RESEARCH HORIZONS

2013

Annual Report

Research Celebrating Excellence

TENNESSEE STATE UNIVERSITY

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RESEARCH HORIZONS: 2013 ANNUAL REPORT

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Research Horizons: 2013 Annual Report

A Message from the Associate Vice President

The Division of Research and Sponsored Programs (RSP) of Tennessee State University (TSU) is pleased to present the 2013 edition of *Research Horizons* to chronicle and celebrate the research enterprise.

Research at TSU is vital to higher education because it is a vehicle to challenge and change the status quo of current knowledge into advanced thinking and continual discovery. Research permits faculty the academic time to advance the research mission of the University via a wide range of professional endeavors that are important, as funding priorities, to the university's stakeholders, including international companies. Research provides faculty the pedagogical opportunity to further enhance the educational experiences of their undergraduate and graduate students via their students and student interns engaging in broad, multi-disciplinary scholarly activities. Research propels students to explore opportunities in the international arena via various study abroad programs.

But research also substantially contributes to the day-to-day operations of TSU, because the university receives a form of reimbursement, or a fee of sorts, for its faculty and staff conducting research, and students participating in the research learning environment. This reimbursement fee is called Facilities and Administration (F&A) costs, or indirect costs, which are received by the university as a standard percentage paid by an external funder. Indirect costs are designed to compensate the university for the tangible, intangible, and often-unseen elements of the institution, and also for the hidden or overhead costs of institutional operations and amenities that it offers to its stakeholders and students.

For every dollar that TSU receives in research dollars, which happens as a result of a TSU researcher taking the initiative to seek and secure external funding, about 40% of each award is received in the general coffers of the institution, with the remainder going toward the specific research being conducted for the funds. Such external support for research, and for other sponsored programs, serves to promote innovative scholarship and discovery by TSU faculty and students which in turn creates new knowledge and skills, unveils new areas of thinking and commerce, and plays an effective role in enhancing the life, business, and career experience of each university stakeholder.

In the following report, a selection of projects is highlighted featuring both research faculty and staff together with the students mentored by them to *Think, Work, and Serve*. This Report provides examples of the processes of Tennessee State University to continue this tradition of research excellence. Our annual report concludes with a financial summary of grant proposal submissions and awards totaling external funding for TSU Research.

This 2013 Annual Report is a record of the caliber of activity and innovation to which we continually strive for the acceleration of human progress and economic development.

Sincerely,

Michael Busby, Ph.D.
Associate Vice President, Academic Affairs
for Research and Sponsored Programs

Animal Biotechnology Research:

Application of Emerging Technologies to Improve Quality of Poultry and Poultry Products

SAMUEL N. NAHASHON, Ph.D.
PRINCIPAL INVESTIGATOR

Since Dr. Samuel Nahashon (Research Professor, Department of Agricultural and Environmental Sciences) arrived at Tennessee State University (TSU) eleven years ago, animal biotechnology research was initiated with the central focus of employing emerging technologies to enhance production performance and quality of poultry products. The program has great emphasis on student training, teaching, and addressing the needs of consumers and the larger poultry industry, both traditional and alternative.

The United States is the world's largest poultry producer, with poultry meat production totaling over 43 billion pounds annually and more than $45 billion in retail sales. These numbers have been steadily increasing in recent years, as more people turn to chicken as a healthy alternative to beef and pork. As a result, competitiveness in the poultry industry to increase production and profitability through genetic selection, nutrition, and management has compromised the quality of poultry and poultry products by (1) increased fat accumulation in broiler chickens and (2) excessive use of antibiotics or growth promotants. Fat accretion in poultry directly influences the efficiency of feed utilization and consumer acceptability of poultry and poultry products. It is estimated that the poultry processing industry and consumers lose about $250-300 million annually in pollution control, extraction, and disposal of excess carcass fat.

To better understand the factors underlying the fat deposition in broiler chickens, TSU researchers have employed a model comprising the guinea fowl; a close relative of the chicken, but the guinea fowl is leaner than the broiler chicken and tends to be more resistant to poultry diseases. Through a collaborative mechanism of the agricultural poultry laboratory and those laboratories of Dr. Xiaofei Wang (Associate Professor, Department of Biological Sciences) and Dr. Fur-Chi Chen (Research Associate Professor, Department of Family and Consumer Sciences), several genes and proteins that may be associated with fat accretion in broiler chickens have been identified, several of which are now being characterized. Evaluation of about 28 million gene sequences from the guinea fowl hypothalamus, liver, adipose tissue, and

pancreas has also identified gene sequences translating to molecules associated with the metabolic process that leads to excessive fat deposition. The ultimate goal is to employ a more targeted approach to curtail excess fat accumulation through genetic selection or interruption of key metabolic pathways in broiler chickens.

"Our research is also addressing the increasing concerns of excessive use of antibiotics in poultry production leading to antimicrobial drug resistance in poultry and poultry products as well as consumers," expressed Dr. Nahashon. "More restrictions on antibiotic use in food animals have been inevitable, requiring an urgent search for alternatives."

Nahashon's research team is collaborating with Dr. Agnes Kilonzo-Nthenge (Research Assistant Professor, Department of Family and Consumer Sciences) to evaluate potential non-pathogenic microorganisms to develop probiotics that alter host metabolic processes which confer health, regulate feed efficiency and adiposity, and enhance overall poultry performance. The long-term research goal is to replace antibiotics in poultry feeding with these probiotics.

To date, the animal biotechnology research program has attracted over $2 million directly or indirectly through partnerships and collaborations. Some of the ongoing research projects are listed below:

Project Title: Establishing a Professional Science Master's Program to Develop Future Biotechnology Workforce with Business Skills for Sustainable Agriculture. S. Nahashon, N. Aziz, C. Dumenyo and C. Reddy.

