budget: We seek a budget of $\$299,717$ for the purchase and installation of the WiMAX testbed on the two sites at Temple and Drexel, as well as the necessary equipment to conduct experiments. The personnel costs of the respective projects are not included. The budget includes $5,000 sub-contracted to PI Yoo to explore applying the proposed research projects to current and potential City of Philadelphia's services that benefit the social welfare of the general public. The remainder of the consultant services are for experts involved in the installation and management of the testbed.

Broader Impacts: Besides making the WiMAX testbed available to the wider research community though participation in the GENI network, efforts will be made to incorporate the testbed into the respective curricula at Temple and Drexel. These include advance networking courses for undergraduates and graduates students, such as "Computer Networks" and "Wireless Networks and Security". Temple and Drexel are both located in a metropolitan area with a significant number of minority and under-represented students. This project will expose next generation wireless technology to these students.

In addition, the testbed will also be used in the community outreach programs conducted by both universities. Temple University hosts an annual *Future of Computing* (FoC) competition which is open to local high school students as well as Temple students to spur interest in computing and information sciences. Drexel University runs the *University Engineering Projects in Community Service* (EPICS) which, among other activities, pairs undergraduates with local high school students to conduct mini-projects.

The City of Philadelphia is a leader in adopting new technologies, especially the use of wireless technology to improve City services. The City is very supportive of the proposed testbed deployment, and is especially interested in the projects related to air quality monitoring, WiMAX data network for law enforcement and tourist related applications. A supporting letter from the City of Philadelphia is attached.

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[8] F. Girardin, F. Calabrese, F.D. Fiore, C. Ratti, and J. Blat. Digital Footprinting: Uncovering Tourists with User-Generated Content. In *IEEE Pervasive Computing*, volume 7, 2008.

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[10] M. Grossglauser and N.C. Tse. Mobility increases the capacity of ad hoc wireless networks. In *IEEE/ACM ToN*, volume 10, August 2002.

[11] T. Jiang, W. Xiang, H. Chen, and Q. Ni. Multicast Broadcast Services Support in OFDMA-Based WiMAX Systems [Advances in Mobile Multimedia]. In *IEEE Communications Magazine*, volume 45, August 2007.

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[15] N. Li, M. Hao, R.F. Phalen, W.C. Hinds, and A.E. Nel. Particulate air pollutants and asthma: A paradigm for the role of oxidative stress in PM-induced adverse health effects. In *Clinical Immunology*, volume 109, 2003.

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[17] G.T. O'Connor, L. Neas, B. Vaughn, M. Kattan, H. Mitchell, E.F. Crain, R. Evans III, R. Gruchalla, W. Morgan, J. Stout, G.K. Adams, and M. Lippmann. Acute respiratory health effects of air pollution on children with asthma in US inner cities. In *Journal of Allergy and Clinical Immunology*, volume 121, 2008.

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[21] L. Trasande and G.D. Thurston. The role of air pollution in asthma and other pediatric morbidities. In *Journal of Allergy and Clinical Immunology*, volume 115, 2005.

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Jie Wu

Areas of Research

Mobile computing and wireless networks, parallel/distributed computing, and trustworthy computing.

Education

- PhD in Computer Engineering (August 1989): Florida Atlantic University (FAU), Boca Raton, FL.
- MS in Computer Science (July 1985): Shanghai University of Science & Technology (SUST), Shanghai, P. R. China.
- BS in Computer Engineering (July 1982): SUST, Shanghai, P. R. China.

Employment and Work Experience

- Chair and Professor, Dept. of Computer and Info. Sci., Temple University, July 2009 - present.
- Program Director, NeTS/CNS/CISE, National Science Foundation, Jan. 2007 - Dec. 2008.
- Distinguished Professor, Dept. of Computer Sci. & Eng. (CSE), FAU, Sept. 2006 - July 2009.
- Professor/Associate Professor/Assistant Professor, CSE, FAU, Sept. 1998 - Aug. 2006/Sept. 1994 - Aug. 1998/Sept. 1989 - Aug. 1994.

Synergistic Activities

- Editorial Boards
  - Associate Editor of nice journals, including *IEEE Transactions on Mobile Computing*, *IEEE Transactions on Computers*, and *Journal of Parallel and Distributed Computing*.
  - Guest-Editor: *IEEE Computer*, *Journal of Parallel and Distributed Computing*, and *IEEE Transactions on Parallel and Distributed Systems*
- Conference Organizations
  - General Chair: DCOSS-2009, IEEE IPDPS-2008, and IEEE MASS-2006.
  - Program Chair: IEEE INFOCOM-2011, IEEE ICDCN-2010, and IEEE MASS-2004.
  - Program Vice Chair: IEEE ICDCS-2009, IEEE ICDCS-2001, and ICPP-2000.
- Professional Societies
  - Chair: IEEE Technical Committee on Distributed Processing (TCDP), Dec. 2005 - present.
  - IEEE Distinguished Visitor: Computer Society, Sept. 1998 - Aug. 2001.
  - ACM Distinguished Speaker, Dec. 2009 - present.
  - Fellow of the IEEE.
- Keyword Speeches
  - IEEE ISPA 2009, IEEE TrustCom 2009, FAWANC 2009, IEEE NCA 2008, WASA 2008, IEEE MASS 2007, MOBIQUITOUS 2007, IEEE SAHNT 2007, and MSN 2006.

- Awards/Special Recognitions
  - Researcher of the Year Award: FAU, 2006-2007, 2001-2002, and 1996-1997.
  - Best paper awards: IEEE MASS 2010, ICCNMC 2005, and IEEE MASS 2005.
  - Fulbright Senior Specialist, Dec. 2006 - present.

Publication History: 163 journal papers, 339 conference papers, 2 books, and 29 book chapters.

Five Publications Most Related to this Proposal

1. S. Yang and J. Wu, "Efficient Broadcasting Using Network Coding and Directional Antennas in MANETs," *IEEE Transactions on Parallel and Distributed Systems*, Vol. 21, No. 2, February 2010, 148-161.
2. X. Zhang, H. Gong, M. Liu, S. Lu, and J. Wu, "Quantitative Analysis of the Effect of Transmitting Power on the Capacity of Wireless Ad Hoc Networks," *Proc. of ACM MobiHoc*, 2010.
3. Z. Jiang, J. Wu, R. Ito, "A Metric for Routing in Delay-Sensitive Wireless Sensor Networks," *Proc. of the 7th IEEE International Conference on Mobile Ad-hoc and Sensor Systems* (MASS), 2010. (Received the best paper award.)
4. M. Lu, F. Li, and J. Wu, "Efficient Opportunistic Routing in Utility-Based Ad Hoc Networks," *IEEE Transactions on Reliability*, Vol. 58, No. 3, September 2009, 485-495.
5. S. Yang, J. Wu, and F. Dai, "Efficient Directional Network Backbone Construction in Mobile Ad Hoc Networks," *IEEE Transactions Transactions on Parallel and Distributed Systems*, Vol.19, No. 12, December 2008, 1601-1613.

Five Other Significant Publications

1. C. Liu and J. Wu, "Practical Routing in a Cyclic MobiSpace," accepted to appear in *IEEE/ACM Transactions on Networking*.
2. Q. Yuan, I. Cardei, and J. Wu, "Predict and Relay: An Efficient Prediction-based Routing in Disruption-Tolerant Networks," accepted to appear in *IEEE Transactions on Parallel and Distributed Systems*.
3. F. Li and J. Wu, "Attack and Flee: Game Theory-based Analysis On Interactions Among Nodes in MANETs," *IEEE Transactions on Systems, Man, and Cybernetics–Part B: Cybernetics*, Vol. 40, No. 3, June 2010, 612-622.
4. D. Guo, J. Wu, H. Chen, Y. Yuan, and X. Luo, "The Dynamic Bloom Filters," *IEEE Transactions on Knowledge and Data Engineering*, Vol. 22, No. 1, January 2010, 120-133.
5. C. Liu and J. Wu, "Virtual-Force-Based Geometric Routing Protocol in MANETs," *IEEE Transactions on Parallel and Distributed Systems*, Vol. 20, No. 4, April 2009, 433-445.

Collaborators and Other Affiliations

- **Recent Collaborators**: Dharma P. Agrawal, Jiannong Cao, Ionut Cardei, Mihaela Cardei, Jun-Hong Cui, Xiaojiang Du, Fei Hu, Weijia Jia, Abdallah Khreishah, Qun Li, Yunhao Liu, Jian Ren, Justin Shi, Yang Xiao, and Weiyi Zhang.
- **Graduate Advisor**: Eduardo B. Fernandez.
- **Advisees**: Larry Brown, Xiao Chen, Fei Dai, Praduemn K. Goyal, Ke Huang, Imad Jawhar, Zhen Jiang, Feng Li, Xiuqi Li, Cong Liu, Wei Lou, Avinash Srinivasan, Yijun Wang, Bing Wu, and Shuhui Yang.

