LOUISIANA TECH UNIVERSITY
AND
LOUISIANA STATE UNIVERSITY

# 2009-2010: ANNUAL REPORT

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## LOUISIANA BOR PKSFI
## CENTER FOR SMART CYBER CENTRIC SENSOR SURVEILLANCE SYSTEMS
## GRANT# LEQSF (2007-12)-ENH-PKSFI-PRS-03

PI: Dr. Vir V. Phoha
Co-PIs: Dr. S. S. Iyengar, Dr. Gabrielle Allen, Dr. Peter Chen

Chair of Research and Industrial Advisory Board: Dr. Les Guice

June 15, 2010

**1. PERSONNEL: LIST ALL KEY PERSONNEL AND OTHER STAFF WHO PROVIDED *SIGNIFICANT* CONTRIBUTIONS TO THE PROJECT. PROVIDE INFORMATION ABOUT THE TYPES OF CONTRIBUTIONS MADE BY EACH LISTED PARTICIPANT AND CONTROLS IN PLACE TO ENSURE THAT THESE CONTRIBUTIONS ARE ADEQUATE TO THE PROJECT'S REQUIREMENTS.**

## 1.1. Key Personnel and Their Contributions

### 1.1.1. Project Team

Dr. Vir V. Phoha, (La Tech), PI; Dr. S. S. Iyengar, (LSU), Co-PI; Dr. Peter Chen, (LSU), Co-PI; Dr. Gabrielle Allen, (LSU), Co-PI; Dr. Rastko Selmic, (La Tech), Sr. Researcher; Dr. Tevfik Kosar, (LSU), Sr. Researcher; Dr. Christian Duncan, (La Tech), Sr. Researcher; Dr. Asok Ray, (Penn State University), Sr. Consultant.

### 1.1.2. Core Research Team

Dr. Vir V. Phoha, (LA Tech), PI; Dr. S.S. Iyengar, (LSU), Co-PI; Dr. Peter Chen, (LSU), Co-PI; Dr. Gabrielle Allen, (LSU), Co-PI; Dr. Asok Ray, (Penn State University), Sr. Consultant.

*Tenured/Tenure-track Faculty*: Dr. Travis Atkison, (La Tech); Dr. Christian Duncan, (LA Tech); Dr. Jean Gourd, (La Tech); Dr. Jinko Kanno, (La Tech); Dr. Tevfik Kosar, (LSU); Dr. Supratik Mukhopadhyay, (LSU); Dr. Rastko Selmic, (La Tech); Dr. Jian Zhang, (LSU);

*Research Assistant Professors*: Dr. Kiran Balagani, (La Tech) and Dr. Md Enamul Karim, (La Tech). *Research Associates:* Mr. Vasanth Iyer, (LSU) and Mr. Noureddine Boudriga (LSU).

### 1.1.3. Research Team Contributions

Collectively as a team and individually, the investigators have produced significant research results supported by the P-KSFI grant. Overall, for the 2010 reporting period, the research team has to its credits ***34*** research papers (***25*** published and ***9*** under review), ***2*** issued US patents, ***1*** US patent application, ***6*** book chapters, ***2*** books, and ***11*** funded grants.

The Core Research Team and their students have collaboratively worked on rare and event pattern detection, intelligent placement of sensors, visualization of graphics, malware and malicious executables, anomaly detection, system security, cyber forensics, sensor fusion, secure information dissemination, grid structures and computation, data placement in distributed computer systems, sensor data modeling, information-theoretic feature selection, sensor network programming, statistical machine learning, and network security.

A summary of key contributions made by the core research team members for the 2010 reporting period follows:

Dr. Vir Phoha and Dr. Kiran Balagani were the key personnel involved in developing fusion algorithms for keystroke based biometric user authentication. Fusion algorithms and related codes were transferred to our industry partner, Assured Information Security Inc., Rome, NY, under the "Cyber Weapons" project effort. In partnership with Air Force Research Laboratory (AFRL), Dr. Phoha and Dr. Balagani led a campus wide effort to collect keystroke patterns to facilitate large-scale evaluations of keystroke based biometric authentication systems. The data collection effort has been very successful, and has attracted more than 1,500 unique participants. The keystroke database resulting from the data collection effort currently has more than 117,000 fixed-text typing samples, and 2,500 free-text typing samples, making it the most comprehensive evaluation database available in keystroke authentication field. Efforts toward analyzing the keystroke data and publishing key insights from the analysis are ongoing.

Dr. Balagani, Dr. Phoha, and Dr. S. S. Iyengar have collaboratively worked on developing mathematical proofs, relating Bayes error bounds to several information-theoretic feature selection criteria. The developed proofs validate the lower-order dependency assumptions of the feature selection criteria, and justify their utility by relating to Bayes classification error. This research has been published in *2* journal papers: IEEE Transactions on PAMI, 2010, and IEEE Transactions on SMC - Part A, 2010.

Dr. Balagani and Dr. Phoha, in collaboration with Dr. Asok Ray from Penn State University, have developed a novel theoretical framework to analyze the discriminability of keystroke features for authentication. Findings from the analysis have indicated strong connections between the inherent discriminability in keystroke features, the correlation structure of keystroke features, and the lengths of reference phrases. A manuscript reporting this work is currently under review in the journal Pattern Recognition Letters.

