What is an I/UCRC?

- A National Science Foundation program
- Designed to link the research and development needs of industry with university research capabilities.
- There are more than 75 I-UCRC's across US
Goals of an I/UCRC

- Long-term industry/university relations
- Increased support for research
- Leveraging of company funds
- Focus on industry research needs
- Graduate student involvement
- Cost-sharing of major research projects by members with common technology interests

NCSS Center Overview

- **Mission**
  - A primary source for fundamental research for the modeling, analysis, design, implementation, verification and validation, testing, deployment, and evolution of *Cloud-based and net-centric* software and systems.

- **History**
  - Started in 2007 as an idea for a research consortium among DFW universities
  - Explored different options and finally decided to form an NSF IUCRC

- **Creation**
  - NCSS I/UCRC formally established in early 2009
  - Current Academic Partners
    - University of North Texas (UNT)
    - Southern Methodist University (SMU)
    - University of Texas at Dallas (UTD)
    - Arizona State University (ASU)
    - Missouri University of Science and Technology (MUST) joined in 2012 but dropped out in 2016
  - Industrial Partners
    - Each partner contributes $35K annual membership (a different membership for small businesses)
      - Multiple memberships permitted
      - At least 3 memberships required for each university and a minimum of $175K per year
      - At least 2 universities required to form an I/UCRC
Director's Report

NCSS I/UCRC Development Timeline

- NSF Net-Centric I/UCRC approved with UNT as lead, UTD as a site and SMU as an affiliated site
- February 2009
- Kickoff meeting in Dallas April 2009
- ASU becomes a site August 2009
- MST becomes a site August 2012
- ASU becomes Phase II site in Aug 2015
- MST drops out in late 2014
- New NSF program guidelines (late 2016)
- UNT and UTD receive approval as Phase II UCRC in March 2018
- October 2016 Meeting at UNT
- April 2017 Meeting at UTD
- October 2017 Meeting at UNT
- April 2018 Meeting at ASU
- June-Aug 2018 Phase III proposal
- October 2018 Meeting (Final?)

Our Net-centric and Cloud (NCSS) I/UCRC

Combined totals for all sites since 2009 through October 2017

- Total Industrial Memberships raised >$4,505,000
- Other funds leveraged (including NSF) >$5,150,000
- Total publications >240
- Publications with industrial partners >50
- Patents filed or received 9
- Total number of students that participated >150
- Women and minority students involved >65
- Number of PhDs graduated 36
- Number of MSs graduated 77
- Number of BSs graduated 53
- Graduates employed by member companies 45
- Total number of faculty involved > 25
- Number of women faculty involved 10
Value Proposition

- Access to university experts in the net-centric and cloud domains: 4 major universities with combined Center research budget of $1M (UNT, UTD, ASU, MST, and SMU)
- Substantially reduced overhead costs compared to using in-house resources
- Demonstrated competencies in net-centric and cloud systems
- Host to over 100 research projects across 20 companies in the past 5 years (now in 2nd 5-year phase of operation)
- High approval ratings from industry members for management of Center operations and practices
- Selected as the 2012 Tech Titan of the Future at the university-level by the (DFW) Metroplex Technology Business Council (MTBC)

Value Proposition (2 of 2)

Outcomes from a cooperatively defined and managed portfolio of industry-precompetitive fundamental research.

- High value research projects
- Investment leveraging
- Sector networking, learning from industry peers and customers
- Access to intellectual property
- Pre-publication access to research
- Center researchers and facilities
- Access to students
- New research and education program dimensions
- Leverage proof of concept results for new funding
- Trusted relationships with industry
- Ready partners for translation of discoveries
- Student recruitment and placement
- Organize industry sector relationships
- Means to achieve institutional mission
Competencies and Capabilities

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net-Centric Solutions</td>
<td>Web Services, Cloud Computing, QoS, Quality Improvement, SoS Integration</td>
</tr>
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<td>Software Engineering</td>
<td>Testing, Safety, Performance, Verification</td>
</tr>
<tr>
<td>Information Assurance</td>
<td>Intrusion Detection, Access Control, Data Security, Threat Assessment, Trusted Hardware</td>
</tr>
<tr>
<td>Signal Processing</td>
<td>Video Analytics, Image Processing, Wireless Comm, Kinesiology</td>
</tr>
<tr>
<td>Big Data</td>
<td>Analysis, Visualization</td>
</tr>
<tr>
<td>Next-Generation Network</td>
<td>QoS, Software Defined Networking</td>
</tr>
</tbody>
</table>

How the Center Works

- Supported principally by industry memberships
- NSF funding offsets administrative costs
  - Every membership dollar goes into research
- Projects are proposed either by industry members or university faculty
- Industry Advisory Board is comprised of reps from each member company and IAB meets semi-annually
- IAB evaluates and selects projects to be funded
- Projects may leverage funds from other sources
- $35K annual industry membership fee
  - Different membership level for Small Businesses is available
I/UCRC Membership Agreement