Eugene Kwatny

Areas of Research

Real-time systems, laboratory automation, and signal processing.

Education

- PhD in Biomedical Engineering, (1971): Drexel University, Philadelphia, PA.
- MS in Biomedical Engineering (1968): Drexel University, Philadelphia, PA.
- BS in Electrical Engineering (1966): Drexel University, Philadelphia, PA.

Employment and Work Experience

- Professor, Department of Computer and Information Sciences, Temple University, July, 1992-present.
- Associate Professor, Department of Computer and Information Sciences, Temple University, July, 1984 - June, 1992.
- Assistant Professor, Department of Computer and Information Sciences, Temple University, September, 1979 - June, 1984.
- Visiting Assistant Professor, Electrical Engineering Department, Drexel University, September, 1978 - June, 1979.
- Assistant Professor of Rehabilitation Medicine, School of Medicine, Temple University, 1971 - September, 1979.
- Director, Computer and Information Sciences, Krusen Center for Research and Engineering, Moss Rehabilitation Hospital, September, 1974 - February, 1983.
- Principal Investigator, Visual Systems, Krusen Center for Research and Engineering, Moss Rehabilitation Hospital, June, 1971 - September, 1979.
- Adjunct Assistant Professor of Visual Science and Biomedical Engineering, Pennsylvania College of Optometry, December, 1974 - September 1978.
- National Institutes of Health Predoctoral Fellow, Drexel University, September, 1966 - June, 1971.

Synergistic Activities and Awards

- "High Performance Network Connection for Knowledge Discovery Research", National Science Foundation, CISE/ANIR, PI with Z. Obradovic, R. Stafford and V. Megalooikonomou, September 2001 - August 2003.
- Coordinator, Internet 2 for Temple University, Office of the Vice President for Computer and Information Services, September, 2001 - present.
- Member, National Science Foundation Review Panel:High Performance Networking Grants, April 2002 - 2007.

- Principal faculty for graduate (CIS8512) and undergraduate (CIS3207) operating systems courses in CIS Department, with significant redesign of course content to include concurrency and modern operating system design.
- Membership: *IEEE* (Life Member), *ACM*

Five Publications Most Related to this Proposal

- "Performance Comparison of Interprocessor Communication Schemes for A Hashing Technique on the Connection Machine," with Z. Khan, *International Journal of Computer Systems Science and Engineering.*, pp 189 - 195, Vol 11 No. 4, July, 1996
- "Performance of a Distributed, Pipelined, MultiJoin Algorithm in a Distributed Heterogeneous Supercomputing Environment," with Z. Khan, *Proc. Seventh SIAM Conference on Parallel Processing for Scientific Computing*, February, 1995
- "Performance Comparison of Interprocessor Communication Schemes for Hashing Techniques on the Connection Machine," with Z. Khan, *Proc. of the Massively Parallel Computing Systems Conference*, pp 167 - 172, IEEE Computer Society Press, May, 1994
- "Performance of Parallel Hashing Algorithms on the Connection Machine," with Z. Khan, *Proc. of the International Conference on Computers and their Applications*, Ed. D.C. Pheanis, pp 123 - 127, (ISBN 1-880843-08-0), March 1994
- "Removing Duplicates in Parallel on a Distributed Supercomputing Environment," with Z. Khan, *Proc. SS'93 High Performance Computing Conference*, June, 1993.

Five Other Significant Publications

- "Effectiveness of Join Processing Techniques on Parallel and Distributed Architectures," with Z. Khan, *Proc. of the IEEE International Conference on Parallel and Distributed Computing and Systems*, ed: R. Melhem, October, 1992.
- "Simulation of a Regional Scheduling Problem," with B. Lev, *Interfaces*, 18(2), pp. 28-37, March - April, 1988.
- "A High Level Language System for Signal Processing," with D. Peltzman, *Proc. 1987 IEEE Workstation Technology & Systems Workshop*, May, 1987.
- "Automated Analysis of Beagle Electrocardiograms," with D. Peltzman and D. Detweiler, *Proc. 13th Northeast Bioengineering Conference*, March, 1987.
- "An Application of Signal Processing Techniques to the Study of Myoelectric Signals," with D. H. Thomas and H. G. Kwatny, *IEEE Transactions on Biomedical Engineering,* Vol. BME-17, No. 4, pp. 303-313, Oct. 1970.

Collaborators and Other Affiliations

- **Graduate Advisor**: Michael Negin
- **Advisees**: R. Bhatia, Z. Khan, R. Kaplan

Shan Lin

Areas of Research

Wireless networks, sensor networks, cyber physical systems, and networked information systems.

Education

- PhD in Computer Science, (May 2010): University of Virginia (UVA), Charlottesville, VA.
- MS in Computer Science, (Jan 2007): University of Virginia (UVA), Charlottesville, VA.
- BS in Computer Science and Engineering, (June 2004): Shanghai Jiao Tong University, Shanghai, P. R. China.

Employment and Work Experience

- Assistant Professor, Department of Computer and Information Sciences, Temple University, July 2010 - present.

Synergistic Activities

- Technical Program Committee member for multiple conferences (IEEE ICDCS, IEEE NAS, IEEE BodyNets, ICCCN, etc)
- Reviewer for multiple major journals (ACM Transactions on Sensor Networks, IEEE Transactions on Wireless Communications, and IEEE Transactions on Industrial Informatics).
- Member of the IEEE and ACM.

Five Publications Most Related to this Proposal

1. S. Lin, G. Zhou, K. Whitehouse, Y. Wu, J. A. Stankovic, and T. He, "Towards Stable Network Performance in Wireless Sensor Networks", *Proc. of the 30th IEEE Real-Time Systems Symposium (RTSS '09), 2009.*
2. G. Zhou, Q. Li, J. Li, Y. Wu, S. Lin, J. Lu, C. Wan, M. D. Yarvis, and J. A. Stankovic, "Adaptive and Radio-Agnostic QoS for Body Sensor Networks", *ACM Transactions on Embedded Computing Systems (TECS) 2011.*
3. S. Munir, S. Lin, E. Hoque, S. M. Nirjon, J. A. Stankovic, and K. Whitehouse, "Addressing Burstiness for Reliable Communication and Latency Bound Generation in Wireless Sensor Networks", *Proc. of the 9th ACM/IEEE Conference on Information Processing in Sensor Networks (IPSN10), 2010*
4. H. Liu, J. Li, Z. Xie, S. Lin, J. A. Stankovic, K. Whitehouse, D. Siu, "Automatic and Robust Breadcrumb System Deployment for Indoor Fire-fighter Applications", *Proc. of the 8th Annual International Conference on Mobile Systems, Applications and Services (MobiSys10), 2010.*
5. J. A. Stankovic, Q. Cao, T. Doan, L. Fang, Z. He, R. Kiran, S. Lin, S. Son, R. Stoleru, A. Wood, "Wireless Sensor Networks for In-Home Healthcare: Potential and Challenges", *Proc. of the High Confidence Medical Device Software and Systems Workshop (HCMDSS '05)*, 2005.

Five Other Significant Publications

1. S. Lin, J. Zhang, G. Zhou, L. Gu, T. He, and J. A. Stankovic, "ATPC: Adaptive Transmission Power Control for Wireless Sensor Networks", *Proc. of the 4th ACM Conference on Embedded Networked Sensor Systems (SenSys'06)*, 2006.

2. Y. Wu, T. He, J. A. Stankovic, and S. Lin, "Realistic and Efficient Multi-Channel Communications in Dense Sensor Networks", *Proc. of the 27th Conference on Computer Communications (Infocom '07)*, 2007.

3. G. Virone, A. Wood, L. Selavo, Q. Cao, L. Fang, T. Doan, Z. He, R. Stoleru, S. Lin and J. A. Stankovic, "An Advanced Wireless Sensor Network for Health Monitoring", *Proc. of the 1st Transdisciplinary Conference on Distributed Diagnosis and Home Healthcare (D2H2 '06)*, 2006.

4. S. Lin, and J. A. Stankovic, "Taming Wireless Networking Challenges with Feedback Control", *Ph.D. Thesis*, University of Virginia, 2010.

5. A. Wood, G. Virone, T. Doan, Q. Cao, L. Selavo, Y. Wu, L. Fang, Z. He, S. Lin, and J. Stankovic, "ALARM-NET: Wireless Sensor Networks for Assisted-Living and Residential Monitoring", *TR CS-2006-11*, 2006.

Collaborators and Other Affiliations

- **Recent Collaborators**: Jie Wu.
- **Graduate Advisor**: John A. Stankovic.
- **Advisees**: Zhenyu Zhao.

Chiu C. Tan

Areas of Research

Cyber security, location privacy, cloud computing, and wireless security (RFID, 802.11, vehicular network, sensor, wearable sensor).

Education

- PhD in Computer Science (August 2010): College of William and Mary, Williamsburg, Va.
- BS in Computer Science (May 2004): The University of Texas at Austin, Austin, Tx.
- BS in Economics (May 2004): The University of Texas at Austin, Austin, Tx.