Dr. Iyengar has been addressing various problems in sensor fusion, sensor data aggregation, and source localization from sensor network data. Together with students and collaborators, he has published 2 journal papers: IEEE Transactions on Wireless Communications, and ACM Transactions on Sensor Networks, 2010. In addition, Dr. Iyengar has received a $284,413 NSF grant to research intelligent and uncertainty-resilient tracking sensor networks. Dr. Peter Chen and his students have developed algorithms applicable to counter-terrorism, learning, and conceptual modeling.

Dr. Enamul Karim and Dr. Phoha, in collaboration with Dr. Keesook Han (AFRL), have developed a new framework and software prototype for identifying malicious botnet traffic through local manipulation of packets and for effective white-listing of IPs. To research botnet detection and mitigation, Dr. Karim has recieved $84,000 funding from Air Force Office of Scientific Research.

Dr. Rastko Selmic, in collaboration with AFRL researchers Lt. R. Carr and A. K. Mitra, are addressing problems related to cooperative control of Micro-Aerial Vehicles (MAVs) for localization of unknown or hidden electromagnetic sources. Dr. Christian Duncan, Dr. Rastko Selmic, and Dr. Vir Phoha are collaboratively working on problems related to sensor placement, sensor coverage, applications of socio-biology to task allocation in sensor networks, and other associated problems.

Dr. Travis Atkison has been working on malicious application detection algorithms. Dr. Atkison has developed data-slicing methodologies, and has proposed a randomized projection algorithm to create a low-order embedding of the high-dimensional malware data.

Dr. Jean Gourd has developed a theoretical model of a mobile agent framework in API-S calculus. His research on mobile agents has earlier appeared in the journal: The Journal of Management and Engineering Integration. Another paper is under review in the same journal.

Dr. Tevfik Kosar and his students have been working on high performance data transfer models. Specifically, his team has developed new models to adaptively approximate optimal number of parallel streams in wide-area network data transfers. Dr. Kosar has published his work in the IEEE Transactions on Parallel and Distributed Computing, 2010. In addition, Dr. Kosar and Dr. Gabrielle Allen together are working on problems related to failure prediction in data-aware scheduling and meta-data management.

Dr. Supratik Mukhopadhyay has been developing modeling techniques for capturing failure semantics in workflow systems, and for rapidly deploying adaptable situation-aware secure service-based systems. Dr. Jian Zhang is developing new stochastic machine learning algorithms and Bayesian methods for early prediction of Cyber attacks. In this area, he has published 1 journal and 2 conference papers, 1 book chapter, and has received $152,462 NSF funding to research multi-perspective Bayesian learning methods for detecting advanced malware.

### 1.1.4. Research and Industrial Advisory Board

The Research and Industry Board (RIAB) for this project consists of key technology companies and research entities in the region, as well as major industry players from across the country. Dr. Les Guice (La Tech), is the Chair of the Research and Industrial Advisory Board and VP for Research and Development.

The RIAB will facilitate partnerships that drive the development of relationships with leading technology companies, to enhance technology transfer and economic development in the state. Eventually, industrial and government organizations that are represented in the RIAB, will be asked to contribute in-kind or cash resources to support the operations of the Center. Louisiana Tech has employed such a model quite successfully for its Trenchless Technology Center for 15 years.

### 1.1.5. Research and Industrial Advisory Board Contributions

Dr. Les Guice, Louisiana Tech Vice President for Research and Development, has been a major resource and motivator to make this project a success. The project has established a Research and Industrial Advisory Board (RIAB) consisting of industry leaders, and has helped develop important contacts with the Air Force National Laboratories such as Air Force Research Laboratory, Air Force Office of Scientific Research, Sandia National Labs, and industry partners such as NetQoS, Radiance Technologies, and Assured Information Security Inc, etc.

The RIAB consists of the following members:

Doris Carver, Associate Vice Chancellor, Research & Economic Development, Louisiana State University; Stan Napper, Dean, College of Engineering & Science, Louisiana Tech University; Joel Trammell, Chairman of the Board, CEO, Co-Founder, NETQoS, Inc.; Chris Mangum, CenturyLink, Inc.; Craig Spohn, Executive Director/President, Cyber Innovation Center; Bob Fudickar, Director, Technology, Louisiana Office of Economic Development; Bill Bailey, Radiance Technologies, Inc.

### 1.1.6. New Hires Supported By PKSFI Funding

- Tenure-track assistant professor Dr. Travis Atkison began his duties at Louisiana Tech University in September 2009.
- Tenure-track assistant professor Dr. Supratik Mukhopadhyay began his duties at Louisiana State University in July 2009.
- Research Associates: Mr. Vasanth Iyer (LSU) and Mr. Noureddine Boudriga (LSU).

### 1.1.7. Technical and Administrative Support Team

Dr. Scott Forrest (La Tech), Director of the Technology Transfer Center Shreveport, LA, Ms. Brenda S. Brooks (La Tech), Administrative Assistant.