- Annual membership fee structure
- Patent rights are normally held by the university with royalty free, non-exclusive rights to center members
  - NSF-preferred model
  - Encourages multi-university and multi-sponsor collaboration
  - Notwithstanding, a sponsor also has the option to seek exclusive access to intellectual property produced by a project they sponsor
- Publication delay policy gives industry sponsors final approval on the content of information released in technical papers

Academic and Industry Membership

Some Former Companies
Boeing, CISCO,
Lockheed Martin Aero
Other divisions of Raytheon
other small companies

Other companies
Ashum, Futurewei, Nwave, Aperio DSP, and PSG
Join us as an Industrial Member today!
And help us recruit new members

For more information: netcentric.unt.edu

krishna.kavi@unt.edu
melanie.dewey@unt.edu
Net-Centric Cloud Software and Systems I/UCRC

Dynamic Multi-Group Secure Data Sharing Scheme for Cloud

Project Lead: Sanjay Madria, Missouri S & T
Date: October 11, 2017
Problem Statement

- Why is this research needed?
  - Cloud cannot be fully trusted to act honestly; it can alter or expose some sensitive data to the revoked users or to some other adversaries.
  - Secure data sharing has become more important than ever before as privacy of big data sharing via cloud is needed.
  - Fine-grained access control on shared data is also desirable since different members of the group can have different levels of privileges.
  - Security and confidentiality of the shared files should be maintained in such group membership change event without causing too much overhead.

- What is the specific problem to be solved?
  - Develop a cryptographic scheme that can provide an effective solution for secure data sharing in a dynamic multi-group setting.
  - Group level data isolation so that data shared in one group should not be accessed by the members of another group.
  - Current users do not need to change their secret keys when an existing user leaves a group or new user joins in.
Project Description

› How will this project approach the problem?
  - We first construct a new flexible ciphertext-policy attribute-based encryption (CP-ABE) scheme called Flex-CPABE by utilizing Brethen’s original CP-ABE scheme and TGDH (Tree-based Group Diffie-Hellman) protocol as fundamental building blocks.
  - Using Flex-CPABE scheme, we build DMG-SDS - a dynamic multi-group secure data sharing scheme for cloud.

› Preliminary results from this or previous projects:
  - We have developed access control using cloud in our earlier work in 2015, which has motivated this problem.
  - Some basic building blocks have been designed and currently alternatives are being studied.
Project Pictorial
### Connection to NCSS Competencies/Capabilities

<table>
<thead>
<tr>
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<td>Cloud Computing</td>
</tr>
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<td>Quality Improvement</td>
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<td>SoS Integration</td>
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<td>Big Data</td>
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<tr>
<td>Next Generation Network</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mem/Proc Optimization</td>
<td>QoS</td>
</tr>
<tr>
<td>Hardware Design</td>
<td>Power Management</td>
</tr>
<tr>
<td>Testing</td>
<td>Wireless Devices</td>
</tr>
<tr>
<td>Safety</td>
<td>Network Processors</td>
</tr>
<tr>
<td>Performance</td>
<td></td>
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<tr>
<td>Verification</td>
<td></td>
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<tr>
<td>Intrusion Detection</td>
<td></td>
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<tr>
<td>Access Control</td>
<td></td>
</tr>
<tr>
<td>Data Security</td>
<td>Threat Assessment</td>
</tr>
<tr>
<td>Video Analytics</td>
<td>Trusted Hardware</td>
</tr>
<tr>
<td>Image Processing</td>
<td></td>
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<tr>
<td>Wireless Comms</td>
<td></td>
</tr>
<tr>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>Visualization</td>
<td></td>
</tr>
<tr>
<td>QoS</td>
<td></td>
</tr>
<tr>
<td>Software Defined Networking</td>
<td></td>
</tr>
</tbody>
</table>

1=Primary, 2=Secondary, 3=Tertiary
## Statement of Work

Work to be performed, timeline, and budget for 5 most significant tasks.

<table>
<thead>
<tr>
<th>Task</th>
<th>K$</th>
<th>Start Date</th>
<th>End Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>July 2017</td>
<td>Aug 2017</td>
<td>Survey of the work in the area of group security</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Sept 2017</td>
<td>Nov 2017</td>
<td>Scheme design and other alternatives</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Dec 2017</td>
<td>Feb 2017</td>
<td>Analysis, implementation, and initial experiments</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>March 2017</td>
<td>May 2017</td>
<td>Security proofs, and experiments</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>June 2017</td>
<td>July 2017</td>
<td>Technical writing and presentation of results</td>
</tr>
</tbody>
</table>
## Deliverables

Summary of 3 most significant deliverables expected at end of Year 1.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Algorithm design</td>
</tr>
<tr>
<td>2</td>
<td>Analysis and security proofs</td>
</tr>
<tr>
<td>3</td>
<td>Experiments and evaluations of the scheme using Cloud environment</td>
</tr>
</tbody>
</table>
Project Differentiators