Employment and Work Experience

- Research Assistant Professor, Dept. of Computer and Info. Sci., Temple University, Aug. 2010 - present.
- Research Assistant, Dept. of Computer Science, College of William and Mary, Jun. 2007 - July. 2010.
- Teaching Assistant, Dept. of Computer Science, College of William and Mary, Jan. 2005 - May. 2007.

Synergistic Activities

- Technical Program Committee Member for multiple conferences (Globecom, IEEE RFID, UIC)
- Journal Reviewer for multiple journals (IEEE Journal on Selected Areas in Communications, IEEE Transactions on Wireless Communications, and IEEE Transactions on Parallel and Distributed Systems).
- Membership: IEEE

Publication History: 6 journal papers, and 17 conference papers.

Five Publications Most Related to this Proposal

1. C. Tan, H. Wang, S. Zhong, and Q. Li, "IBE-Lite: A Lightweight Identity Based Cryptography for Body Sensor Networks," *IEEE Transactions on Information Technology in BioMedicine. Special issue on Body Sensor Networks.* Pages 926-933, Nov 2009.
2. F. Xu, Z. Qin, C. Tan, B. Wang, and Q. Li, "IMDGuard: Securing Implantable Medical Devices with the External Wearable Guardian, *Proc. of the 29th Annual Joint Conf. of IEEE Conference on Computer Communications Society* (INFOCOM). April 2011.
3. H. Han, F. Xu, C. Tan, Y. Zhang, and Q. Li, "Defending Against Vehicular Rogue AP, *Proc. of the 29th Annual Joint Conf. of IEEE Conference on Computer Communications Society* (INFOCOM). April 2011.
4. H. Han, B. Sheng, C. Tan, Q. Li, and S. Lu, "A Timing Based Scheme for Rogue AP Detection," To appear in *IEEE Transactions on Parallel and Distributed Systems.*
5. C. Tan, B. Sheng, and Q. Li, "Secure and Serverless RFID Authentication and Search Protocols," *IEEE Transactions on Wireless Communications.* Pages 1400-1407, April 2008.

Five Other Significant Publications

1. C. Tan, B. Sheng, and Q. Li, "Efficient Techniques for Monitoring Missing RFID Tags," To appear in *IEEE Transactions on Wireless Communications*.

2. C. Tan, B. Sheng and Q. Li, "How to Monitor for Missing RFID Tags," *Proc. of the 28th Int'l Conf. on Distributed Computing Systems* (ICDCS). June 2008.

3. C. Tan, B. Sheng, H. Wang, and Q. Li, "Microsearch:A Search Engine for Embedded Devices Used in Pervasive Computing, *ACM Transactions on Embedded Computing Systems* (TECS). Vol 9. No.4, Article 43, March 2010.

4. H. Wang, C. Tan, and Q. Li, "Snoogle: Searching for the Physical World," To appear in *IEEE Transactions on Parallel and Distributed Systems*.

5. H. Wang, B. Sheng, C. Tan, and Q. Li, "Public-Key Based Access Control in Sensornet, To appear in *Wireless Networks*.

Collaborators and Other Affiliations

- **Recent Collaborators**: Qun Li, Jie Wu, Bo Sheng, Fengyuan Xu, Hao Han, Sheng Zhong, and Yifan Zhang.
- **Graduate Advisor**: Qun Li.

Youngjin Yoo

Areas of Research

Digital Innovation, Design, Virtual Materiality, Evolutionary Analysis of Digital Artifacts, Ubiquitous Computing, and Knowledge Management

Education

- Ph.D. in Management, R. H. Smith School of Business, University of Maryland, College Park, MD, 1997.
- MBA (Concentration: Information Systems), Seoul National University, Seoul, Korea, 1991.
- B.S. in Business Administration, Seoul National University, Seoul, Korea, 1988.

Employment and Work Experience

- Associate Professor, Department of Information Systems, Fox School of Business and Management, Temple University, 2007 C Present.
- Visiting Professor, Viktoria Institute, Sweden, 2008 C Present.
- Lewis-Progressive Chair in Management, Department of Information Systems, Weatherhead School of Management, Case Western Reserve University, 2003 - 2006.
- Associate Professor, Department of Information Systems, Weatherhead School of Management, Case Western Reserve University, 2003 - 2006.
- Assistant Professor, Department of Information Systems, Weatherhead School of Management, Case Western Reserve University, 1997 C 2003.
- Lecturer, Information Systems Department, R. H. Smith School of Business, University of Maryland, 1996 C 1997.

Synergistic Activities

- Editorial Boards
  - Senior Editor: *Journal of Strategic Information Systems* 2006 C 2009.
  - Associate Editor: *MIS Quarterly* 2010 C present, *Information Systems Research* 2005 C 2009, *Management Science* 2007 C 2008.
  - Editorial Board: including *Organization Science*, *Information and Organization*, *Scandinavian Journal of Information Systems*, *Journal of AIS*
  - Guest Editor: *Organization Science*, *Journal of AIS*, *Information and Organization*, *Information Systems and E-Business Management*, *Designing and Implementing Effectively High Impact Ubiquitous Computing Environments*, *Communications of the ACM*.
- Conference Organizations
  - Program Chair: Americas Conference on Information Systems 2012, Mobility Roundtable 2007, International Conference on Mobile Business 2006, and IFIP 8.2 Working Conference 2005
  - Keynote Speeches: IFIP 8.2 Working Conference, 2011

- Consortium Faculty: AMCIS 2007, AoM OCIS Division 2007, ICIS 2005.

- Awards
  - Ranked 1st in the world for research productivity in 2010 (Association of Information Systems)
  - Researcher of the Year, MIS Department, Temple University, 2008, 2009, 2011.
  - Best Published Paper, OCIS Division of the Academy of Management, 2008.

Publication History: 104 journal articles, conference papers and book chapters, and 3 edited books.

Five Publications Most Related to this Proposal

1. Yoo, Y., Henfridsson, O., and Lyytinen, K, "The new organizing logic of digital innovation: An agenda for information systems research", *Information Systems Research*, 2010.
2. Yoo, Y., "Computing in Everyday Life: A Call for Research on Experiential Computing", *MIS Quarterly*, 2010.
3. Boland, R. J., Jr., Lyytinen, K. and Yoo, Y, "Wakes of Innovation in Project Network: The case of digital 3-D representations in architecture, engineering, and construction", *Organization Science*, 2007.
4. Yoo, Y., Boland, R. K., Jr., and Lyytinen, K, "From organization design to organization designing", *Organization Science*, 2006.
5. Lyytinen, K., and Yoo, Y, "The next wave of nomadic computing", *Information Systems Research*, 2002.

Five Other Significant Publications

1. Lyytinen, K., and Yoo, Y, "Ubiquitous computing in the next wave: Issues and challenges", *Communications of the ACM*, 2002.
2. Yoo, Y., and Alavi, M, "Emergent leadership in virtual teams: What do emergent leaders do?", *Information and Organization*, 2004.
3. Carlo, J. L. and Yoo, Y, "How may I help you? Politeness in computer-mediated and face-to-face library reference transactions", *Information and Organization*, 2007.
4. Kanawattanachai, P. and Yoo, Y, "The impact of knowledge coordination on virtual team performance over time", *MIS Quarterly*, 2007.
5. Berente, N., Srinivasan, N., Lyytinen, K. and Yoo, Y, "Design principles for IT in doubly distributed design networks", *Proc. of the International Conference on Information Systems*, 2008.

Collaborators and Other Affiliations

- **Recent Collaborators**: Maryam Alavi, Richard J. Boland, Daniel Fesenmaier, Ola Hendfrisson, Prasert Kanawattanachai, Kalle Lyytinen, Timo Saari.
- **Advisor**: Maryam Alavi, Fred Davis, George Marakas, Kent L. Norman, Bradley C. Wheeler
- **Thesis Advising**: Hee-Dong Yang, Alex Citurs, Kevin Gallagher, Rama Hart, Prasert Kanawattanachai, Ryan Baxter, Uri Gal, David Tilson, Sunyoung Cho, Danail Ivanov, Nick Berente, Zixing Shen.

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Professional Preparation:

2001	Ph.D.	University of Texas, Austin, Electrical and Computer Engineering (advisor: G. Xu)
1998	M.S.E.	University of Texas, Austin, Electrical and Computer Engineering (advisor: G. Xu)
1997	B.S.E.E.	University of Virginia, Electrical Engineering (advisor: R. Weikle)
1993		Thomas Jefferson High School for Science and Technology

Appointments:

2008 –	Assistant Department Head for Graduate Affairs, Drexel University, Philadelphia, PA
2007 –	Associate Professor, Drexel University, Philadelphia, PA
2001 – 2007	Assistant Professor, Drexel University, Philadelphia, PA
1997 – 2001	Graduate Research Assistant, University of Texas, Austin, Austin, TX
1993 – 1997	Engineer, United States Naval Research Laboratory, Washington, D.C.
1996 – 1996	Continuing Education Teacher, Fairfax County Public Schools, Fairfax, VA
1992 – 1992	Software Engineer, United States Naval Observatory, Washington, D.C.