Funding Source: USDA/NIFA

Award: $227,801

Duration: January 10, 2010 to September 30, 2014

Project Title: Integrated Evaluation of Genetic Variations in Broiler Chickens. X. Wang, S. Nahashon, and F. Chen.

Funding Source: USDA/NIFA

Award: $227,788

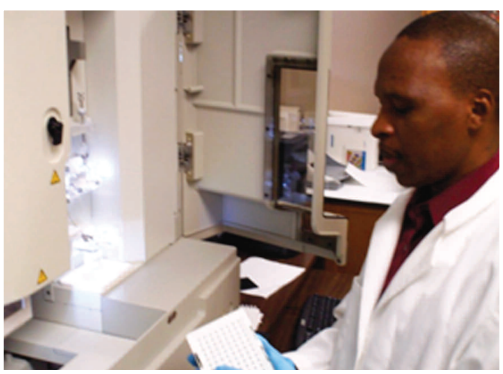
Duration: January 10, 2010 to September 30, 2014

Project Title: Approach to Control *Clostridium Difficile* from Limited Resource Poultry and Pig Farms to Consumers. A. Kilonzo-Nthenge, S. N. Nahashon, J. Dunn, and A. Peischel.

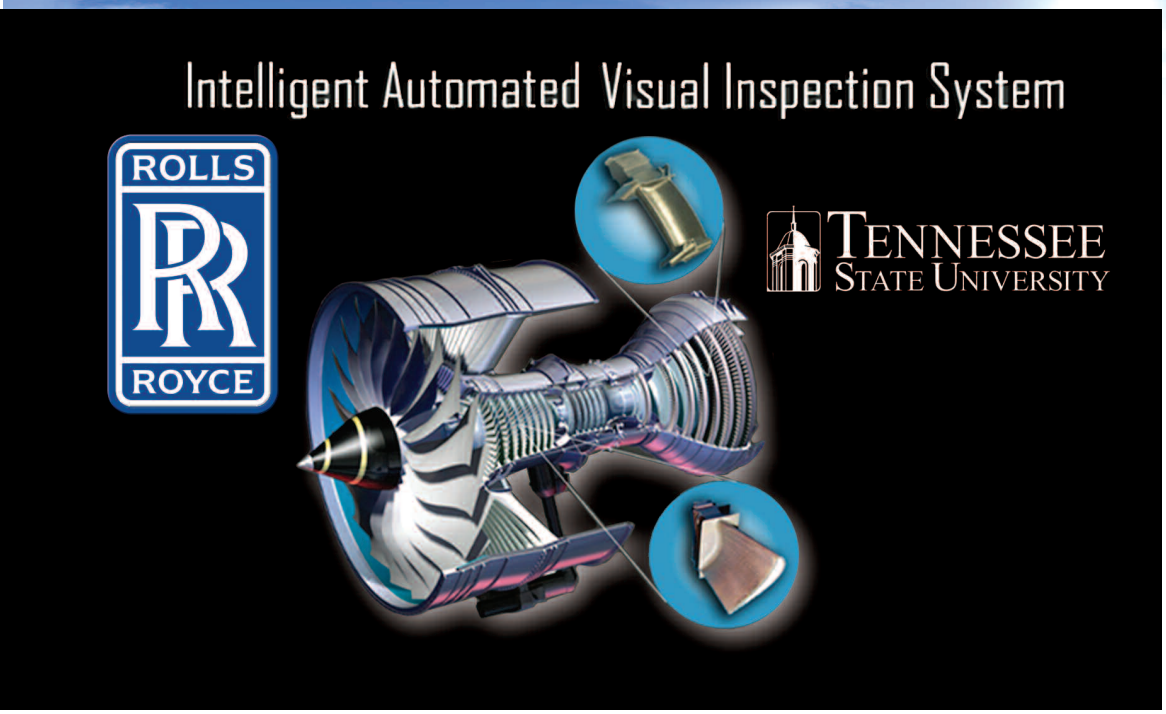
Funding Source: USDA/NIFA-AFRI

Award: $100,000

Duration: January 10, 2011 to September 30, 2014



Improving Safety
of Commercial and Military Aircraft



AMIR SHIRKHODAIE, Ph.D.
PRINCIPAL INVESTIGATOR

The College of Engineering is conducting a multi-year funded research investigation for improving safety in commercial and military aircraft manufactured by the Rolls Royce Corporation (RRC) headquarters in England which is led by Tennessee State University Principal Investigator Dr. Amir Shirkhodaie (Professor, Department of Mechanical and Manufacturing Engineering). The project, sponsored by the Rolls Royce Corporation of North America (RRC-NA), located in Indianapolis, Ind., started with a feasibility study in 2006, and has received seven annual funding awards from RRC-NA to develop the next generation Intelligent Automatic Visual Inspection System (I-AVIS).

A typical jet engine includes thousands of turbine blades designed in a variety of sizes and forms to provide optimum aerodynamics and mass center location. The turbine blades are constituted of advanced metal alloy castings and composites to increase strength, resist extreme temperature, and avoid corrosion. To guarantee optimum blade position and aerodynamic operation, tight tolerances apply to both the geometry and alignment of turbine blades. This is an essential design requirement to ensure the jet engine is going to produce maximum thrust at minimum fuel consumption level. The turbine blades are made of some proprietary dense metal alloy materials and manufactured through a single crystal casting processing to ensure total structural integrity of the blades. The turbine blades, in particular, present specific challenges for their inspection.

Some turbine blades are, for example, constructed with hollow cavities to allow cool airflow through the blades at high elevated operational temperatures. Internal air cooling allows turbine blades to operate under extremely high temperatures up to 1000°C. Structural and surface condition imperfections and defects, including cracks and inclusions, may place blade lifetime at risk and hence jeopardize the safety of the whole aircraft. According to Dr. Shirkhodaie, "The approaches undertaken by our research team to develop I-AVIS capability for Rolls Royce

Corporation has received international attention. The parent RRC-England, in collaboration with RRC at Indianapolis, is currently working with TSU towards advancing this new I-AVIS technology that is expected to significantly improve safety of jet engines manufactured by Rolls Royce Corporation."