Dr. Scott Forrest has been the Director of the Technology Transfer Center (T2C) in Shreveport. He has been representing Louisiana Tech in his research activities in the development of micro and nano technologies with military, homeland defense, and aerospace applications. Dr. Forrest facilitates the integration of the Cyberspace project activities with the Air Force, the Cyber Innovation Center, Barksdale Air Force Base, and the overall university commercialization infrastructure. As Technology Coordinator, Dr. Forrest maintains a relationship with the 8$^{th}$ Air Force. Dr. Forrest attends monthly meetings at the Cyber Innovation Center (CIC), and meets biweekly with Craig Spohn, Director of the Cyber Innovation Center. Dr. Forrest utilizes all initiative and funding opportunities with constant interaction and coordination. Through AFCEA, Louisiana Tech CEnIT, Louisiana Tech Enterprise Center, Louisiana Tech Technology Business Development Center, LSU BTI, and the Louisiana Technology Transfer Center, Dr. Forrest exercises the opportunity to capitalize on business support efforts, and integrate project activities with academia and industry.

Dr. Forrest has formed an initiative toward Remote Sensing Platforms with the Air Force and Louisiana Tech University using the LONI network. The Business of Airborne Remote Sensing Research and Development (AARecon), comprised of three employees, is the first small business to be located at the CIC. This company services a contract with the Louisiana Department of Wildlife and Fisheries to supply helicopter support for video recon on Lake Bistineau. The contract was awarded to help them track the spread of the invasive plant species, Giant Salvinia. Dr. Forrest has recently submitted a whitepaper to the CIC highlighting some of

his promising unmanned Aircraft (UA) technologies. Consequently, his technologies are under consideration for seed funding from the CIC to expedite these new technologies to the market place.

Dr. Forrest has partnered with Business Collaborators in Bossier City to form a new company called Precision Aerial Reconnaissance (PAR). AARecon will continue as a separate entity with a research and development emphasis, especially on UA technologies. PAR will provide manned aircraft remote sensing services while integrating the UA capabilities that AARecon can provide. Precision Aerial Reconnaissance will be moving into spaces at the CIC on August 1, 2010, and will be working closely with AARecon on related projects.

Ms. Brenda S. Brooks (La Tech), Grants Administrative Assistant, was hired in November 2008, replacing Tina Allen, to provide administrative support for the Center. She is responsible for all administrative functions required in the day-to-day operations of the center. This includes account monitoring, purchasing, travel, and assisting the faculty with submitting proposals and research publications. She monitors grant status on a daily basis. She is responsible for the CSC Newsletter that is released quarterly and is a means of providing research updates and information on the activities at the Center for Secure Cyberspace at Louisiana Tech. Ms. Brooks is also responsible for maintaining the Center's website and continued composition of the quarterly newsletter. She also assisted in the organization and planning of the Second Annual Cyberspace Workshop held in connection with Cyber Innovation Center's Air Force Symposium held in June, and Cyberstorm 2010 held in May.

## 1.2. Controls in Place to Ensure Project Requirements

The PIs, Co-PIs, and senior researchers have met and discussed research progress and directions of research during the project period. The coordination mechanisms include face-to-face meetings, phone and conference calls, and quarterly newsletters.

The PI Phoha, and the LSU lead Co-PI Iyengar, and Senior Consultant Ray meet every week by phone to discuss progress of the project and overcome deficiencies in research. In addition, almost all the researchers have had frequent face-to face meetings.

Details of the meetings in which all (or most of the PKSFI team) were present follow:

**Cyberspace Research Workshop**

(June 15, 2009): This workshop was held in Shreveport, Louisiana. It provided a venue to share eleven peer reviewed research papers with peers across the country, and coincided with the Air Force Cyberspace symposium. The conference received high attendance and extensive media coverage.

(November 15, 2010) The 3rd Cyberspace Research Workshop is slated for mid November in Shreveport, LA in conjunction with the Cyber Innovation Center and the Global Strike Command.

**Research and Industrial Advisory Board Meetings**

(June 15, 2009): The second meeting of the RIAB was held at the Hilton Convention Center in Shreveport, Louisiana.

(November 15, 2010): The third meeting of the RIAB is slated for mid November in Shreveport, LA in conjunction with the 3rd Cyberspace Research Workshop.

**Meetings at LSU**

(July 2009): The most recent meeting of the PKSFI research team was held in on the campus of Louisiana Tech to discuss the progress of the PKSFI research. Those present were PI Phoha and Co-PI Iyengar.

The above meetings are in addition to the regular meetings that PI Phoha has with individual researchers and Co-PI Iyengar has with LSU on part of the PKSFI team.

**Bi-weekly Multidisciplinary Cyberspace Meetings (at La Tech)**

The bi-weekly multidisciplinary cyberspace meeting brings together 12 faculty members and 13 graduate students from several disciplines including cyber security, computer science, electrical engineering, mathematics, psychology, business, and entrepreneurship. The purpose of the bi-weekly meetings is to generate new ideas for research, to explore synergistic cross-disciplinary collaborations, and to create a forum to openly discuss and critique works in progress. The bi-weekly meetings are conducted in the Center for Secure Cyberspace (Nethken Hall, Room 248) at Louisiana Tech University. Guest speakers are invited to discuss leading topics at their departments/universities to encourage continued progress in other fields interrelated with Cyberspace. During the Spring 2010 Quarter, Dr. K. R. Rao, Professor of Electrical Engineering at the University of Texas at Arlington was invited as the guest speaker.