Publications

Relevant to Proposed Project:

available at http://www.ece.drexel.edu/wireless

1. D. Hamel, M. Chwastek, S. Garcia, B. Farouk, M. Kam, and **K.R. Dandekar**, "Sensor placement for urban homeland security applications," To appear in *International Journal of Distributed Sensor Networks*, 2011
2. D. Piazza, N.J. Kirsch, A. Forenza, R.W. Heath, Jr., and **K.R. Dandekar**, "Design and Evaluation of a Reconfigurable Antenna Array for MIMO Systems" *IEEE Transactions on Antennas and Propagation*, vol. 56, no. 3, March 2008.
3. C. Liang and **K.R. Dandekar**, "Power management in MIMO ad hoc networks: A game theoretic approach," *IEEE Transactions on Wireless Communications*, vol. 6, no. 4, pp. 1164-1170, April 2007.
4. M. Garfield, C. Liang, T.P. Kurzweg, and **K.R. Dandekar**, "MIMO space-time coding for diffuse optical communication," *Microwave and Optical Technology Letters*, vol. 48, no. 6, pp. 1108-1110, June 2006.
5. D. Piazza and **K.R. Dandekar**, "Reconfigurable antenna solution for MIMO-OFDM systems," *IEE Electronics Letters*, vol. 42, no. 8, pp. 446-447, April 2006.

Other Significant Publications:

available at http://www.ece.drexel.edu/wireless

6. J. Kountouriotis, N.J. Kirsch, and **K.R. Dandekar**, "Software defined radio demonstration of MIMO-OFDM rate adaptation," *Proceedings of the IEEE Workshop on Network Technologies for Software Defined Radio Networks*, 2007.
7. N.J. Kirsch, C. Liang, and **K.R. Dandekar**, "Experimental characterization of resource allocation algorithms in MIMO-OFDM ad hoc networks," *Proceedings of the IEEE Radio and Wireless Symposium*, 2007.
8. **K.R. Dandekar** and R.W. Heath Jr., "Modeling realistic electromagnetic effects on MIMO system capacity," *IEE Electronics Letters*, vol. 38, no. 25, December 2002.

9. **K.R. Dandekar**, A. Arredondo, H. Ling, and G. Xu, "Modeling and prediction of the wireless vector channel encountered by smart antenna systems," *Microwave and Optical Technology Letters*, vol. 35, no. 4, pp. 281-283, November, 2002.
10. **K.R. Dandekar**, H. Ling, and G. Xu, "Experimental study of mutual coupling compensation in smart antenna applications," *IEEE Transactions on Wireless Communications*, vol. 1, no. 3, July 2002.

Synergistic Activities:

1. Fairfax County Public Schools
   - Continuing education high school teacher
   - Developed laboratory and course notes
2. IEEE
   - Editorial Board - IEEE Expert Now
   - Member - IEEE Educational Activities Board
   - Chair - Philadelphia IEEE Vehicular Technology Society and Communications Society
3. Drexel University Educational Outreach Programs
   - Co-chair of Drexel Engineering Projects in Community Service (EPICS) program
   - College of Engineering high school program engineering mentor
4. Conference Program Committee Member
   - IEEE Radio and Wireless Symposium
   - IEEE Vehicular Technology Conference
   - IEEE Global Communications Conference
5. Drexel University Electrical and Computer Engineering Department
   - Coordinator of the Telecommunications and Networking Curriculum and Research group
   - Senior design committee member
   - Telecommunications seminar series organizer

External Collaborators:

- Felipe Catedra - Universidad de Alcala
- Michele D'Amico - Politecnico di Milano
- Antonio Forenza - Rearden Communications
- Robert Heath - University of Texas
- Hao Ling - University of Texas
- Ravi Marawar - National Instruments
- Andreas Molisch - MERL
- Akbar Sayeed - University of Wisconsin
- Scott Nettles - University of Texas
- James Templeman - NRL

Graduate/Undergraduate Advisors:

- Graduate: Guanghan Xu (University of Texas at Austin)
- Undergraduate: Robert Weikle (University of Virginia)

Students Supervised in the Past Five Years:

- Ph.D. Students Currently Supervised: John Kountouriotis, Alex Lackpour, Prathaban Mookiah, Douglas Pfeil
- Ph.D. Students Graduated: Nicholas Kirsch, Chao Liang, Daniele Piazza
- M.S. Students Currently Supervised: James Chacko, Mihnea Elian Dumitru, Renee Dorsey, Kevin Johnson, Danh Nguyen, Boris Shishkin, Guillermo Sosa, Kevin Wanuga
- M.S. Students Graduated: Matthew Chwastek, Rocco Dragone, Matthew Garfield, David Hamel, Abhishek Khemka, William Norman, Sumant Kawale, Maralle Fakhereddin, Michael Warde

MOSHE KAM

Department Head and Robert Quinn Professor

Electrical and Computer Engineering Department, Drexel University, Philadelphia, PA 19104
Phone: (215) 895 6920; Fax: (215) 895 1695; kam@drexel.edu

Professional Interests

Detection and Estimation, Distributed Detection, Sensor Fusion, Pattern Recognition, Robot Navigation, Information Assurance, Engineering Education

Professional Preparation

From	To	Degree	Advisor
Drexel University, Department of Electrical and Computer Engineering			
Sep 84	Sep 86	PhD: *Entropy and the Basic Precepts of System Theory*	Paul Kalata
Sep 83	Sep 84	MS (EE): *Glint Power Spectral Density in Conical Scan Laser Target Tracking*	Paul Kalata
Tel Aviv University Department of Electrical Engineering and Electronics			
Sep 72	Jun 76	B.Sc. (EE)	

Appointments

Department of Electrical and Computer Engineering, Drexel University

Jul 07	Present	ECE Department Head
Sep 02	Jul 09	Technical Coordinator – Project ACIN (funded by the US Army CERDEC)
Sep 01	Present	Director, NSA/DHS Center for Excellence in Information Assurance Education
Jul 01	Present	Robert Quinn Professor
Sep 96	Jun 01	Professor
Jun 90	Dec 97	Assistant Department Head for Development
Apr 90	Sep 96	Associate Professor
Oct 87	Mar 90	Assistant Professor

Selected Publications

Relevant to the proposed project

1. D. Hamel, M. Chwastek, S. Garcia, B. Farouk, M. Kam, and K.R. Dandekar, "Sensor Placement for Urban Homeland Security Applications," *International Journal of Distributed Sensor Networks*, 2010 (Volume 2010, Article ID 859263, 15 pages)
2. D. Dorsey and M. Kam: "Optimal deployment and replenishment of monitoring wireless sensor networks," *Proceedings of the IEEE Military Communications Conference MILCOM 2010*, pp.136-141, 2010.
3. D. Dorsey, J. Carandang, C. Gaughan and M. Kam, "Self-Adaptive Dissemination of Data in Dynamic Sensor Networks", *IEEE Intl. Conf. on Self-Adaptive and Self-Organizing Systems,* 2008.
4. X. Zhu, Y. Yuan, C. Rorres, and M. Kam: "Distributed M-ary Hypothesis Testing with Binary Local Decisions," *Information Fusion*, Volume 5, No. 3, September 2004, pp. 157-167.
5. Y. Yuan and M. Kam: "Distributed Decision Fusion with a Random –access Channel for Sensor Network Applications," *IEEE Transactions on Instrumentation and Measurement*, Vol. 53, No. 4, pp. 1339 – 1344, August 2004.

Other significant publications

1. D. Dorsey and M. Kam, "Non-uniform deployment of nodes in clustered wireless sensor networks," *Proceedings of the 43rd Annual Conference on Information Sciences and Systems (CISS)*, pp.823-828, 18-20 March 2009.
2. P. Abichandani, H.Y. Benson, and M. Kam: "Multi-vehicle path coordination in support of communication," *Proceedings of the IEEE International Conference on Robotics and Automation, ICRA '09* , pp.3237-3244, 2009.
3. J. Wildman, D. Hamel, R. Measel, D. Oakum, S. Weber, and M. Kam: "Performance and Scaling of Wireless Ad Hoc IPv6 Stateless Address Autoconfiguration under Mobile Gateways," *Proceedings of the IEEE Military Communications Conference MILCOM 2007,* pp.1-9, 2007.
4. Mianyu Wang; Nagarajan Kandasamy, Allon Guez, and Moshe Kam: Distributed Cooperative Control for Adaptive Performance Management, *IEEE Internet Computing*, Volume 11, Issue 1, Jan.-Feb. 2007, pages 31-39.
5. J. Kopena, E. Sultanik, G. Naik, I. Howley, M. Peysakhov, V.A. Cicirello, M. Kam, and W. Regli: "Service-Based Computing on MANETs: Enabling Dynamic Interoperability of First Responders," *IEEE Intelligent Systems*, Vol. 20, Issue 5, Sep-Oct 2005, pp. 17-25.