› What results does this project seek that are different (better) than others?
  - There are no previous works that specifically address secure data sharing in the multi-group setting.
  - None provide provide a flexible and scalable solution for the multi-group setting
  - Evaluation and experimental evaluations to show the feasibility and effectiveness of the solution

› What specific innovations or insights are sought by this research that distinguish it from related work?
  - Design of the algorithm which operates with little overhead and can handle large number of groups
  - Correctness proof to guarantee security in a multi-group setting
  - Real cloud implementation of the algorithm to evaluate the performance
Potential Member Company Benefits

› What specific benefits are sought for the industry members?
  – There are no previous works that specifically address secure data sharing in the multi-group setting.
  – Our framework can be utilized by small, medium and large corporations with an interest in creating private or hybrid cloud systems or migrating to public Cloud systems, to assess the potential security threats and risk levels.

› What leverage does the research provide to industry member R&D plans?
  – Security solutions can be applied in other settings like IoT and Cyber-physical systems domain
  – The cloud framework can be expanded into a web-service, leading to commercialization of the service.
Sponsorship and Collaboration

› Efforts to involve multiple companies in project sponsorship:
  – Looking for feedback and opportunities for collaboration

› Efforts to involve multiple university collaborators in the project:
  – Looking for the collaboration with other universities on cloud or IoT security involving multiple groups
# Project Quality Attributes

PI’s assessment of extent to which project demonstrates each QA.

**Scale:**
- 5=To a LARGE extent
- 4=To a MODERATE extent
- 3=To SOME extent
- 2=To LITTLE extent
- 1=Not at All
- 0=Unrated

<table>
<thead>
<tr>
<th>QA</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment w/Competencies</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Sponsor-acknowledged Leverage for R&amp;D</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Multi-company Sponsorship</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Multi-PI Collaboration</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Compliance with NSF Operations Requirements</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Objective Deliverables</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Innovation &amp; Technology Evolution</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Potential for Derivative Services</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Commercialization Opportunities</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Past Performance</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Net-Centric Cloud Software and Systems I/UCRC

Solar Array Analytics and Optimization using Vision and Machine Learning

Project Lead: Andreas Spanias and Cihan Tepedelenlioglu, ASU
Date: October 11, 2017
Problem Statement

 › Why is this research needed?
   › Optimize performance of Solar arrays
   › Fault Detection

 › What is the specific problem to be solved?
   › Track cloud movement, predict panel shading and change connections to optimize output power;
   › Use machine learning to detect faults;
   › Experimental and simulation work to validate algorithms;
Project Description

› How will this project approach the problem?
  - Examine I-V curves and detect deviation from maximum power point
  - Use video tracking algorithms to predict shading

› Preliminary results from this or previous projects:
  - Simulations with Euclidian distance showed potential for detecting faults
  - Machine learning could be used to better estimate faults
Solar Array Monitoring Concept - Simulations

Figure 3. Improvement of array output under shading by changing the array topology. Example taken from [2].

Figure 6. I-V Curves and fault detection (from [2]).
Connection to NCSS Competencies/Capabilities

- Net-Centric Solutions
- Next Gen HW and Tools
- Software Engineering
- Information Assurance
- Signal Processing
- Big Data
- Next Generation Network

**Competencies**

- Web Services
- Cloud Computing
- QoS
- Quality Improvement
- SoS Integration
- Memory/Proc Optimization
- Hardware Design
- Power Management
- Wireless Devices
- Network Processors
- Testing
- Safety
- Performance
- Verification
- Intrusion Detection
- Access Control
- Data Security
- Threat Assessment
- Trusted Hardware
- Video Analytics
- Image Processing
- Wireless Comms
- Kinesiology
- Analysis
- Visualization
- QoS
- Software Defined Networking

**Capabilities**

1=Primary, 2=Secondary, 3=Tertiary
**Statement of Work**

Work to be performed, timeline, and budget for 4 most significant tasks.

<table>
<thead>
<tr>
<th>Task#</th>
<th>Description</th>
<th>Budget</th>
<th>Deliverable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task-1</td>
<td>Develop electronics and software for a new SMD</td>
<td>$15K (6 mos)</td>
<td>SMD prototype design and report.</td>
</tr>
<tr>
<td>Task-2</td>
<td>Develop algorithms for imaging and cloud movement prediction.</td>
<td>$20K (6 mos)</td>
<td>Algorithms and software running on PC</td>
</tr>
<tr>
<td>Task-3</td>
<td>Install Prototype on MTW Facility</td>
<td>25k (9 mos)</td>
<td>Report on analytics and on prospects for optimizing power output with different shading conditions.</td>
</tr>
<tr>
<td>Task-4</td>
<td>Characterize all algorithms.</td>
<td>$10K (3 mos)</td>
<td>Final Report</td>
</tr>
</tbody>
</table>
Project Differentiators