**Newsletters**

A newsletter is designed every quarter to compile recent events and accomplishments from the team. This newsletter is circulated via campus email, and posted the CSC website.

# 2. ACTIVITIES AND FINDINGS

## 2.1. Major Research and Educational Activities Undertaken

### 2.1.1. Research Activities

**Table 1. A description of four major research activities and their status. Check mark indicates that work on the task is ongoing or has started.**

| Research Activities | Task Description | Status |
|---|---|---|
| ***Research Area #1*** ***Investigate network formulation providing robust placement algorithms in uncertain environments and ill defined topologies.*** | • T.1.1 Network Architectural Design Using Socio-Biological Principles<br>• T.1.2 Adaptive Sensing in Non-stationary Environments.<br>T.1.3 Embedding of Sensor Information at Grid Locations. | ☑<br>☑<br>☑ |
| ***Research Area #2*** ***Develop secure transmission to distributed cyber systems and build energy-efficient survivable communications routing and protocols for sensor data dissemination.*** | • T.2.1 Adaptive Attack Detection Mechanisms for Secure Transmission to Distributed Cyber Systems<br>• T.2.2 Network Centric Behavioral Biometrics and Remote Suspect Identification<br>• T.2.3 Botnet, Malware, and Rogue Application Detection and Mitigation<br>• T.2.4 Algorithms for Optimal Transmission Scheduling | ☑<br>☑<br>☑<br>☑ |
| ***Research Area #3*** ***Develop automatic sensor data fusion, processing, and tools for integrated prediction, detection, and estimation for disaster precursors.*** | • T.3.1 Rare Event Pattern Identification<br>• T.3.2 Finding the Spatial-temporal Origins of Rare Events Based on Sensor Data<br>• T.3.3 Secure Sensor Data Aggregation<br>• T.3.4 Robust Sensor Data Fusion and Decision Fusion | ☑<br>☑<br>☑<br>☑ |
| ***Research Area #4*** ***Develop visualization software modules and perform experimental validation with simulated and actual sensors.*** | • T.4.1 Develop Visualization Tools<br>• T.4.2 Develop Smart Micro and Nano Scale Sensor Nodes<br>• T.4.3 Validate Mathematical and Software Tools in the Center of Excellence | ☑<br>☑<br>☑ |

### 2.1.2. Educational Activities

#### 2.1.2.1. Cyber Discovery Camp

In its third year, Louisiana Tech University welcomed 20 area high school teachers, and 60 of their students are now better cyber-citizens after completing the College of Engineering and Science's annual Cyber Discovery Camp. Faculty members from the College of Engineering and Science, including Professors Jean Gourd, Travis Atkison, and Christian Duncan of the Center for Secure Cyberspace (CSC), teamed with the College of Liberal Arts to develop a residential camp experience aimed at high school teachers and students.

During the camp, lasting a full week on campus with teachers and students, facilitators demonstrated how to help rather than hinder security efforts by making participants aware of the benefits and dangers of cyberspace. This goal was defined by full immersion of all participants in the issues of cyberspace - from basic programming of a 'BOE-bot' machine to the architectural design of a cyber fort - to writing essays on legal and policy issues (enabling in the development of a story-line for the camp's Final Cyber Challenge).

The camp introduced to teachers how to integrate cyber into every element of the classroom. Whether they are teaching mathematics, history, ethics, engineering, or the arts, awareness in technology and cyberspace should be omnipresent.

Benton High School took top honors for the 2010 Cyber Discovery Camp. Ruston High School came in second, and Parkway High School came third. These teams received awards donated by the Cyber Innovation Center. This year's awards included funds available to enhance their school's technology, and 20 computers, donated by Dell, which were used during the camp.

The Cyber Discovery Camp is funded by a U.S. Department of Education grant, with support from the Cyber Innovation Center in Bossier City, Louisiana. The first Cyber Discovery Camp was held in the summer of 2008. Since that time, the Cyber Innovation Center has partnered with Louisiana Tech on this new model for teacher professional development.

#### 2.1.2.2. Cyber Storm 2010

CSC member Dr. Jean Gourd introduced the first 'Cyber Storm 2010' event held at Louisiana Tech University in May of 2010. Dr. Gourd developed the Cyber Storm competition coinciding with Tech's 400-level cyber security course, the first of its kind, designed to provide students with practical cyber security experience, while expanding theoretical foundations. Throughout the event, students focused on computer network defense and computer network attack. Two teams used a variety of equipment taken from class lectures and labs and placed in a day long "hackfest". The students worked in groups and had remote virtualized access to isolated environments that assisted them in completing their projects.