Synergistic Activities

IEEE: 2011 President and CEO; 2003-2007, 2010-2012 Member of the IEEE Board of Directors; 2005-2007 Vice President, Educational Activities; 2003-2004, Director Region 2
IEEE: 2006-2008 Editor, TryEngineering.org
ABET: 2008-10 Member, Board of Directors; 2005-2007 Alternate Member, Board of Directors
Conferences:
Transforming Engineering Education (Dublin, Ireland), Program Chair, 2009.
Meeting the Growing Demand for Engineers and Their Educators 2010-2020 International Conference (Munich, Germany), Planning Committee Member, 2007.
Secure Agent Workshop (Philadelphia, PA), General Chair, 2005.

Collaborators

Li Bai (Temple University), Andres Lebaudy (Fairmount Automation), Robert Conn (Gray Rock Professional Alliance), Chris Gaughan (U.S. Army Edgewood Chemical Biological Center), David Dorsey and Boris Gelfand (Lockheed Martin ATL), Charles Graff (US Army, CERDEC).

Graduate Advisor

Paul Kalata

Students Supervised in the last Five years

Ram Achuthanandam; J. Quinn; Pramod Abichandani; Lit-Hsin Loo; David Hamel; Matthew Chwastek; David Dorsey; George Sworo; Richard Primerano; Jeffrey Wildman; Ryan Measel; Mianyu Wang; Ray Canzanese; Brian Hipszer; Yingqin Yuan; Alex Fridman; Bradford Boyle; Chris Lester; Scott Haney; Wendy Chen; John Quinn.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
TEMPLE UNIVERSITY OF THE COMMONWEALTH SYSTEM OF HIGHER EDUCATION

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jie Wu

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jie Wu - none**	0.00	0.00	0.00	$ **0**	$
2. **Eugene Kwatny - none**	0.00	0.00	0.00	**0**	
3. **Shan Lin - none**	0.00	0.00	0.00	**0**	
4. **Chiu C Tan - none**	0.00	0.00	0.00	**0**	
5. **Youngjin Yoo**	0.00	0.00	0.00	**0**	
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**5**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**20,000**	
3. (**2**) GRADUATE STUDENTS				**16,690**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**36,690**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**4,537**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**41,227**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
Testing equipment (camera,smartphone, laptops, vehicular setups) $ **15,799**					
WiMAX base station and server **38,000**					
WiMAX installation **40,000**					
TOTAL EQUIPMENT				**93,799**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**8,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**2,000**	
3. CONSULTANT SERVICES				**4,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**5,000**	
6. OTHER				**9,000**	
TOTAL OTHER DIRECT COSTS				**20,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**163,026**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
Facilities and administrative costs (Rate: 53.0000, Base: 69227)					
TOTAL INDIRECT COSTS (F&A)				**36,690**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**199,716**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **199,716**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jie Wu

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
TEMPLE UNIVERSITY OF THE COMMONWEALTH SYSTEM OF HIGHER EDUCATION

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jie Wu

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jie Wu - none**	0.00	0.00	0.00	$ **0**	$
2. **Eugene Kwatny - none**	0.00	0.00	0.00	**0**	
3. **Shan Lin - none**	0.00	0.00	0.00	**0**	
4. **Chiu C Tan - none**	0.00	0.00	0.00	**0**	
5. **Youngjin Yoo**	0.00	0.00	0.00	**0**	
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**5**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**20,000**	
3. (**2**) GRADUATE STUDENTS				**16,690**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**36,690**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**4,537**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**41,227**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ **93,799**					
TOTAL EQUIPMENT				**93,799**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**8,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**2,000**	
3. CONSULTANT SERVICES				**4,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**5,000**	
6. OTHER				**9,000**	
TOTAL OTHER DIRECT COSTS				**20,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**163,026**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**36,690**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**199,716**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **199,716**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jie Wu

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Explanation Page

1. **Salary**. The requested budget is for the following personal. (1) Two graduate students will be supported for Summer semester. (2) One half-time staff supported is budgeted at $\$20,000$.

2. **Equipment**. The WiMAX base station hardware is budgeted to be $\$35,000$. The cost of installing the WiMAX equipment is budgeted to be $\$43,000$. The testing equipment is budgeted at $\$15,799$. This includes WiMAX cameras, phones, laptops, and vehicular units (WiMAX units mounted on vehicules) to be used for field testing.

3. **Travel**. The requested travel budget is for participants (students and PIs) to present results at major conferences in the field. In addition, the travel budget also covers attending various GENI conferences as part of the larger GENI network.

4. **Subcontracts**. Senior personal Yoo will be subcontracted $\$5,000$ to explore intergration of proposed testbed with existing and future City of Philadelphia IT projects.

5. **Other direct costs**. The cost of connecting the base station to Internet2 is budgeted at $\$7,000$.

6. **Fringe benefit**. Fringe benefit rate is 8.5% of (half-time) staff salaries and 17% of graduate student' wages.

7. **Indirect cost**. The rate of indirect cost is 53%.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Drexel University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Kapil R Dandekar

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Kapil R Dandekar - Associate Professor**	0.00	0.20	0.30	$ **6,399**	$
2. **Moshe Kam - Associate Professor**	0.00	0.00	0.30	**5,267**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.20	0.60	**11,666**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**14,210**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**25,876**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**3,757**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**29,633**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**2,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**27,500**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**8,640**	
TOTAL OTHER DIRECT COSTS				**38,140**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**67,773**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 54.5000, Base: 59132)**					
TOTAL INDIRECT COSTS (F&A)				**32,227**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**100,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **100,000**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Kapil R Dandekar

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Drexel University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Kapil R Dandekar

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Kapil R Dandekar - Associate Professor**	0.00	0.20	0.30	$ **6,399**	$
2. **Moshe Kam - Associate Professor**	0.00	0.00	0.30	**5,267**	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.20	0.60	**11,666**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**14,210**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**25,876**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**3,757**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**29,633**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**2,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**27,500**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**8,640**	
TOTAL OTHER DIRECT COSTS				**38,140**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**67,773**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**32,227**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**100,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **100,000**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Kapil R Dandekar

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Justification – Drexel University

Principal Investigator – Kapil R. Dandekar
- 0.2 Months AY Salary for 1 Year
- 0.3 Months Summer Salary for 1 Year

Co-Principal Investigator – Moshe Kam
- 0.3 Months Summer Salary for 1 Year

Fringe Benefits on Faculty Salary
- 32.2% fringe benefit rate for 1 year

0.5 Research Assistant
- 0.5 full time RA salary over (1) 12 month appointment

Total Personnel Expenses **$29,633**

Supplies **$2,000**

Miscellaneous supplies for installation of WiMAX hardware at Drexel University.

Purchased Services **$27,500**

Support for costs for installation of hardware at Drexel University (approx. $20,000) and Drexel IRT support costs ($7,500).

Indirect Costs **$32,227**

Drexel University's federally approved rate is 54.5%; it excludes capital equipment and tuition costs.

Other **$8,640**

Other costs include tuition for 0.5 GRAs (12 month appointments for 1 year) at Drexel University tuition rates.

Total Sponsor Funding **$100,000**

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Jie Wu	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Energy-Efficient Design in Wireless Networks Using Cooperating Communications

Source of Support: NSF(PI)
Total Award Amount: $ 277,370 Total Award Period Covered: 09/01/08 - 08/31/11
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: EAGER:A New Algorithmic and Graph Model for Networking in Challenged Environment

Source of Support: NSF(PI)
Total Award Amount: $ 199,391 Total Award Period Covered: 09/01/09 - 08/31/11
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.50

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRI-R2:Acquisition:A Hybrid High-Performance GPU/CPU System

Source of Support: NSF(PI)
Total Award Amount: $ 839,221 Total Award Period Covered: 05/01/10 - 04/30/13
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: EAGER:Mobile Multicore Computing

Source of Support: NSF(PI)
Total Award Amount: $ 144,409 Total Award Period Covered: 09/01/10 - 08/31/12
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.50

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NeTS:Small:Collaborative Research:Holistic Optimization Design for Vehicular Networks

Source of Support: NSF(PI)
Total Award Amount: $ 239,879 Total Award Period Covered: 07/01/11 - 06/30/14
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Summ: 1.00

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Jie Wu	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NeTS:Medium:Collaborative Research: Mobile Content Sharing Networks: Theory to Implementation

Source of Support: NSF(PI)
Total Award Amount: $ 457,000 Total Award Period Covered: 07/01/11 - 06/30/15
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CNS:Computing Research Infrastructure:A Meso-Scale GENI WiMAX Project

Source of Support: NSF
Total Award Amount: $ 299,717 Total Award Period Covered: 09/01/11 - 08/30/12
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CCSS: An Architecture for Joint Integration of Inter and Intrasession Network Coding in Lossy Wireless Multihop Networks