This effort has so far produced three official US patents in 2012. The first patent describes a novel system developed at TSU for illuminating airfoil during inspection imaging. The second patent details the technical approach and new methodologies invented and implemented in development of the I-AVIS airfoil visual inspection system. The last patent reveals an innovative high-dexterous, low-cost, two-finger robotic manipulator system for full-motion 3D visual inspection and imaging of turbine blades with different sizes and shapes.

Since 2006, this research project has engaged engineering undergraduate and graduate students at TSU in various facets of developing visual inspection technology. These students have had the first-hand experiential opportunity to learn and contribute towards development and enhancement of this project. A number of former students involved with this project are currently employed by Rolls Royce Corporation and other students have enjoyed conducting their industrial summer internship program at Rolls Royce manufacturing facilities. Shirkhodaie reflects, "This is an example of a true, long-lasting, industry-academic collaborative research partnership."

Project Title: Visual Auto Inspection Sys (I-AVIS)

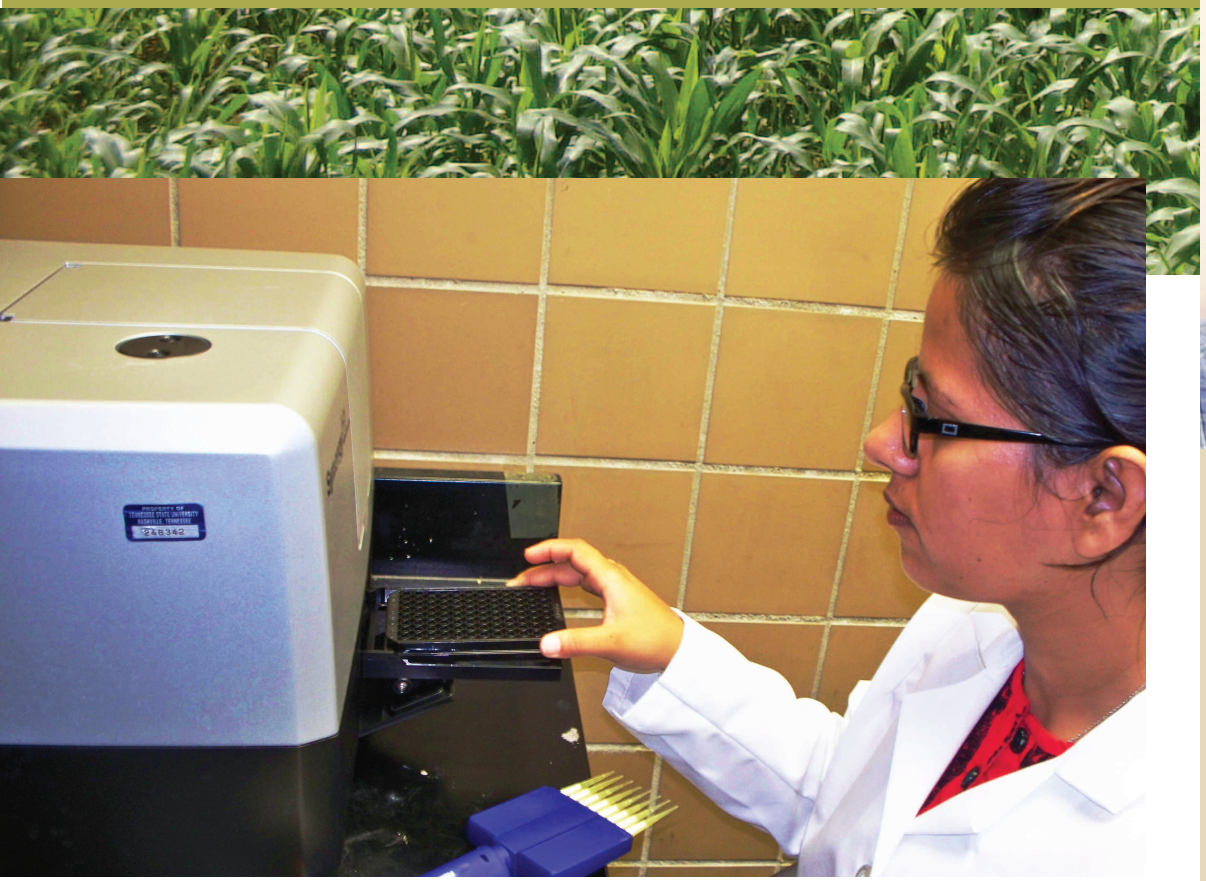
Funding Source: Rolls-Royce Corporation

Award: $135,481.58

Duration: March 12, 2008 to December 31, 2012

Plant Diseases Meet Their Match:

An Investigation of the Elusive Ways of Plant Pathogens



C. KORSI DUMENYO, Ph.D.
PRINCIPAL INVESTIGATOR

Tennessee State University (TSU) researcher Dr. Korsi Dumenyo (Research Assistant Professor, Department of Agriculture and Environmental Sciences, College of Agriculture, Human and Natural Sciences) has been involved in solving the mysteries of plant diseases for the past many years that have resulted in insights into how pathogens inflict harm on plants.

Together with his graduate students, Peter Prestwich, Niamul Kabir and Urmila Adhikari; and collaborators at Iowa State University and the Pittsburgh Supercomputing Center, Dr. Dumenyo is working to unravel the hidden secrets in the genomes of plant pathogens and reveal how these pathogens determine their interaction with food plants resulting in plant disease. The research activities in his laboratory have two foci: two important vegetable diseases. Bacterial soft rot and bacterial blackleg disease complex affect over 80 crop species including, many fruits and vegetables. The disease complex infects crops in the field as well as produce in storage. The second disease Dumenyo works on is bacterial wilt of cucurbits which also affects plants exclusively in the gourd family, including cantaloupes, cucumber, and squash.