› What results does this project seek that are different (better) than others?
  – Competitive technology is micro inverters (analytics on AC side are available)
  – Cloud movement prediction can be used to optimize connection topology
  – Machine learning to estimate faults and by pass faulty panels

› At specific innovations or insights are sought by this research that distinguish it from related work?
  – Machine Learning fault detection
  – Cloud motion estimation using sky cameras and features
  – Camera can be used to detect soiling
Potential Member Company Benefits

How this Project is Different from Related Work:

What results does this project seek that are different (better) than others?
What specific innovations or insights are sought by this research that distinguish it from related work? (identify the related work)

The project is multidisciplinary and uses advanced signal processing for energy and sustainability applications. The SMD design will be unique and will help industry develop new standards for development of solar PV. Byproducts include software implementation for secure access.

Potential Member Company Benefits:

What specific benefits are sought for the industry members?
What leverage does the research provide to industry member R&D plans? (identify interested members)

The algorithms and hardware will be useful for engagement of three company members, namely, Poundra, PSG and possibly Aperio DSP.
Sponsorship and Collaboration

› Efforts to involve multiple companies in project sponsorship:
  ‒ NXP (new sensor technology)
  ‒ Poundra
  ‒ Energy as IoT

› Efforts to involve multiple university collaborators in the project:
  ‒ UTD potentially on machine learning
  ‒ Tech de Monterrey (international partner)
### Project Quality Attributes

PI’s assessment of extent to which project demonstrates each QA.

<table>
<thead>
<tr>
<th>To what extent does the project demonstrate each Quality Attribute?</th>
<th>Rating</th>
<th>Comments (Required if Rating &lt; 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment with Center Competencies</td>
<td>4</td>
<td>Machine learning, signal processing, sensors</td>
</tr>
<tr>
<td>Sponsor-acknowledged Leverage to R&amp;D</td>
<td>4</td>
<td>Machine learning algorithms and associated sensor electronics important to NXP.</td>
</tr>
<tr>
<td>Multi-company Sponsorship</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Multi-university Collaboration</td>
<td>2</td>
<td>We will explore with UTD.</td>
</tr>
<tr>
<td>Compliance with NSF Operations Requirements</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Objective Deliverables</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Innovation &amp; Technology Evolution</td>
<td>3</td>
<td>With additional funding the technology can have important IP.</td>
</tr>
<tr>
<td>Potential for Derivative Services</td>
<td>4</td>
<td>Machine Learning Algorithms can be of use to other members</td>
</tr>
<tr>
<td>Commercialization Opportunities</td>
<td>3</td>
<td>.</td>
</tr>
<tr>
<td>Past Performance</td>
<td>4</td>
<td>Publications and monograph</td>
</tr>
</tbody>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

Secure Information Sharing in IoT Systems (UTD-2017-10-1)

Project Lead: Dr. I-Ling Yen, UTD
Date: October 11, 2017
Problem Statement

› Why is this research needed?
  – Growth of IoT
  – Security for IoT has not caught up with IoT growth

› What is the specific problem to be solved?
  – Security problems
    › Faulty device ⇒ Redundancy
    › Attack vulnerability ⇒ Improve the development process, use immutable code base
    › Communication ⇒ Encryption
    › Illegitimate access and information flow (due to access control loopholes or attacks)
      – Access the information of the device, issue control commands to the device, update the code on the device
      ⇒ How to assure effective access control with limited device capabilities
  – Untrustable information
    – Can the information from another party (device or other entities in the system) be trusted?
    ⇒ How to efficiently and effectively perform data provenance on resource constrained devices?
Project Description

› How will this project approach the problem?
  - Consider dynamic IoT
  - Consider relative role-based access control
    › Because in a dynamic IoT network, it is impossible to have a federated role hierarchy to understand the roles of other nodes in the nearby area
    › Access control policies, data provenance, trust establishment ... should all be based on the relative role hierarchy

› Preliminary results from this or previous projects:
  - Integrated data provenance and information flow control techniques
  - Fine-grained data provenance
  - Semi-automated key update protocol
Static IoT systems

Dynamic IoT systems

Smart car coordination ⇒ Dynamically form vehicle network

Hit and run ⇒ Report to police
(1 minute ago, a red car with ...)
Dynamically form camera and processing network
(from road side and vehicles on road,
1 minute driving range from accident)
Identify and track suspect cars

Some one drowns at the sea shore
Gather nearby devices with sensors to locate the person.
Get nearby boats and people to rescue
Project Pictorial

Static IoT systems

Known IoT devices and communication links (may change due to failure or new config.)
⇒ Security can be managed statically
  • Statically decide access control policies for known nodes (and their roles)
  • Each node can have pre-assigned keying materials