#### 2.1.2.3. Computer Forensics Course

CSC member Dr. Travis Atkison has developed the first Computer Forensics course for Louisiana Tech University. This 400-level class for upper level undergraduates and graduate students majoring in computer science or cyber security is a research-oriented course working with live incident response, network based forensics, forensics analysis techniques, online and mobile based forensics, and creating forensics toolkits.

#### 2.1.2.4. Computer Forensics Cyber Crime Initiative

A proposal has been submitted in which Louisiana Tech University proposes to enter into a collaborative arrangement with the Louisiana State Police under Cyber Crime Initiative. This collaborative project will significantly benefit both parties' goals of increasing the knowledge and capabilities of the Louisiana State Police in the use of tools, methods and techniques for cyber crime investigations. Long-term success of this collaboration will increase knowledge and capabilities of both parties in developing methodologies to fight cyber crime. If the proposal receives funding, the first stage of the process will begin in February, 2011 with the engagement of an onsite Investigator and CSC researcher, Dr. Atkison, working together to establish a Problem-Based Learning Approach. During that process, a training course will be developed for the summer of 2011 for Federal, State and Local Law Enforcement Community.

## 2.2. Describe and Provide Data Supporting Major Findings

The research team has met or exceeded the goals promised in the project proposal. Research funded by the PKSFI grant has resulted in ***25*** scholarly publications (published/accepted), ***2*** issued US patents, ***1*** US patent application, ***6*** book chapters, and ***2*** books.

**Table 2. Research Activity: performance measures, expectations promised in the PKSFI proposal, and achievements for Year 3 (1 July 2009 – 30 June 2010).**

| Year 3 | | | |
|---|---|---|---|
| | **Performance Measures** | **Expectations promised in the PKSFI Proposal** | **Achievements** |
| **Research Activity** | Major publications and presentations | 4 publications & 5 presentations | ***13*** journal papers published & ***12*** conference papers presented<br>***2*** books & ***6*** book chapters<br>***6*** journal papers & ***3*** conference papers are under review |
| | Research Milestones | Focus on developing sensor data fusion and visualization tools for integrated detection and estimation of disaster precusors. | Data fusion algorithms and related codes for keystroke based user authentication were transfered to industry partner, Assured Information Security Inc., for integration with US Air Force's Host Based Security System.<br>Dr. Phoha, Dr. Selmic, and Dr. Duncan together are working on the integration of disaster-precursor detection algorithms with visualization tools. |

**Table 3. Infrastructure and Statewide Impact: performance measures, expectations promised in the PKSFI proposal, and achievements for Year 3 (1 July 2009 – 30 June 2010).**

| Year 3 | | | |
|---|---|---|---|
| | **Performance Measures** | **Expectations promised in the PKSFI Proposal** | **Achievements** |
| **Infrastructure** | Support for more research faculty, grad students, and laboratory equipment | Submission of atleast 3 multi-institutional research and infrastructure proposals | • Multi-instiutional proposals: ***4*** submitted, of which ***3*** received funding and ***1*** is under review.<br>• Individual proposals: ***15*** submitted, of which ***8*** received funding; ***2*** proposals are under review.<br>• Total ***19*** proposals submitted, ***11*** received funding and ***3*** are under review. |
| | Strengthened ties with the US Air Force | Integation of the Center's research to Tech's BAFB program. | • A new B. S. program in Cyber Engineering is under development in collaboration with Dr. Kamal Jabbour, Information Directorate, AFRL, Rome, NY.<br>• A new $2.84M Secure Cyberspace Laboratory is under development with funding from AFOSR.<br>• Multiple partnerships between the Center for Secure Cyberspace researchers and researchers at Air Force Research Laboratory, Rome, NY and AFRL, Wright-Patternson AFB, OH. |
| **Statewide Impact** | ROIs, Patent Applications, & SBIRs | 2 ROIs, 1 Patent Application, & 2 SBIRs | • ***2*** US patents issued, ***1*** US patent application submitted, and ***2*** SBIRs submitted. |
| | Startup company | 1 company, 4-5 employees | • A start-up company 'AARecon' for airborne remote sensing R&D has been established. AARecon currently has 3 employees and has been awarded a contract from Louisiana Department of Wildlife and Fisheries. |

## 2.3. Describe the Opportunities for Faculty Recruitment, Retention, and Development, as well as Post-doc, Graduate, and Undergraduate Student Training;

Using PKSFI funds, La Tech recruited one tenure-track assistant professor and LSU recruited one tenure-track assistant professor and two research associates. After a comprehensive national selection process, we have the following new faculty members and research associates in place:

1. Travis Atkison, Tenure-Track Assistant Professor, La Tech

2. Supratik Mukhopadhyay, Tenure-Track Assistant Professor, LSU

3. Vasanth Iyer, Research Associate, LSU

4. Noureddine Boudriga, Research Associate, LSU

**Visiting Scholars:** La Tech has supported Associate Professor Remzi Sekar from the University of Arkansas at Little Rock during 1 July 2009 through 31 July 2009. La Tech is supporting Professor Joseph Kizza from the University of Tennessee Chattanooga during 1 June 2010 through 30 June 2010.