Dr. Dumenyo says that, "Since understanding the problem is half of the solution, our work at understanding the mechanism of plant disease is critical to the maintenance of a healthy food system of the country."

In a bit to understand more of what makes soft rot bacteria "tick" i.e. their inherent (DNA) properties that enable them to inflict so much damage on our precious fruits and vegetables, he has chosen to use the investigative approach of functional genomics to study the disease, specifically the pathogen. Together with his present students and past students who are now colleagues, they have "created" many mutant variants of bacterial culprit of the soft rot disease, a bacterium known by the name *Pectobacterium carotovorum*. Each of these variants is altered in the way it

infects the plant host and has a defect in a different unit of the genetic material called a gene. This work has led to the characterization of an important protein called CorA. CorA protein is required for the bacterium to obtain the important nutrient of magnesium from the host plant. The team is investigating more of the altered genes in the other mutants. Research into soft rot is continuing with collaboration with Drs. Mohamed Karim and Tasneem Siddiquee of the TSU Department of Chemistry. In this aspect of the project, they are using the tools of chemistry to identify a chemical compound that the plant produces and which "turn" the bacterium onto the disease-causing state. Dumenyo says "with this compound identified, the possible disease management approaches based on that knowledge can be limitless."

The second focus of Dr. Dumenyo's research is the bacterial wilt of the gourd plants. These are creeping vine plants from which we get cucumber, melon, squash, and watermelon. These crops are prone to a debilitating wilting disease for which there are no pathogen-based management methods. Once infected, the plants wilt and ultimately die. In spite of the importance of this disease, the bacterial perpetrator called *Erwinia tracheiphila* has received little attention from the scientific community probably for the reason that it is difficult to work with in the laboratory. Undeterred by that difficulty, Dr. Dumenyo has boldly confronted this devastating disease. In this endeavor, Dumenyo has engaged in a collaboration with fellow scientist, Dr. Mark Gleason and his research team from Iowa State University and Mr. Alex Ropelewski from Pittsburgh Supercomputing Center (PSC). Equipped with his excellent training in bacterial genetics and plant pathology and with the computer infrastructure of PSC, he initiated the project to determine the entire DNA (genome) sequences of three strains of this pathogen. They just recently finished the first draft of three bacterial genomes. They are now frantically searching this massive DNA information for clues on the secret weapons of these pathogens as well. He believes that this genomic treasure troth will yield lots of insight into the weaponry of these pathogens.

Dr. Dumenyo's research has been funded externally by the National Institute of Food and Agriculture and internally by the College of Agriculture, Human, and Natural Sciences and the TSU Office of Research and Sponsored Programs. His past and present graduate students are supported by graduate assistantships from the Departments of Agricultural and Environmental Sciences, and Biological Sciences.

Project Title: Molecular Characterization of *Erwinia tracheiphila* Strains for Cucurbit Host Specificity

Funding Agency: United States Department of Agriculture/National Institute for Food and Agriculture

Award: $150,000

Duration: March 1, 2012 - February 28, 2014

Project Title: Mitigating the Effect of Plant Disease through an Understanding of Bacterial Soft Rot

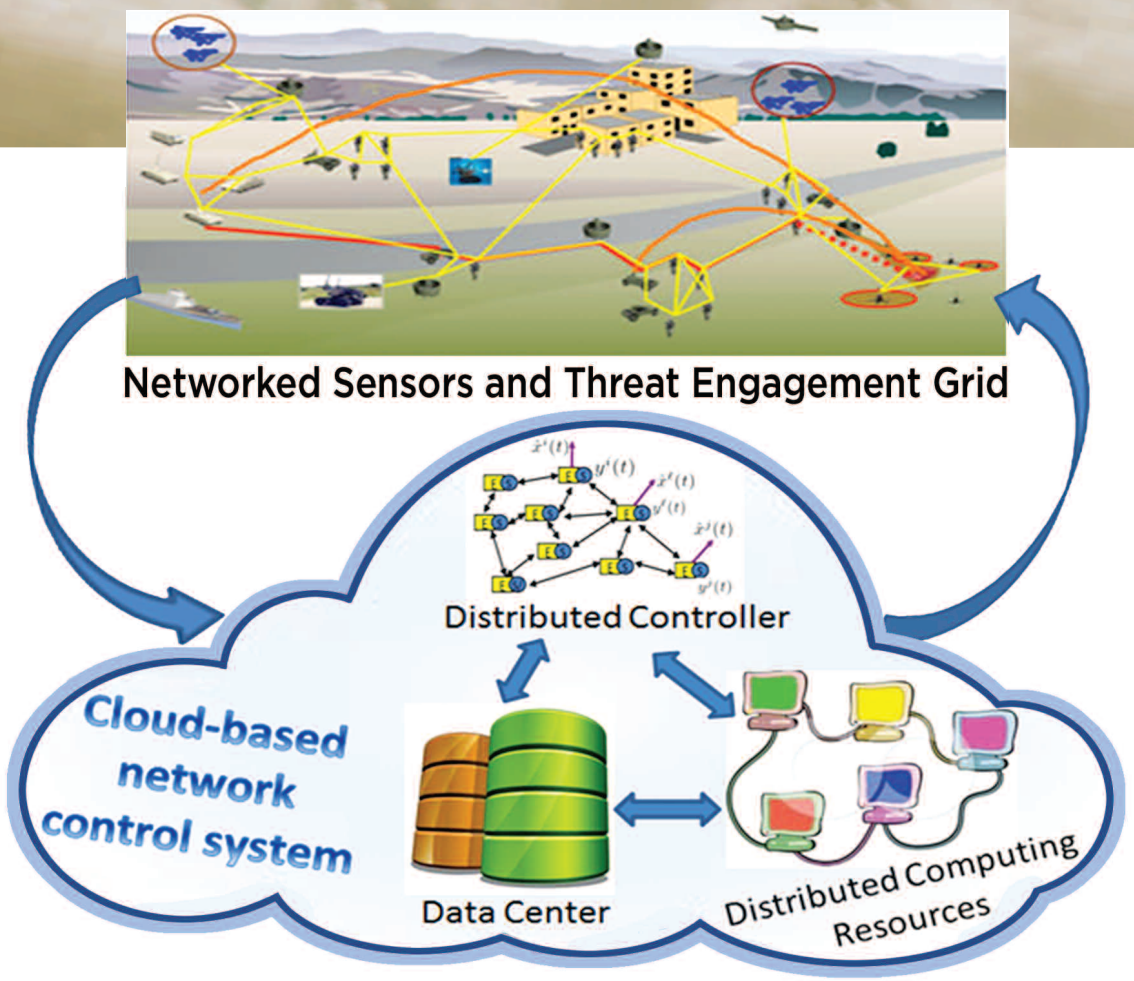
Funding Agency: United States Department of Agriculture / National Institute for Food and Agriculture