Dynamic IoT systems

Dynamically formed IoT network (may change continuously)
⇒
  • How to know who can communicate with who
  • How to decide the access control and information flow control policies for the neighboring nodes
  • How to decide the trustworthiness of information coming from neighboring nodes directly or indirectly
Access control infrastructure for Dynamic IoT

**Identity management**
- Relative role based access control
  - Absolute + Relative roles
  - E.g., Police, friend, same community, ...
- Trust establishment
  - Based on relative roles and trust history

**Protocol for access control**
- X enters a region ⇒ Contact local CA
- Local CA gets transferred trust info about X from parent
- Local CA constructs relative roles for X with other IoT units in the region (this info needs to be updated periodically)
- Access control policies of individual nodes are defined based on relative roles and environment parameters
  - E.g., looser access control level for an emergency

**Secure communication channel establishment**
- Local CA provides additional keying material for X and Y if X and Y are allowed to communicate
- X and Y establish secure communication channels using their own and CA offered keying materials

**Data provenance**
- Trust of data is derived with provenance info
- The role in each provenance record should be mapped to relative roles and the trust of it may be adjusted accordingly

**Security of the CAs**
- Trustworthiness of the CAs can be a problem
  - Verification by multiple CAs
  - IoT nodes can randomly select to contact higher level CAs for verification
### Connection to NCSS Competencies/Capabilities

#### Competencies
- Net-Centric Solutions
- Next Gen HW and Tools
- Software Engineering
- Information Assurance
- Signal Processing
- Big Data
- Next Generation Network

#### Capabilities
- Web Services
- Cloud Computing
- QoS
- Quality Improvement
- SoS Integration
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- Data Security
- Threat Assessment
- Trusted Hardware
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- Image Processing
- Wireless Comms
- Kinesiology
- Analysis
- Visualization
- QoS
- Software Defined Networking

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Statement of Work
Work to be performed, timeline, and budget for 5 most significant tasks.

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<th>K$</th>
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<th>End Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>Oct 2017</td>
<td>Sep 2018</td>
<td>Integrated access control and data provenance infrastructure for IoT systems</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>Oct 2017</td>
<td>Sep 2018</td>
<td>Role-based trust establishment and certificate validation protocol</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>Oct 2017</td>
<td>Sep 2018</td>
<td>Automated key renewal and sync with Certificate Authority</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td></td>
<td></td>
<td>Prototype system for concept validation and evaluation</td>
</tr>
</tbody>
</table>
Deliverables
Summary of 3 most significant deliverables expected at end of Year 1.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Documents discussing the infrastructure design of the secure IoT system</td>
</tr>
<tr>
<td>2</td>
<td>Prototype system for fine-grained data provenance and information flow control</td>
</tr>
</tbody>
</table>
Project Differentiators

› **What results does this project seek that are different (better) than others?**
  
  – The access control schemes in sensor networks can be used for IoT system; however, these schemes only consider how to generate secure communication keys among the things that are authorized to communicate, do not consider how to decide which things are authorized to communicate

  ⇒ We consider how to validate access control policies before IoT nodes are allowed to establish secure communication channels

  – Current access control infrastructures do not offer good identity management solutions for IoT systems + In dynamic IoT systems, the interacting IoT groups keep on changing, which implies much more complex policies and access validation procedures + information flow issues

  ⇒ We propose a relative role-based protocol for access policy specification and enforcement

› **What specific innovations or insights are sought by this research that distinguish it from related work?**
  
  – Resolve the problems that have not been addressed in the literature
Potential Member Company Benefits

› **What specific benefits are sought for the industry members?**
  - Our technology can be used by our industrial members to enhance the security of IoT application systems
  - Our data provenance technology can be used by our industrial members to enhance the collaboration of IoT things (being able to analyze the trustability of information from other IoT things)

› **What leverage does the research provide to industry member R&D plans?**
  - Our security and data provenance technology for IoT systems can be adapted to other application systems for security enhancement
Sponsorship and Collaboration

› **Efforts to involve multiple companies in project sponsorship:**
  - Due to the importance of the research, many companies dealing with emerging Smart City, Smart Transportation, and other IoT applications may be interested in this research
    › We have met representatives from several companies to discuss the security issues
    › The monthly meetings and other events will provide opportunities for exploring potential interest in this research project

› **Efforts to involve multiple university collaborators in the project:**
  - Security and provenance research is very important for net-centric and cloud computing systems and requires diverse expertises
    › Collaboration among researchers from ASU, UNT, and UTD will be beneficial
    › The PI will also explore the opportunities in collaborating with researchers from other NSF I/UCRCs
## Project Quality Attributes

PI’s assessment of extent to which project demonstrates each QA.