Source of Support: NSF
Total Award Amount: $ 329,163 Total Award Period Covered: 08/01/11 - 07/30/14
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Eugene Kwatny	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRI-R2:Acquisition:A Hybrid High-Performance GPU/CPU System

Source of Support: NSF

Total Award Amount: $ 839,211 Total Award Period Covered: 05/01/10 - 04/30/13

Location of Project: Temple University

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CNS:Computing Research Infrastructure:A Meso-Scale GENI WiMAX Project

Source of Support: NSF

Total Award Amount: $ 299,717 Total Award Period Covered: 09/01/11 - 08/30/12

Location of Project: Temple University

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Shan Lin	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NeTS:Small: Towards Wireless Network Performance Assurance: Hierarchical Control Architecture for Wireless Networks

Source of Support: NSF

Total Award Amount: $ 313,535 Total Award Period Covered: 07/01/11 - 06/30/14

Location of Project: Temple University

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CNS:Computing Research Infrastructure:A Meso-Scale GENI WiMAX Project

Source of Support: NSF

Total Award Amount: $ 299,717 Total Award Period Covered: 09/01/11 - 08/30/12

Location of Project: Temple University

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Chiu Tan

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: CNS:Computing Research Infrastructure:A Meso-Scale GENI WiMAX Project

Source of Support: NSF
Total Award Amount: $ 299,717 Total Award Period Covered: 09/01/11 - 08/30/12
Location of Project: Temple University
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Youngjin Yoo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CNS:Computing Research Infrastructure:A Meso-Scale GENI WiMAX Project

Source of Support: NSF

Total Award Amount: $ 0 Total Award Period Covered: 09/01/11 - 08/30/12

Location of Project: Temple University

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Kapil R. Dandekar**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **Applied Communications and Information Networking Program**

Source of Support: **U.S. Army CERDEC**
Total Award Amount: **$400,000** Total Award Period Covered: **04/01/10** **03/31/11**
Location of Project: **Drexel University - ACIN Camden Center**
Person-Months Per Year Committed to the Project. Cal: **2.00** Acad: **0.00** Sumr: **2.00**

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **II-NEW: MIMO Software Defined Communications Testbed for Radio and Optical Wireless Networking**
Source of Support: **National Science Foundation**
Total Award Amount: **$609,646** Total Award Period Covered: **09/01/09** **08/31/12**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **MRI: Development of Software Defined Communications Testbed for Radio and Optical Wireless Networking**

Source of Support: **National Science Foundation**
Total Award Amount: **$888,500** Total Award Period Covered: **09/01/09** **08/31/13**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **NETS:Small: Cognitive Antennas for Wireless Ad Hoc Networks**

Source of Support: **National Science Foundation**
Total Award Amount: **$479,962** Total Award Period Covered: **09/01/09** **08/31/12**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: **0.81** Acad: **0.36** Sumr: **0.45**

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **NETS: Medium: Collaborative Research: Cooperative beamforming for efficient and secure wireless communication**
Source of Support: **National Science Foundation**
Total Award Amount: **$399,942** Total Award Period Covered: **09/01/09** **08/31/12**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: **0.50** Acad: **0.00** Sumr: **0.50**

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **A Framework for Wireless Network Security Based on Reconfigurable Antennas**
Source of Support: **National Science Foundation**
Total Award Amount: **$359,506** Total Award Period Covered: **09/01/10** **08/32/13**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: **0.40** Acad: **0.20** Sumr: **0.20**

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* If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Kapil R. Dandekar**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **Below-Decks Electromagnetic Environment Characterization for RF Wireless Network Operation**
Source of Support: **ONR**
Total Award Amount: **$980,000** Total Award Period Covered: **pending**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: [ ] Current [X] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **Air Quality Sensor Networks for Urban Environmental Monitoring**

Source of Support: **National Science Foundation**
Total Award Amount: **#** Total Award Period Covered: **###** **###**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.20** Sumr: **0.00**

Support: [ ] Current [X] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **Low Cost Sensor Networks for Pervasive Urban Air Quality Measurement**

Source of Support: **Environmental Protection Agency**
Total Award Amount: **$494,012** Total Award Period Covered: **09/01/11** **08/31/14**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: **0.50** Acad: **0.20** Sumr: **0.30**

Support: [ ] Current [X] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **CI-TEAM Demo: Cyberinfrastructure for the STEM Population in the "App" Age**

Source of Support: **National Science Foundation**
Total Award Amount: **$250,000** Total Award Period Covered: **09/01/11** **08/31/13**
Location of Project: **Drexel University**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: **4.30**

Support: [ ] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: [ ] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

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* If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Moshe Kam	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: 'Below-Deck Electromagnetic Environment Characterization for RF Wireless Network Operation

Source of Support: ONR
Total Award Amount: $ 90,000 Total Award Period Covered: 03/01/11 - 02/28/12
Location of Project: Philadelphia, PA and Canden, NJ
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.60 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Signal Detection and Demodulation with High Power Interference

Source of Support: US Army CERDEC
Total Award Amount: $ 200,000 Total Award Period Covered: 03/01/11 - 02/28/12
Location of Project: Camden, NJ
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.60 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: CREW Network Centric Operations

Source of Support: US Army CERDEC
Total Award Amount: $ 200,000 Total Award Period Covered: 03/01/11 - 02/28/12
Location of Project: Camden, NJ
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.60 Sumr: 1.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Nuclear Engineering Education Laboratory

Source of Support: NRC
Total Award Amount: $ 150,000 Total Award Period Covered: 07/01/10 - 06/30/12
Location of Project: Pennsylvania, PA
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.10 Sumr: 0.20

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Department Equipment Summary at Temple University

- **SGI Altix 3000 Series Computer**
  32 Processors, 32 GB
  2 Terabytes of Memory
  NUMA Interconnect

- **IBM HS20 Cluster** (10 Nodes)
  2 × 2.4 Ghz CPUs/Node, 2 GB Memory/Node
  Gigabit Ethernet Interconnect

- **Sun X2200** (3 Nodes)
  8 GB Memory, 2 × 250 GB SATA Hard Drive
  2 × 2.0 Ghz AMD Opteron CPUs

- **Dell PowerEdge 2950** (1 Node)
  4 GB Memory, 6 × 143 GB Hard Drive
  2 x 3.0 Ghz Dual-Core CPUs

- **Dell PowerEdge 1950** (5 Nodes)
  4 GB Memory, 3 × 143 GB Hard Drive
  2 × 3.0 Ghz Dual-Core CPUs

- **Dell PowerEdge 2850** (4 Nodes)
  4 GB Memory, 2 × 73 GB Hard Drive
  2 × 2.4 Ghz Dual-Core CPUs

- **Citrix Cluster**
  2 × Dell PE 1950 - 2 × 3 Ghz CPU, 8 GB, 3 × 143 GB Hard Drive
  2 × Dell SC 1435 - 2 × 3 Ghz CPU, 4 GB, 2 × 73 GB Hard Drive
  1 × Dell PE 2950 - 2 × 3 Ghz CPU, 8 GB, 6 × 143 GB Hard Drive

- **Storage & Backup**
  Netapp F240c Cluster Storage Server; 4 Terabytes
  Promise VTRACK 15100 SCSI Storage; 4 Terabytes
  Sun SE3300 SCSI Storage; 2 Terabytes
  Dell PowerVault TL2000 Tape Backup

Drexel Wireless Systems Laboratory (DWSL) Facilities

Drexel University recently established its principal institutional priorities by establishing strategic areas of research in emerging technology. One of these key areas is in the area of Information Technology – the focus of the new A.J. Drexel Institute for Applied Communications and Information Networking. The Bossone Research Enterprise Building, constructed in 2005, is a $36M, 150,000 square-foot facility that features infrastructure for research in information technology. The Drexel Wireless Systems Laboratory (http://wireless.ece.drexel.edu) is located in this building.

Drexel University has made an institutional commitment to the development and maintenance of laboratory facilities. The Electrical and Computer Engineering Department employs a full-time Director of Laboratory Services who has a staff of 6 technicians. This group has previous experience in developing maintenance plans and machine-shop support for NSF-supported laboratories (Drexel DSP Laboratory, Drexel Industrial Control Laboratory) and maintains Drexel Wireless Systems Laboratory facilities. Relevant facilities for this project include:

Anechoic Chamber

The Drexel University Anechoic Chamber Testing (DUACT) facility, installed in 2007 by TDK RF Solutions is a custom design room that is isolated from external electromagnetic radiation sources and prevents the internal reflection of electromagnetic waves. It is used to perform antenna and radiating system characterization in support of DWSL research efforts. Electromagnetic absorbers used in the chamber are rated to perform at frequencies between 100 MHz and 100 GHz. DUACT is a state of the art research facility in which military, industrial, and academic institutions can test and develop next generation communication systems.