Award: $185,902

Duration: January 1, 2010 to September 30, 2013

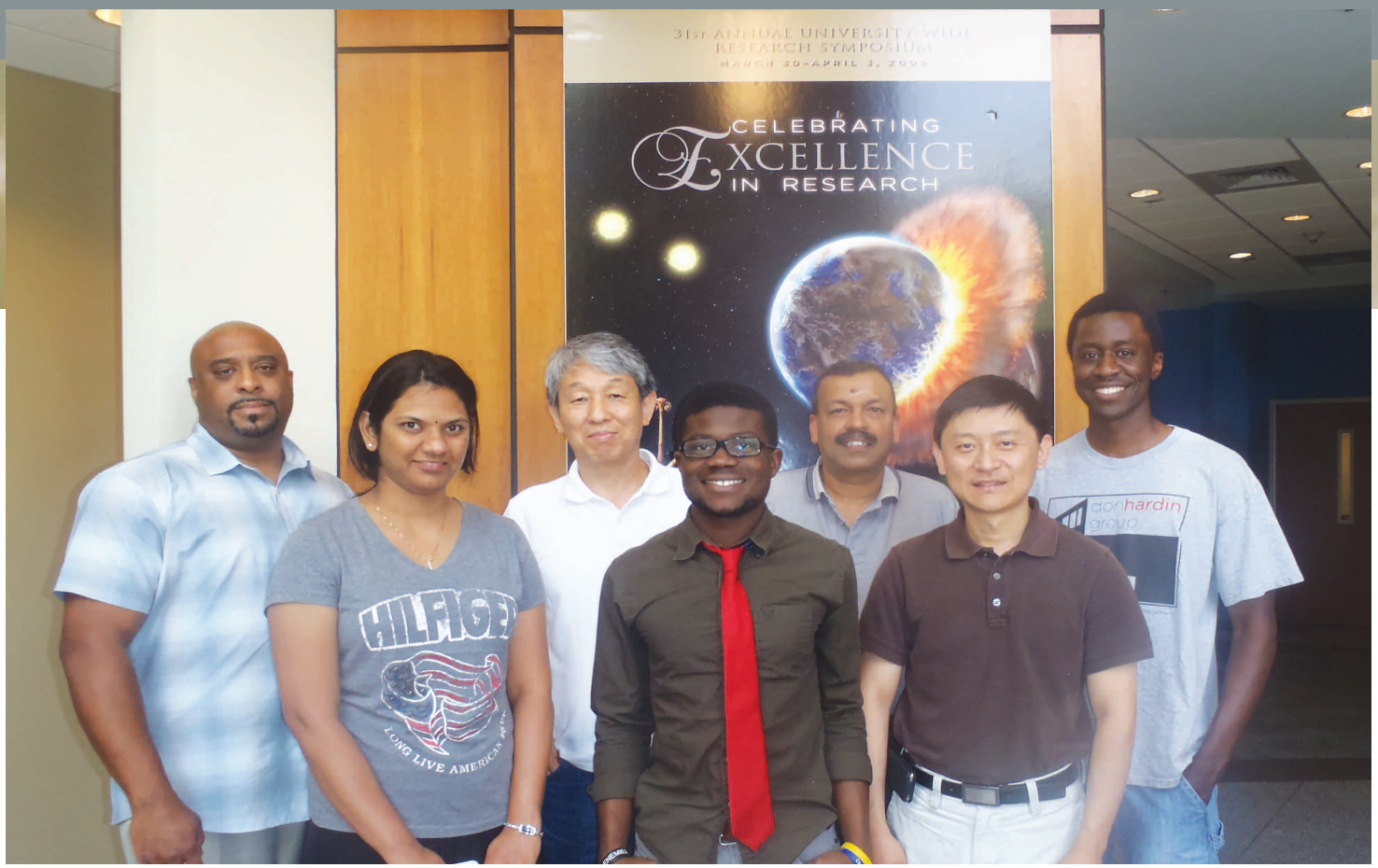
A New Protocol
of Networked Control Systems via Cloud Computing

LEE-HYUN KEEL, Ph.D.
PRINCIPAL INVESTIGATOR



When we set the thermostat in a building, we expect rooms to maintain a certain temperature regardless of the outside temperature. We achieve this through control systems. With control systems, we position and maintain a satellite at a precise location. In fact, control systems are everywhere around us. They are in our cars, airplanes, cell phones, and other electronic devices. For the past several years, control engineers have been facing new challenges that arise in control systems whose controllers, sensors, and actuators are connected through communication networks which we now refer to as networked control systems. As technologies in the computer and communication fields continue to advance, networked control systems will indeed become one of the most important engineering systems for decades to come.