<table>
<thead>
<tr>
<th>QA</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment w/Competencies</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Sponsor-acknowledged Leverage for R&amp;D</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Multi-company Sponsorship</td>
<td>3</td>
<td>IoT security is highly critical to IoT developers</td>
</tr>
<tr>
<td>Multi-PI Collaboration</td>
<td>5</td>
<td>Exploring collaboration with PIs from other universities</td>
</tr>
<tr>
<td>Compliance with NSF Operations Requirements</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Objective Deliverables</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Innovation &amp; Technology Evolution</td>
<td>5</td>
<td>The technology can lead to deployment of secure IoT systems</td>
</tr>
<tr>
<td>Potential for Derivative Services</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Commercialization Opportunities</td>
<td>4</td>
<td>Good potential for IoT developing companies</td>
</tr>
<tr>
<td>Past Performance</td>
<td>5</td>
<td>Publications, invited talks, IoT industry events</td>
</tr>
</tbody>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

Semantic-Based Learning and Control of Autonomous Vehicles (UTD-2017-10-2)

Project Lead: Dr. Farokh Bastani and Dr. I-Ling Yen, UTD
Date: October 11, 2017
Problem Statement

› **Why is this research needed?**
  - Autonomous vehicle (AV) is currently being widely studied
    › Most of the current AV research focuses on image processing
  - Control and communication of AV still require further research
    › Need to consider autonomous mixed with human drivers
      – AV’s cautious driving may, on the contrary, cause accidents
      – E.g., Google car accidents
    › Communication in AV network may help improve control decisions

› **What is the specific problem to be solved?**
  - Use learning technologies to learn critical AV control decisions from human drivers
  - Use semantic information to enhance the learning effect
Project Description

› How will this project approach the problem?
  - Define a semantic model to represent the AV related knowledge
    › Use the perception model as the basis and enhance it with additional semantic information
    › Examples
      - Driving control in regular, rainy, snowy, foggy, ... environments may vary
      - Driving control in a school zone, the mountainous area, ... may differ
        › May have children, animals, ... come to the road suddenly
      - Knowledge to be exchanged may differ for different situations
    - Develop semantic based learning techniques for AV control
      › What to learn: driving control parameters + object motion prediction
    - Build a simple simulation environment for evaluation

› Preliminary results from this or previous projects:
  - Developed a preliminary semantic model
  - Investigated control decision making algorithms
Project Pictorial

Warn the overtaking car about the coming cars in the opposite lane

Warn about on the curly road

Use semantic data to help decide:
- What info to send
- When to communicate
- Who to communicate with

Side view
Fuse videos from
⇒ Warn about
Semantic model for AV
- Environment (road segment and surroundings)
  - Has objects, each object has an object class
  - Each object class describes the common characteristics
- Situation (impacts control and communication)
  - Critical categories based on distinct control/commu. Patterns
- Detailed description to help in enhancing the knowledge
- Vehicle components
- Sensing, control, communication components
Project Pictorial

Vehicular Cloud VC

Object motion prediction functions
Vehicle Driving Parameter Derivations

Download rules, filtered by environment/object/vehicle parameters

Basic Compute with semantic info of V (BV)
Basic Compute with semantic info of VC (BVC)
Compute by rules with semantic info of VC (LVC)

⇒ Driving control parameter settings for V
## Connection to NCSS Competencies/Capabilities

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net-Centric Solutions</td>
<td>Web Services</td>
</tr>
<tr>
<td></td>
<td>Cloud Computing</td>
</tr>
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<td></td>
<td>QoS</td>
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<tr>
<td>Next Gen HW and Tools</td>
<td></td>
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<tr>
<td></td>
<td>Memory/Proc Optimization</td>
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<td></td>
<td>Hardware Design</td>
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<td>Power Management</td>
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<td></td>
<td>Wireless Devices</td>
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<td>Network Processors</td>
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<tr>
<td>Software Engineering</td>
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<tr>
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<td>Testing</td>
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<td>Safety (1)</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
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<td>Verification</td>
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<td>Information Assurance</td>
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<td>Intrusion Detection</td>
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<td></td>
<td>Access Control</td>
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<td></td>
<td>Data Security</td>
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<td></td>
<td>Threat Assessment</td>
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<td></td>
<td>Trusted Hardware</td>
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<td>Signal Processing</td>
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<td>Video Analytics</td>
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<tr>
<td></td>
<td>Image Processing</td>
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<tr>
<td></td>
<td>Wireless (2)</td>
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<tr>
<td></td>
<td>Kinesiology</td>
</tr>
<tr>
<td>Big Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analysis (3)</td>
</tr>
<tr>
<td></td>
<td>Visualization</td>
</tr>
<tr>
<td>Next Generation Network</td>
<td>QoS</td>
</tr>
<tr>
<td></td>
<td>Software Defined Networking</td>
</tr>
</tbody>
</table>

\( ^1 = \text{Primary}, \ ^2 = \text{Secondary}, \ ^3 = \text{Tertiary} \)
Statement of Work
Work to be performed, timeline, and budget for 5 most significant tasks.