Both La Tech and LSU have supported graduate and undergraduate students. Most publications produced by the the core research team have students as co-authors. A list of students supported during this reporting period are:

**Graduate Students (La Tech):** Jun Dong Chen, Md. Shafaeat Hossain, David Irakiza, Ankunda Kiremire, Abena Primo, Khandaker Abir Rahman, Abdul Serwada, Md. Arafat Sultan, and Zibo Wang.

**Graduate Students (LSU):** Srini Srivasta, Ismail Akturk, and Huy Phamg.

**Undergraduate Students (La Tech):** William Ryan Lockwood, Chuka Okoye, and Stephan White.

## 2.4. Describe the Nature and Scope of Partnership Activities

CSC researchers have made considerable progress in connecting major Air Force Research Laboratories, industry and government partners, and universities.

CSC team members Dr. Vir Phoha and Dr. Kiran Balagani have partnered with Air Force Research Laboratory and industry (Assured Information Security (AIS) Inc., Rome, NY, Booz Allen Hamilton, McLean, VA, and Praeses LLC, Shreveport, LA) to design and field-adapt keystroke based authentication technologies. Prototype level software codes implementing Hidden Markov Model based and ‘similarity metric’ based authentication algorithms were

delivered to AIS Inc. to mature and field-adapt them to address the operational needs of the USAF. To support large-scale evaluations of text keystroke authentication algorithms, CSC researchers, in collaboration with AIS and Air Force Research Laboratory, undertook a major campus-wide data collection effort in two phases, Phase I was undertaken in October 2009 and Phase II was undertaken in April 2010. In these efforts, approximately 1500 participants provided more than 20,000 keystroke typing patterns. To further support large scale evaluation of keystroke authentication algorithms, CSC researchers are planning to undertake another keystroke data collection effort. The keystroke database resulting from the data collection effort currently has more than 117,000 fixed text typing samples, and 2,500 free text typing samples, making it the most comprehensive evaluation database in keystroke authentication field.

Louisiana Tech and Air Force Research Laboratory (AFRL) have signed Education Partnerships Agreement (EPA). Under this agreement, CSC members Dr. Vir Phoha and Dr. Md Karim, are collaborating with Dr. Keesook Han and her team from AFRL to research anti-botnet technologies. Dr. Keesook Han directs CSC's anti-botnet research from an Air Force perspective and has agreed to facilitate access to beneficial resources. A recent outcome of the partnership has been the development of a prototype-level network traffic analyzer.

CSC researchers Dr. Vir Phoha and Dr. Enamul Karim have partnered with researchers Dr. Arun Lakhotia and Dr. Andrew Walenstein from University of Louisiana at Lafayette, to conduct malware research and share expertise and resources (e.g., datasets and tools) in this area. The two teams jointly have won a Louisiana DEPSCOR grant to conduct research on obfuscation and de-obfuscation games for malware analysis. The teams at both universities have been working closely with an initial focus towards understanding the attacker and victim strategies from game-theoretic perspective and efficient interpretation of obfuscated codes.

CSC researchers Dr. Iyengar (LSU) and Dr. Jian Zhang (LSU) have partnered with researchers from University of Florida, Gainesville, and Purdue University, West Lafayette, to develop intelligent and uncertainty resilient sensor networks for identification and tracking of chemical, biological, radiological, nuclear, and explosive plumes. Recently, the joint partnership has received $284,413 NSF funding to collaboratively solve research problems pertaining to: 1) network formation by sensor selection, placement, and coverage; 2) sensor tasking protocols with temporal and spatial uncertainty management; and 3) protocols for reliable sensor-cyber communication.

CSC researcher Dr. Iyengar (LSU) has been collaborating with Dr. Nagi S. V. Rao, Oak Ridge National Laboratory (ORNL), Dr. Qishi Wu, University of Memphis, and Dr. Mengxia Zhu, Southern Illinois University, Carbondale, to develop fusion algorithms for target detection using sensor networks. Their recent research results appear in the ACM Transactions on Sensor Networks. As a result of the partnership with ORNL, Dr. Iyengar and his students at LSU have access to the state-of-the-art sensor network testbeds at ORNL.

Table 4. below summarizes ongoing major research activities of the Center and the collaborating units associated with the research activities.

**Table 4. A list of the ongoing major research activities and the collaborating units associated with the research activities.**

| CSC Research Activities (Tasks) | Collaborating Units |
|---|---|
| Network-centric Behavioral Biometrics | Louisiana Tech University, Air Force Research Laboratory, Rome, NY, Assured Information Security Inc., Rome, NY, Booz Allen Hamilton, McLean, VA, & Praeses, LLC, Shreveport, LA |
| Insider Threat Detection | |
| Remote Suspect Identification | |
| Rare Event Pattern Identification | Louisiana Tech University & Penn State University<br><br>Louisiana State University & SRI International |
| Finding Spatial/Temporal Origins of Anomalies | |
| Adaptive Attack Detection Mechanisms | |
| Mobile Agent Framework for Intelligent Attack Response | |
| Feature Discovery and Selection | |
| Botnet Detection | Louisiana Tech University & Air Force Research Laboratory, Rome, NY |
| Adversarial Code Detection | |
| Malware and Rogue Application Detection | |
| Sensor Coverage and Hole Detection | Louisiana Tech University & Air Force Research Lab, Wright-Patterson, OH<br><br>Louisiana State University, University of Florida, & Purdue University |
| Sensor Networks for MAVs | |
| Applications of Socio-biological Principles in Sensor Networks | |
| Robust Routing Protocols for Sensor Networks | Louisiana State University & Oak Ridge National Laboratory, TN |
| Optimal Transmission Scheduling Algorithms for Sensor Networks | |
| Information and Decision Fusion Algorithms and Applications | Louisiana State University, Louisiana Tech University, & Penn State University |

## 2.5. Describe any Problems Encountered During the Last Year of Project Activities;

None.