A team of researchers, led by Dr. Lee-Hyun Keel (Professor, Department of Electrical and Computer Engineering) at Tennessee State University (TSU), engages in this state-of-the-art research. The United States Army Research Office recently awarded TSU $628,556 for the research to further expand networked control system technology by employing cloud computing to control structures. This research is beneficial to the United States Army due to its pressing concerns that many of the military applications and miniature agents (or vehicles) are disposable and thus inexpensive, yet these applications have limited capabilities. In this case, cloud-based computing can be an excellent solution to obtain necessary capacity

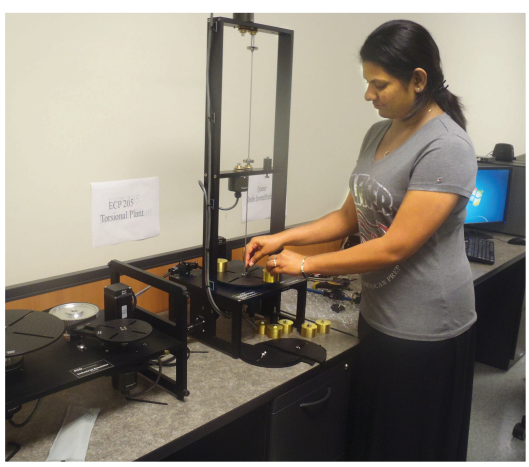


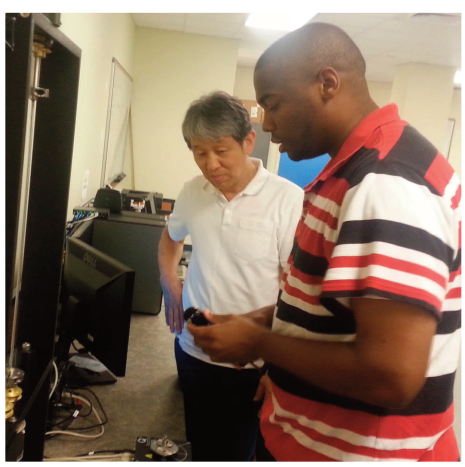
for computation and storage. The TSU team researches the development of a cloud-based wireless control system that resembles a typical networked control system, but its controller is located in the cloud. This controller is to uniquely manage sharing common network resources from a fixed hierarchical centralized system to a flexible distributed wireless network of intelligent sensors and actuators while maintaining guaranteed control performance.

Progressively, the research approach takes into account some of the most realistic problems, including drawbacks of wireless networks, such as unreliability of communication; communication link failures; noised data; and inaccuracy of models and data exchanged.

In previous related research, TSU students and researchers achieved results in stochastic control, switching systems, and graph theory through research awards from the United States Army Research Office and the National Science Foundation. Currently, those solutions are being applied to this cloud computing research.

In addition, the proposed research will significantly impact the establishment of a state-of-the art leading edge graduate research program at Tennessee State University. It will provide a unique opportunity for our students to engage in high level research and become prepared for our nation's technological needs.





Bioinformatics

Comes to Tennessee State University

TERRANCE JOHNSON, Ph.D.
PRINCIPAL INVESTIGATOR

The advent of the Human Genome Project (HGP) completed in 2003 stimulated the biology faculty at Tennessee State University to ensure that their students began to receive the most current training and exposure to an innovative academic and research program in bioinformatics that could possibly be offered.

Early deliberations in 2004 between Dr. Terrance Johnson (Professor and Department Head for Biological Sciences) and Dr. E. Lewis Myles (Professor of Biology) created the foundation for investigating the incorporation of bioinformatics into the biological sciences curriculum at Tennessee State University (TSU). Dr. Myles was given the charge to visit institutions with bioinformatics programs; and he began with a site visit to the University of Maryland and attendance at their professional workshop on bioinformatics. In 2006, individuals from the Carnegie Mellon University, Pittsburgh Supercomputing Center, better known as PSC visited Dr. Johnson in their efforts to recruit minority institutions and engage those institutions in PSC's bioinformatics project. Hence, the PSC and TSU relationship began for bioinformatics. Promptly, Dr. Johnson submitted a proposal and in 2008 he was granted leadership to establish a bioinformatics program in research and academics at Tennessee State University through a grant as a sub-award from PSC.

In an interview with Dr. Johnson, Principal Investigator, he shared his views on the past, present, and future of the bioinformatics program at TSU sponsored through the project, "Assisting Bioinformatics Efforts at Minority Institutions."

Martin: What was the focus of the bioinformatics project at TSU?
Johnson: Initially, there were two primary objectives for our program and they were to establish bioinformatics courses and curricula in our training programs at TSU and to establish bioinformatics research activities at TSU.

Martin: What has been the history on the funding for this project?
Johnson: We have been getting the sub-award from Carnegie Mellon, our first one was in 2008-2009 and we have received it every single year since that time. In the first year, we received $41,000 and each year thereafter, a range of $30,000 to $40,000. The approximate total to date has been $160,000 over the 5-year period and the most recent award was $30,288 for the period, February 1, 2013 – January 31, 2014.

Martin: Dr. Johnson, are you the sole principal investigator (PI)?
Johnson: Yes, I am the sole PI; however, there are four other faculty members who assist with the activities of the grant developing courses in order that we infuse this academic support into the curriculum. These faculty members are Drs. Heh Miao, Wei Chen, and Ali Sekmen from Computer Science, and Dr. Xiaofei Wang from the Department of Biological Sciences.

Martin: Dr. Johnson, specifically what is the role of the Computer Science faculty in this effort?
Johnson: The nature of bioinformatics itself is very much so computer driven. One category of the field of bioinformatics has to do with developing or improving algorithms that are used for conducting data analyses.

Martin: What other disciplines are benefiting from bioinformatics?
Johnson: Bioinformatics is important to the drug industry, especially in the field of pharmacology and pharmaceuticals. It is of extreme importance to the discipline of biology, especially in instances where people are asking some basic questions about evolutionary processes. One of the things where biology is experiencing grand excitement and interest in bioinformatics that is escalating is taking the whole genome of a person and by performing genome analyses; you can predict what genetic diseases to which the individual is pre-disposed. So some hospitals like M.D. Anderson in Houston,

Texas, now have an instrument what we call "Next Generation Gene Sequencing System."