<table>
<thead>
<tr>
<th>Task</th>
<th>K$</th>
<th>Start Date</th>
<th>End Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>Oct 2017</td>
<td>Dec 2017</td>
<td>Semantic models for most effective knowledge representation in the smart vehicle application domain</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>Oct 2017</td>
<td>Mar 2018</td>
<td>Rule based AV control algorithms enhanced by semantic information</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>Oct 2017</td>
<td>Sep 2018</td>
<td>Semantic based learning for AV control (partial)</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Future</td>
<td></td>
<td>Semantic based AV communication</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>Oct 2017</td>
<td>Sep 2018</td>
<td>Experimental evaluation of the semantic based approach (partial)</td>
</tr>
</tbody>
</table>
Deliverables
Summary of 3 most significant deliverables expected at end of Year 1.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A document discussing the semantic model and their application in example scenarios.</td>
</tr>
<tr>
<td>2</td>
<td>A document discussing the basic algorithms and rules for AV control parameter derivation</td>
</tr>
<tr>
<td>3</td>
<td>A document discussing the semantic based learning algorithms for AV control and preliminary evaluation results</td>
</tr>
</tbody>
</table>
Project Differentiators

› What results does this project seek that are different (better) than others?
  - Most of the current AV research focuses on image processing
  - Current AV driving control decisions are mainly based on the perception model built by the local sensors, without the consideration of deeper semantic information or communication

› What specific innovations or insights are sought by this research that distinguish it from related work?
  - The semantic model helps separate high level semantics from low level sensor data and facilitates upper level operations, such as communication, control, prediction, learning, etc.
  - We also propose to develop semantic-based learning techniques to support AV control, changing environment prediction, etc.
  - We consider learning and evolution of the control rules based on the learning results
Potential Member Company Benefits

› What specific benefits are sought for the industry members?
  - Our research results can be used by our industrial members to enhance autonomous driving technologies
  - The semantic-based learning methods can be extended to other application domains

› What leverage does the research provide to industry member R&D plans?
  - This research will improve the decision process of the AVs via semantic-based learning of AV control and semantic-based communication
Sponsorship and Collaboration

› **Efforts to involve multiple companies in project sponsorship:**
  - Due to the importance of the research, many companies dealing with autonomous control (vehicles and robots) may be interested in this research
    ‣ We are actively participating in various events (AV/IoT Conferences, Tech Titans IoT Forum, etc.) to discuss our ideas and explore potential collaboration

› **Efforts to involve multiple university collaborators in the project:**
  - This research is important for net-centric and cloud computing systems and requires multi-disciplinary expertise
    ‣ Collaboration among researchers from ASU, UNT, and UTD
    ‣ The PI will also explore the opportunities in collaborating with researchers from other NSF I/UCRCs
# Project Quality Attributes

PI’s assessment of extent to which project demonstrates each QA.

<table>
<thead>
<tr>
<th>QA</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment w/Competencies</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Sponsor-acknowledged Leverage for R&amp;D</td>
<td>4</td>
<td>Discussed with members from research division of potential sponsor</td>
</tr>
<tr>
<td>Multi-company Sponsorship</td>
<td>3</td>
<td>IoT encompasses technologies that are of interest to our members</td>
</tr>
<tr>
<td>Multi-PI Collaboration</td>
<td>5</td>
<td>Exploring collaboration with PIs from other sites of our NSF I/UCRC</td>
</tr>
<tr>
<td>Compliance with NSF Operations Requirements</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Objective Deliverables</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Innovation &amp; Technology Evolution</td>
<td>5</td>
<td>The technology can lead to deployment of high quality Smart Vehicle and Smart Transportation systems</td>
</tr>
<tr>
<td>Potential for Derivative Services</td>
<td>3</td>
<td>High quality communication and highly dependable inter-vehicle coordination method</td>
</tr>
<tr>
<td>Commercialization Opportunities</td>
<td>5</td>
<td>Good potential for IoT communication and computing products</td>
</tr>
<tr>
<td>Past Performance</td>
<td>5</td>
<td>Publications, invited talks, IoT industry events, and IoT workshop</td>
</tr>
</tbody>
</table>
Net-Centric Cloud Software and Systems I/UCRC

Evaluating the Performance of Different Thread Scheduling Techniques in Multi-core Systems with Emerging Memory Technologies

Project Lead: Dr. Krishna Kavi and Shashank Adavally (PhD student), UNT
Date: October 11, 2017
Problem Statement

› Why is this research needed?
  - Main memory technologies are advancing to overcome the speed gap between processor speeds and DRAM speeds
  - 3D-stacked DRAM can deliver high bandwidths and possibly access to wider data paths.
  - A key research question is, how can we structure applications to take advantage of 3D DRAMs (HBM, HMC or MCDRAM).
  - Scheduling multithreaded applications on multicore systems need to be carefully evaluated to eliminate memory access conflicts to benefit from newer memory technologies the architecture of PIM cores (GPUs vs ARM cores vs specialized compute units)

› What is the specific problem to be solved?
  - Evaluate multithreaded scheduling for their memory access patterns, utilization of shared Last Level Caches, as well benefiting from wide data paths.
  - Investigate how to spread applications’ data inside DRAM memories to obtain large amounts of data on each memory access while not cause access conflicts among multiple threads of an application
  - Explore new data prefetching techniques to further improve memory access performance
Project Description

› How will this project approach the problem?