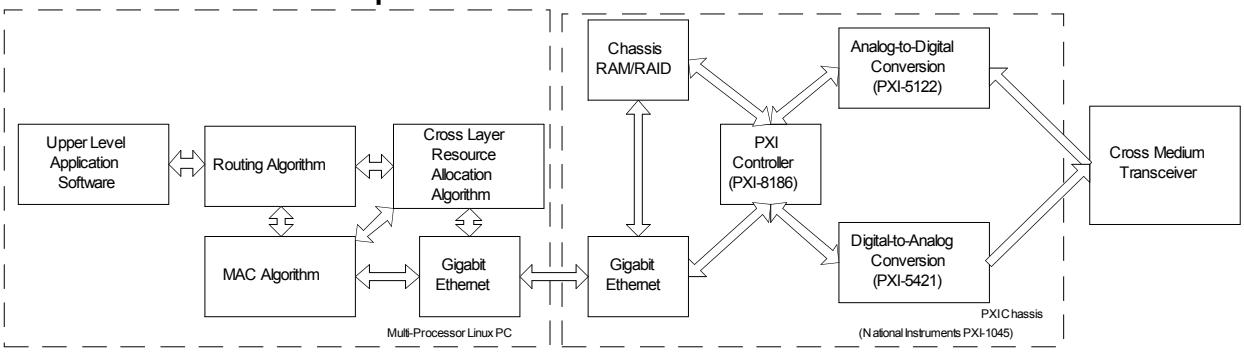
Drexel University Anechoic Chamber Testing (DUACT) Facility

Capital Equipment

Model	Description
Agilent N5230A	PNA Series 2-port Network Analyzer 300 kHz to 13.15 GHz (Options 1CM, N4691B)
Agilent N5230A-PA-L	PNA Series 4-port Network Analyzer 300 kHz to 20.00 GHz
Aeroflex WiMAX PCT	Protocol conformance testing equipment for the WiMAX standard
Agilent 54855A	6 GHz Infiniium oscilloscope 4 channel, 20 GSa/s per channel
Tektronix 1400	GigaBert analyzer and generator

	1 to 1000-Mbps pattern generator/ analyzer
TDKRF PP-02	Field probe positioner for remote x-y positioning in EMC test environments
TDKRF SI-300	Multi-purpose controller system interface designed for manual or computer controlled EMC test systems
Agilent E4404B	ESA-E Spectrum Analyzer – 9kHz to 6.7 GHz (Options B74, 229, B70, 903)
Agilent E4438C	ESG Vector Signal Generator – 250 kHz to 6 GHz (Options 506, UNJ)
Agilent 54624A	4 Channel 100 MHz Megazoom Oscilloscope (Options 004, ABA 903)
AR LN1G11	Broadband low noise amplifier
Agilent 33250A	80 MHz Arbitrary Waveform Generator (Options ABA, 903)
Agilent E3630A	Laboratory DC Power Supply – Triple Output (2) (Options OEM, 903)
Agilent 34401A	Digital Multimeter (Options 001,0B0, 120, 903)
Tessco 44722	2.400 – 2.4835 GHz 6 dBi Omni Antenna (8)
Tessco 499367	5.725 – 5.875 GHz 9 dBi Omni Antenna (8)

Software Defined Radio Capabilities



The above figure shows a basic block diagram of the MIMO software defined radio system developed by DWSL in collaboration with the University of Texas at Austin. We have five such nodes in the laboratory. Each node currently has 2 RF antenna array elements and transceivers, and the system can be expanded without re-design to 4 array elements and transceivers. In each node, there are three main components, an analog front end / transceiver that can include conformal or standalone antenna arrays, a frequency agile RF transceiver donated from Texas Instruments (RCS 110), a software defined baseband data acquisition system (PXI 5122 and 5421), and general purpose PCs for the MAC and higher layers. The RF transceiver cards are capable of transmitting at all channels in both the Industrial, Science, and Medicine (ISM) band between 2.4 and 2.5 GHz as well as in the Unlicensed National Information Infrastructure (UNII) band between 4.9 and 5.9 GHz. The cards are designed to operate independently of existing wireless standards, and thus provide us with maximum flexibility.

The analog front end and the baseband data acquisition system are all contained in a PXI chassis from National Instruments. Analog signals are converted to and from digital using PXI data acquisition cards from National Instruments and then passed to a dedicated chassis

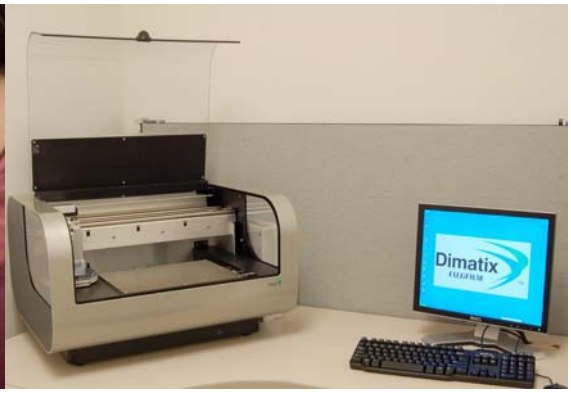
processor (PXI-8186) which implements the physical layer in LabVIEW. This processor then communicates over gigabit ethernet with a general purpose host which runs the MAC, higher layer network protocols, and any application software.

DWSL also owns 5 MIMO nodes of the Wireless Open-Access Resarch Platform (WARP) developed by Rice University. Baseband processing in WARP is achieved using a Xilinx Virtex-II PRO FPGA capable of processing data at 100s of Megabits per second with onboard embedded PowerPC processor cores. Each WARP node daughtercard has ISM and UNII band radio transmitters with dual 65 MS/sec 14-bit ADCs and dual 125 MS/sec 16-bit DACs. This platform is flexible, allowing for software reconfigurability of all layers of the protocol stack. WARP is also modular so that new daughtercard modules can be implemented to prototype communication networks with other frequency bands, radio standards, or communication modalities (e.g., optical, ultrasound). Programming WARP can be accomplished using a variety of interfaces ranging from low level VHDL code, Xilinx System Generator, and Matlab for physical layer algorithm development and Platform Studio in C/C++ for implementing higher layers of the protocol stack. Furthermore, WARP has a large community of users to provide technical support and a vehicle for dissemination of research results and newly developed communication and networking techniques.

Antenna Fabrication Facilities

DWSL owns a printed circuit board milling machine from T-Tech. The laboratory also contains all the necessary accessories for fabricating multi-layer (up to 6 layers) circuit boards, vias for inter-layer connections, and solder masks. Import of various CAD formats is possible with this fabrication tool. Milling of antennas and circuit boards has been accomplished on a variety of substrates including FR-4 and Rogers Duroid.

Printed Circuit Board Milling Machine



Materials Printer

For printing conformal antennas out of unconventional materials on non-traditional substrates, the Fujifilm-Dimatix DMP-2831 materials printer makes use of a unique fluid deposition system

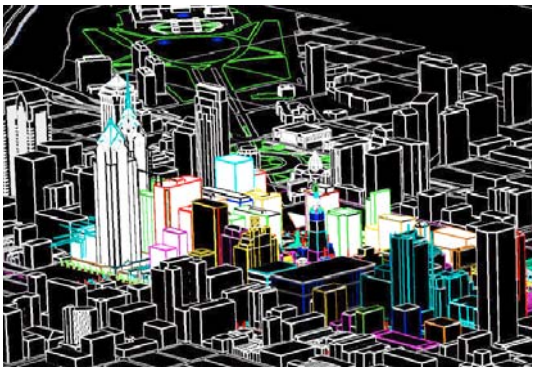
including a MEM print-head that uses an electrically controlled membrane to eject fluids. The printer can deposit controllable drop sizes down to the pico-Liter scale, and is capable of printing on virtually any substrate. The print cartridges are filled easily via syringe, and the correct printing parameters can be observed through the use of a drop-watching camera which puts the 16 nozzles of the print head under magnification. To make pattern design simple, the optional Gerber file importing software was purchased allowing virtually any design to be created in a number of CAD environments and imported directly into the printer. Once the printing if finished, an included fiducial camera puts the substrate under magnification so that it can be viewed on the single-drop scale to ensure the proper overlapping and layout.

Sensor Network Capabilities

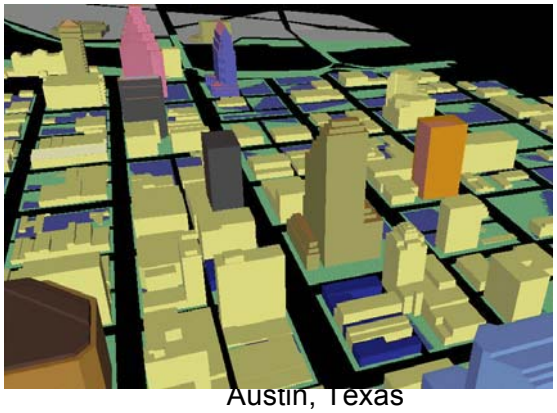
DWSL has access to a variety of ZigBee development kits for rapidly prototyping wireless sensor networks. Using our connections with the Philadelphia Clean Air Council and the Environmental Protection Agency, we have deployed several air quality sensor networks throughout Center City Philadelphia to monitor particulate matter emissions.