# 3. CONTRIBUTIONS: SUMMARIZE EFFORTS MADE TO BUILD RESEARCH AND EDUCATION CAPACITY, SECURE EXTERNAL FEDERAL AND PRIVATE-SECTOR FUNDING, BUILD INFRASTRUCTURE, CONTRIBUTE TO ECONOMIC DEVELOPMENT, AND ENSURE PROJECT SUSTAINABILITY OVER THE LONG TERM.

The team has submitted ***19*** proposals (and a whitepaper) for funding; ***11*** of the proposals have been funded; ***3*** proposals are in review. Details follow.

## 3.1. Funded Proposals

**[1]** " Cyber Weapons," PI: **Vir V. Phoha**; 1 July 2009 through 30 May 2010; Air Force Research Laboratory through Assured Information Security Inc., has been funded for $400,000.

**[2]** **(Multi institutional proposal)** "Science of Autonomy," PI: **Asok Ray** (Penn State University), Co-PI: **Vir V. Phoha**; 1 June 2009 through 31 May 2014; Office of Naval Research/$1.7M for the first 3 years + $1.5M for 2 optional years (subject to results of review after first 3 years).

**[3]** "Cyber K-12: Building a Foundation for Cyber Education in North Louisiana," PI: Galen Turner (Louisiana Tech University), Co-PI: **Christian Duncan**; Department of Education/$951,000 has been funded.

**[4]** **(Multi institutional proposal)** "Obfuscation and De-obfuscating of Intent in Computer Programs," PI: Arun Lakhotia (University of Louisiana at Lafayette), Co-PI: **Vir Phoha**, Co-PI: Andrew Walenstein (University of Louisiana at Lafayette); 1 November 2009 through 31 September 2012; Louisiana Board of Regents/DEPSCoR/$232,544 has been funded.

**[5]** "STCI: Development of Stork Data Scheduler for Mitigating the Data Bottleneck in Petascale Distributed Computing Systems," PI: **Tevfik Kosar**; 1 September 2009 through 31 August 2012; NSF - STCI Program/ $495,514 has been funded.

**[6]** "Collaborative Research: Community Infrastructure for General Relativistic MHD," PI: **Tevfik Kosar**, Co-PI: **Gabrielle Allen**; 1 October 2009 - 30 September 2012; NSF-PIF Program/ $400,000 has been funded.

**[7]** "Recruitment of Superior Graduate Fellows in Computer Science," PI: **Tevfik Kosar**, Co-PI: **S. S. Iyengar**; 21 August 2010 through 15 May 2013; Louisiana Board of Regents - Graduate Fellows Program/ $100,000 has been funded.

**[8]** "Remote Suspect Identification - Improvements and Optimization," PI: **Vir V. Phoha**, Co-PI: **Kiran S. Balagani**; July 2010 through May 2011; Air Force Research Laboratory through Assured Information Security/$400,000 has been funded.

**[9]** "A Composite Scheme for Detection and Disruption of Botnets," PI Md. Enamul Karim; 1 November 2009 through 31 October 2010; Air Force Research Laboratory/ $83,198 has been funded.

**[10]** **(Multi-institutional proposal)** "NeTS: Medium: Collaborative Research: Building an Intelligent, Uncertainty-Reslient Detection and Tracking Sensor Network," PI: **S. S. Iyengar**, Co-PI: **Dr. J. Zhang** , Dr. H.C. Wu (LSU); PI: S. Sahani (University of Florida); PI: D. Yau (Purdue University); 1 June 2010 – 31 May 2011; NSF/ $284,413 has been funded.

**[11]** "LA Tech Proposal for the Cybersecurity Research Program at the Cyberspace Research Laboratory," PI: **Les Guice**, Co-PI: **Vir V. Phoha**, Co-PI: **Md. Enamul Karim**, Co-PI: **Jean Gourd**, Co-PI: **Travis Atkison**, Co-PI: **Sumeet Dua**, Co-PI: **Rastko Selmic**; Air Force Office of Scientific Research/ $1,189,458 has been funded.