We actually have a next generation sequence system at Tennessee State University. We are able to sequence the whole genome of an organism with the sequencer and then conduct genome comparisons using supercomputing capability. Thus, a lot of basic biological questions can be answered from conducting that type of analysis.

Martin: Dr. Johnson, what developments have occurred across the disciplines and in curricula since undertaking the bioinformatics project?

Johnson: In the Biology Department, we developed the graduate level course called Genomics and the undergraduate course called Bioinformatics.

In Computer Science, there was a course that was established called Introduction to Bioinformatics Computing. This course follows the basic computing class, a course already in place and a pre-requisite for the Bioinformatics concentration.

Martin: And is this the first time we have ventured any bioinformatics developments on campus?

Johnson: Under a different grant that was awarded to TSU about two years ago, the "Target Infusion Grant" led by Dr. Ali Sekmen (PI) for which I am the co-PI, that grant called for us to establish bioinformatics concentrations in our degree programs. The concentration in computer science has been established and we are working to establish a concentration in the biological sciences at the undergraduate level.

Now that is unique because I do not know of an undergraduate bioinformatics program residing in computer science or biology at an undergraduate training institution. Although bioinformatics programs exist at large research intensive institutions, they are primarily a graduate training type activity. We (TSU) have worked to design and build one that would expose our undergraduate students to that experience. That way, when our undergraduates gain experience in bioinformatics, they are advanced and highly marketable. This leads to landing positions at bio-tech companies or conducting research.

Martin: What has been the research perspective of bioinformatics at TSU?

Johnson: In 2007, I participated in the Bioinformatics Training Workshop in Pittsburg, preceded by Dr. Philip Ganter (Professor, Biology). Since that time, several of our faculty members from Biology, Agriculture and Computer Science within TSU, have received training at the PSC, including Drs. Korsi Dumenyo, Anthony Ejiofor, Phil Ganter, Brenda McAdory, Heh Miao, Ali Sekmen, Suping Zhou, Xiao Wang, and myself.

In the past, TSU Ph.D. students have been participating and have completed internships (including the workshop) at the PSC. This training directly impacted their ability to complete their Ph.D. dissertation research. These students include Carl Darris, Christianna Howard, and Sidney Trabue and James Tyus (workshop only). Most recently, Rhia Nelson, participated as a summer intern in 2013, and she is our first undergraduate to do so.

Martin: What does the future of bioinformatics appear to be for TSU?

Johnson: Overall, in my opinion, we have had a pretty positive impact on advancing bioinformatics research and training at TSU. Our next task involves focusing on additional funding to continue and maintain the support for this kind of activity.

We have come a long ways – garnering technology for a small institution, building academic curricula in bioinformatics, and expanding faculty capability and the knowledge base for our students in conducting bioinformatics research. I just think our future in bioinformatics and our future in biotechnology training and research is very strong here at TSU and we have been able to do well.

Awards and Submissions

Fiscal Year 2013

SUBMISSIONS by Center/College/School

Academic Affairs	$ 4,936,319
Agriculture, Human, and Natural Sciences	28,829,002
Business	40,000
Center for Service Learning	935
Education	60,000
Engineering, Technology, and Computer Science	4,300,096
Graduate Studies and Research	40,000
Health Sciences	2,249,608
Liberal Arts	51,507
Public Service and Urban Affairs	289,428
Research and Sponsored Programs	5,816,740
Student Affairs	183,000
Total	**$ 46,796,635**

SUBMISSIONS by Agency/Corporation/Foundation

4-H Council and Adobe Foundation	$ 15,924
American Association of Colleges and Universities	935
American Chemical Society PRF grants	129,946
Bill and Melinda Gates Foundation	200,000
NASA	43,800
National Science Foundation	16,795,133
North Dakota Soybean Council	40,736
Robert Wood Johnson Foundation	500,000
Substance Abuse and Mental Health Services Administration	3,000
Tennessee Board of Regents	829,166
Tennessee Department of Transportation	291,984
Tennessee Higher Education Commission	74,719
The Memorial Foundation	64,489
The National Society of Leadership and Success	2,800
TN Department of Commerce	23,500
TN Department of Health	55,000
Tree Research & Education Endowment Fund	10,000
U.S. Department of Agriculture - NIFA	17,214,572
U.S. Department of Education	2,434,118
U.S. Department of Energy	473,513
U.S. Department of Health and Human Services	4,331,675
U.S. Department of Housing and Urban Development	849,858
U.S. Department of Justice	1,624,608
U.S. Department of the Army	442,500
U.S. Department of Transportation	140,000
University of Dayton Research Institute	107,063
USAID	97,596
Total	**$46,796,635**

AWARDS by Center/College/School

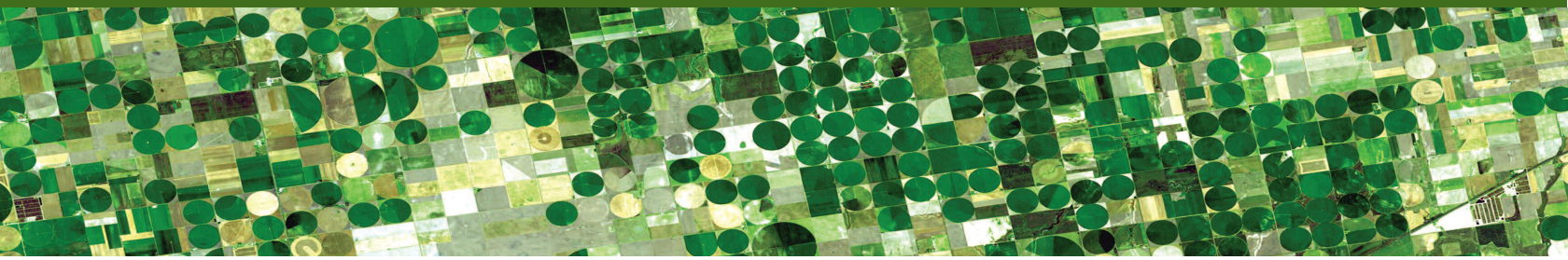
Academic Affairs (6)	$ 805,227
Agriculture (63)	12,962,852
Business (4)	326,068
COE - Information Systems (6)	1,129,319
COE- Learning Sciences (12)	6,137,531
Education (9)	735,511
Engineering (32)	2,525,785
Health Sciences (9)	609,954
Massie Chair (6)	756,671
President's Office (1)	10,000
Public Service and Urban Affairs (2)	67,000
Title III (25)	8,566,527
Total (175)	**$ 34,632,445**