Computational Electromagnetic Simulation Capabilities

DWSL has CAD software to model electromagnetic antennas and propagation. It owns a license of the ray tracing software system, Fasant, developed through collaboration between the PI and Dr. M.F. Catedra of Escuela Politécnica, Universidad de Alcalá in Madrid, Spain. DWSL owns a network of PCs and has computer aided models of several downtown environments (Philadelphia, PA – Austin, TX – Ft. Benning, GA) for conducting computational electromagnetic simulations.



Philadelphia, PA



Austin, Texas

DWSL has access to the FEKO and NEC system for moment method characterizations of near/far field propagation in standalone and conformal antenna arrays. Analysis capabilities include HFSS, ADS, and other specialized computer programs for antenna array synthesis.

Project Data Management Plan
The Principal Investigator (PI) and Temple University commit to maintaining and disseminating data developed during the conduct of the proposed research consistent with the requirements for doing so as articulated in the National Science Foundation (NSF) Grant General Conditions Article 41, "Sharing of Findings, Data, and Other Research Products". For the purposes of precedence, the data management guidelines of the lead directorate at NSF shall take precedence. In the absence of specific guidance from the lead directorate, projects for which the Principal Investigator has a primary appointment in the College of Science and Technology at Temple University will utilize the guidance provided by the NSF. Temple University's guidelines for Research Data: Management, Control and Access (http://www.vprgs.msu.edu/dataguidelines) are consistent with NSF policies.

Definition of Data
Data for the purposes of this management plan includes all published works and source material for data presented in published work. It does not include raw data but does include everything necessary to reproduce the results presented in the published work. The following data is anticipated as part of this project (check all that apply):

☒ Published tables, figures, graphs, and tables of data used for making graphs.

☒ Published journal papers, conference papers, dissertations, theses, annual reports, and the final report.

☒ Physical samples.

☒ Software.

☒ Curriculum materials.

☐ Other materials (specify: _____).

In addition to data, metadata concerning how the data was generated (software, hardware, dates, measurement protocols, etc) will be maintained and disseminated on request.

Storage Custodian and Location
The Principal Investigator is the custodian of the original data and will make a copy available to co-investigators, students, and others by request within 45 days from receipt of the request unless a longer period is necessary for protection of intellectual property (see below). Temple University reserves the right to charge actual costs to provide the data for external requests consistent with the policies of the National Science Foundation. Temple University also reserves the right to withhold data release for a reasonable period of time to protect intellectual property (for the purpose of patent or copyright filings), when release of the data will compromise the privacy, confidentiality, and other rights of human subjects, in cases where release of the data may impede a research integrity investigation, or when required by law.

If the Principal Investigator resigns from the university, the department chairperson for the lead department will become the custodian of the data and will assume all the

responsibilities for data management, control and dissemination on behalf of Temple University.

The Principal Investigator recognizes her/his responsibility for choosing the most appropriate location for storage of digital data. Unless otherwise specified by the grant conditions, the storage of digital data will be maintained as (check the appropriate storage venue for this project):

☒ The Division of Computing Services (DCS) will maintain digital data storage for NSF projects without cost to the project, indexed using a unique identification number assigned by the College of Science and Technology, for a period of three years after completion of the project or date of publication, whichever is later. DCS provides secure hourly snapshot and daily (storage at an off-site facility) back-up of data for disaster recovery purposes. It is the responsibility of the Principal Investigator to establish the de-archive date for the data accrued as part of the research project during the project close-out process. Temple University does not assert that data will be retained, or accessible, after the date specified by the Principal Investigator. Temple University delegates to the Principal Investigator the responsibility to maintain, or eliminate, data after the de-archive date specified by the Principal Investigator or by agency requirements. The Principal Investigator will identify individuals who have the authority to place data in the project's digital repository. Data will be placed in the repository as soon as practical during the conduct of the project. Temple University delegates the Principal Investigator the authority and responsibility for removing data from the project archive. The data will reside behind a firewall and will be routinely backed up by DECS. Temple University will ensure data integrity on a best-effort basis.

☐ Other (specify):

Storage of physical data will be in space maintained by the primary department of the Principal Investigator.

TEMPLE UNIVERSITY®
Computer Services

Timothy C. O'Rourke
Vice President

Philadelphia, Pennsylvania 19122
(215) 204-7077

April 8, 2011

Suzanne Iacono
Senior Science Advisor for the Directorate for
Computer and Information Science and Engineering (CISE)
National Science Foundation (NSF)

Dear Suzanne,

Temple University is fully supportive of the grant proposal entitled, "A Meso-Scale GENI WiMax Project" headed by Professor Jie Wu. The proposal will be a joint effort together with Drexel University.

Temple University is a comprehensive urban research and academic institution offering over 300 academic programs that provide educational opportunities to over 39,000 students. The University's Computer Services Department maintains extensive technological resources and support for over 45,000 students, faculty and staff, including over 60 computer laboratories and more than 450 smart classrooms. Temple University also provides wireless Internet coverage throughout the University campus. We are especially interested in the research projects related to content delivery networks and WiMax, given their potential applications on campus.

Prof. Wu is a world-class researcher in the field of wireless networking, and has held numerous leadership positions. He is currently the chair of the Computer and Information Sciences Department.

In closing, I would like to assure you that the University's Computer Services Department will make every effort to provide the necessary support to ensure the success of the proposal.

Sincerely,

Timothy C. O'Rourke
Vice President, Computer and
Financial Services & CIO

CITY OF PHILADELPHIA
Division of Technology

Thomas Jones
Interim CTO/First Deputy CIO
1234 Market Street, Suite 1850
Philadelphia, PA 19107
Phone: (215) 686-8268
Fax: (215) 686-8258

To Whom It May Concern:

I am delighted to provide this letter to the National Science Foundation in support of Prof. Jie Wu's proposal entitled, "A Meso-Scale GENI WiMax Project". We believe that the proposed project has enormous potential for synergy with the City's vision of "Digital Philadelphia".

The City of Philadelphia is a leader in adopting new wireless technologies. As part of our stimulus funding, a key project will be to extend and improve the City's wireless infrastructure. As such, we are very interested in the outcomes of this research project. We are especially interested in the research projects related to law enforcement and tourism applications, given their potential for integration with the City's existing efforts.

Prof. Wu is a world-class researcher in the field of wireless networking, and has held numerous leadership positions. We have always enjoyed an excellent working relationship with Prof. Wu, and we have the fullest confidence in him and his team at Temple University. We are also pleased that another great Philadelphia institution, Drexel University, have teamed up with Temple University as a partner in this proposal.

In short, we would like to give our strongest endorsement to the proposal, and reaffirm our commitment to the project. We look forward to potential collaborations with Temple University and Drexel University to affect long-term benefits to academic scholarship, the City of Philadelphia, and to society-at-large.

Thomas Jones
Interim CTO/1st Deputy CIO, Information Technology

Drexel
UNIVERSITY

Office of Information Resources and Technology

Professor Kapil R. Dandekar
Associate Professor, Department of Electrical and Computer Engineering
Drexel University
3141 Chestnut St
Philadelphia, PA 19104

May 5, 2011

Dear Prof. Dandekar:

I write to provide support for your proposal "GENI: Drexel University WiMAX Deployment". Drexel University, in collaboration with Temple University and the City of Philadelphia, stands to greatly contribute to and benefit from participation in the Global Environment for Network Innovations (GENI) project.

The Office of Information Resources and Technology (IRT) at Drexel University has read the aforementioned NSF Proposal and we are pleased to see Drexel featured so prominently. There are sufficient IT resources at Drexel University to successfully meet your proposal's goals. Specifically, Drexel, in partnership with the Three Rivers Optical Exchange, is one of only twenty Internet2 connectors. The presence of Internet2 and its Interoperability On-Demand Network (ION) service on Drexel's campus will allow IRT to provide your WiMAX deployment with the necessary connections to the GENI national backbone.

The scope of our assistance will include:

1. Approving the location of an Indoor Site with the necessary network connectivity.
2. Assisting in the installation of any necessary equipment rack at the Indoor Site.
3. Providing an Ethernet connection between the Indoor Site and the three (3) basestation sectors with guaranteed bandwidth of 1 Gbps per sector.
4. Providing an Internet connection to the Indoor Site with a bandwidth of 300 Mbps.
5. Providing an Internet2 connection with ION service to the Indoor Site.

We expect these areas of assistance to cost $ 7,500. With this, we are willing to commit to helping you deploy the WiMAX base station in accordance with the GENI project and this NSF proposal.

In summary, we would like to provide our strongest endorsement for this proposal, and we would be happy to provide more information to support the Drexel application, should it be required.

Sincerely,

John A. Bielec, Ph.D.
Vice President/CIO