## 3.2. Other Proposals

**[1]** Cyber Crime Initiative Proposal with Department of Public Safety and Corrections
Agency: Office of State Police, State of Louisiana
Duration: 8 months
Total Budget: $40,000
Investigator: Travis Atkison, PI
Status: Pending

**[2]** Exposing the Netprint
Agency: DARPA (Cyber Genome Program)
Duration: March 2010
Total Budget: $1,565,738
Investigators: Travis Atkison, Co-PI; Jean Gourd, Co-PI
Status: Pending

**[3]** **(Multi-institutional proposal)**. Virtual Organization for Collaboration and Advancement of Learning Institutes (VOCAL) Agency: NSF (Cyber Enabled Discovery and Innovation)
Collaborating Institutions: University of Southern Mississippi, University of Southern Illinois at Carbondale, and Marshall University
Duration: February 2010
Louisiana Tech's Share: $431,470
Investigator: Jean Gourd, PI
Status: Pending

**[4]** CYEN: A Roadmap to Creating and Deploying Cyber Engineering at Louisiana Tech University (Whitepaper)
Agency: US Department of Homeland Security
Duration: January 2010
Total Budget: $69,484
Investigator: Jean Gourd, PI
Status: Not funded

**[5]** Mobile Agent Framework for Intelligent Attack Response (**SBIR**)
Agency: US Army Research, Development, and Engineering Command
Partnering Industry: Radiance Technologies Inc., Huntsville, AL
Duration: January 2010
Total Budget: $36,000
Investigator: Jean Gourd, PI
Status: Not funded

**[6]** Contained Automated Software Environment (**SBIR**)
Agency: Intelligence Advanced Research Projects Activity
Duration: November 2009
Total Budget: $1,280,618
Investigator: Jean Gourd, PI
Status: Not funded

**[7]** Identifying Vulnerabilities from Binary Executable Code Characteristics
Agency: Intelligence Advanced Research Projects Activity
Duration: November 2009
Total Budget: $904,712
Investigator: Jean Gourd, PI
Status: Not funded

**[8]** Algorithms and Foundations for Robust Intelligence in Autonomous Sensor Networks
Agency: NSF (Information & Intelligent Systems: Robust Intelligence)
Duration: September 1, 2010 - August 31, 2013
Total Budget: $487,877.00
Investigator: Vir V. Phoha, PI and Kiran S. Balagani, Co-PI
Status: Not funded

**[9]** Cyber Actor Characterization and Modeling
PI: John Bay (AIS Inc.); Co-PIs (Louisiana Tech): Vir V. Phoha, Kiran S. Balagani, and Md Enamul Karim
Agency: DARPA Cyber Genome Program (Technical Area 2: Cyber Anthropology and Sociology)
Duration: January 1, 2011 - December 31, 2014
Requested Funding: Total: $6.52M, Louisiana Tech's Share: $1.66M
Status: Not funded

## 3.3. Infrastructure

### 3.3.1. Cyberspace Research Laboratory

The Center for Secure Cyberspace with the support of a ***$2.84M*** Air Force Office of Scientific Research grant (received in April 2009), is establishing a Cyberspace Research Laboratory (CRL) to support a wide spectrum of novel cyber-centric research activities and experiments. CRL is composed of an Internet Replica Lab, a Compressed Sensor Network (CSN)/Micro Aerial Vehicle (MAV) laboratory, a High Performance Computing (HPC) lab, a Visualization laboratory, a Field Programmable Gate Array (FPGA) laboratory, and a Human Factors laboratory. The Internet Replica Laboratory is the core component and is a reconfigurable virtualization facility with high end network infrastructure that can support various cyber-centric experiments as well as serve as a cyber range. In this reporting period, we have acquired proof-of-concept virtualization infrastructure, full FPGA infrastructure, and CSN/MAV equipment. CSC also purchased high end work stations and various software tools. The rest of the equipment are under procurement. CRL is temporarily located at Nethken Hall and the Enterprise Center and Engineering Annex Building of Louisiana Tech. It is expected that the CSL will soon relocate to a new Louisiana Tech Enterprise Campus facility which is currently under construction.

### 3.3.2. Louisiana Tech Enterprise Campus and Tech Pointe Building

Louisiana Tech University has received ***$25M*** in funding from the State of Louisiana to build its new research park to be called as the Louisiana Tech Enterprise Campus. Additional efforts are underway to raise another ***$10M*** in federal and private funds to complete the Enterprise Campus. The Enterprise Campus will provide floor-space for high-tech companies to commercialize intellectual property, and to strengthen their research with Tech faculty and students. A multi-tenant building, called Tech Pointe, will be the first building in the Enterprise Campus. Tech Pointe is envisioned to be the new home of the Center for Secure Cyberspace and the Cyberspace Research Laboratory, and will house private and government entities that endeavor to partner with Louisiana Tech in the areas of research, education, and training, while developing business activities.

# 4. PROJECT REVISION: PROVIDE A LISTING OF AND EXPLANATION FOR ANY SIGNIFICANT CHANGES IN THE WORK PLAN FOR UPCOMING YEAR, INCLUDING ANY CHANGES IN THE AMOUNT OF INVESTIGATORS' TIME DEVOTED TO THE PROJECT. IF YOU MADE SIGNIFICANT CHANGES TO THE PROJECT DESIGN AS OUTLINE IN THE PROPOSAL DURING THE PAST YEAR, PLEASE LIST AND EXPLAIN THE CHANGES, THE PURPOSES FOR THE CHANGES, AND THE RESULTS.

None.