AWARDS by Agency/Corporation/Foundation

National Aeronautics and Space Administration (5)	$ 224,225
National Institutes of Health (6)	1,222,704
National Nuclear Security Administration (1)	286,671
National Science Foundation (10)	1,015,468
Private (8)	472,722
Tennessee State Agencies (14)	1,309,021
U.S. Air Force (4)	416,110
U.S. Army Research Office (7)	1,185,191
U.S. Department of Agriculture (53)	11,116,223
U.S. Department of Defense (2)	21,436
U.S. Department of Education (37)	10,396,403
U.S. Department of Energy (5)	583,337
U.S. Department of Health and Human Services (15)	5,917,334
U.S. Department of the Interior (1)	10,000
U.S. Department of Labor (1)	75,000
U.S. Navy (1)	150,000
U.S. Nuclear Regulatory Commission (2)	40,000
U.S. Department of Transportation (3)	190,600
Total (175)	**$ 34,632,445**

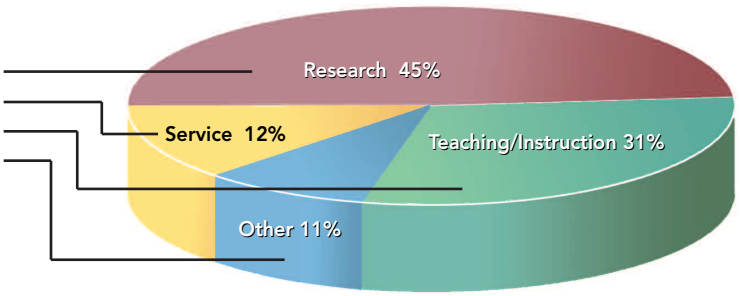
Awards and Submissions

Fiscal Year 2013



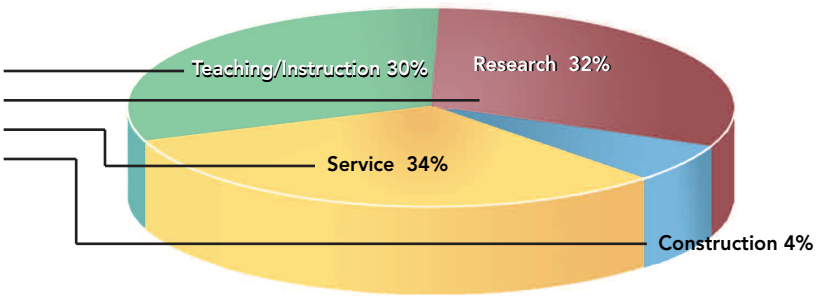
SUBMISSIONS BY PROJECT TYPE

Research	$21,242,887
Service	5,641,505
Teaching/Instruction	14,578,447
Other	5,333,796
TOTAL	**$46,796,635**



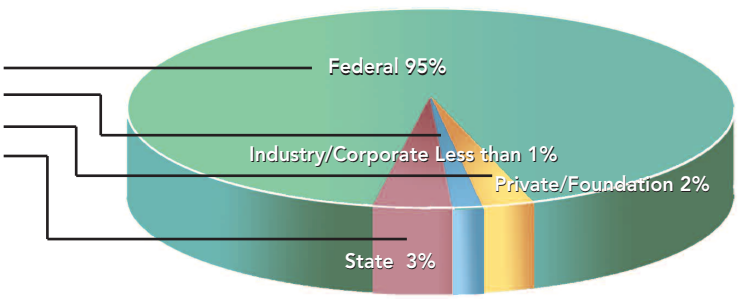
AWARDS BY PROJECT TYPE

Teaching/Instruction	$10,556,344 (55)
Research	11,100,301 (69)
Service	11,675,800 (50)
Construction	1,300,000 (1)
TOTAL	**$34,632,445 (175)**



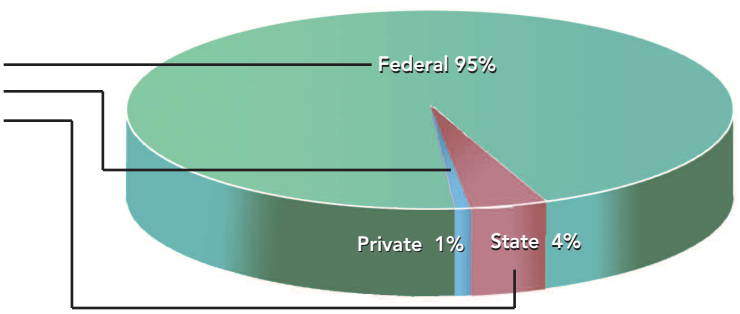
SUBMISSIONS BY SOURCE

Federal	$44,447,373
Industry/Corporate	107,063
Private/Foundation	967,830
State	1,274,369
TOTAL	**$46,796,635**



AWARDS BY SOURCE

Federal	$32,850,702 (153)
Private	472,722 (8)
State	1,309,021 (14)
TOTAL	**$34,632,445 (175)**



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