- Simulate different DRAM organizations to allow memory row buffers to be contained within a memory bank, spread across multiple banks and rows or use multiple memory channels to obtain large amounts of data from DRAM on each access. We will use Ramulator for this purpose.

- Use several thread scheduling approaches available with OpenMP programming systems to evaluate memory access behaviors of applications. The choices include “chunk” scheduling where consecutive loop iterations are assigned to the same thread, “cyclical” where consecutive iterations are assigned to different threads, “dynamic” where iterations are assigned to idle threads (possibly distributing uneven number of iterations to threads). We will use Pin tools to obtain memory traces and feed these traces to Ramulator to evaluate memory access performance.

- We will use HPC benchmarks, Deep Learning and Big Data application kernels for evaluation.

- We will also solicit benchmarks from IUCRC members.
Different ways of distributing DRAM rows
Project Description

› Preliminary results

Fig. 12. Shared L3 vs L1L2 on RoBaRaCoCh with static chunk scheduling

Fig. 5. No Scheduling vs Specific Scheduling

Fig. 6. Static vs Dynamic vs Guided
Connection to NCSS Competencies/Capabilities

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net-Centric Solutions</td>
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<td>Next Gen HW and Tools</td>
<td>Cloud Computing</td>
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<td>Software Engineering</td>
<td>QoS</td>
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<tr>
<td>Information Assurance</td>
<td>Quality Improvement</td>
</tr>
<tr>
<td>Signal Processing</td>
<td>SoS Integration</td>
</tr>
<tr>
<td>Big Data</td>
<td></td>
</tr>
<tr>
<td>Next Generation Network</td>
<td></td>
</tr>
</tbody>
</table>

- Memory/Proc Optimization
- Hardware Design
- Power Management
- Testing
- Safety
- Performance
- Verification
- Intrusion Detection
- Access Control
- Data Security
- Threat Assessment
- Video Analytics
- Image Processing
- Wireless Comm's
- Kinesiology
- Analysis
- Visualization
- QoS
- Software Defined Networking

1 = Primary, 2 = Secondary, 3 = Tertiary
# Statement of Work

Work to be performed, timeline, and budget for 5 most significant tasks.

<table>
<thead>
<tr>
<th>Task</th>
<th>K$</th>
<th>Start Date</th>
<th>End Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>Oct 2017</td>
<td>Dec 2017</td>
<td>Identify representative benchmark applications</td>
</tr>
<tr>
<td>2</td>
<td>15.0</td>
<td>Nov 2017</td>
<td>April 2018</td>
<td>Design and test our techniques to use Ramulator and Pin tools for our experiments</td>
</tr>
<tr>
<td>3</td>
<td>10.0</td>
<td>Dec 2017</td>
<td>Sept 2018</td>
<td>Simulate various benchmarks using different scheduling methods and different data layout approaches</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Dec 2017</td>
<td>Sept 2018</td>
<td>Evaluate the usefulness of large L3 caches</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>May 2018</td>
<td>Sept 2018</td>
<td>Evaluate new prefetching techniques to buffer commonly used DRAM row buffers</td>
</tr>
</tbody>
</table>
### Deliverables

Summary of 3 most significant deliverables expected at end of Year 1.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Detailed scripts and documentation on how to use our tools to conduct evaluations of new applications, new thread scheduling approaches and new DRAM organizations</td>
</tr>
<tr>
<td>2</td>
<td>Detailed analysis of chosen benchmarks to identify optimal thread scheduling, if L2 should be used, how to distributed data across memory banks and if prefetching row buffers is useful</td>
</tr>
<tr>
<td>3</td>
<td>A report to understand potential differences between DDR and 3D stacked memory in terms of our study</td>
</tr>
</tbody>
</table>
Project Differentiators

› What results does this project seek that are different (better) than others?
  - To the best of our knowledge, no one explored the impact thread scheduling on memory accesses, and in turn DRAM performance
  - While some of the DRAM organizations proposed in our study are possible previous studies did not explore the potential benefits of different organization
  - While some studies have shown the diminishing usefulness of L3 caches, we conduct a more thorough evaluation

› What specific innovations or insights are sought by this research that distinguish it from related work?
  - Thread scheduling and its impact on memory accesses and performance
  - DRAM organization that permit vast amounts of data per memory access
  - Buffering heavily accessed DRAM row buffers may lead to better performance
Potential Member Company Benefits

› What specific benefits are sought for the industry members?
  - For CPU and Memory designers, our study provides insights on different memory organizations including spreading a row buffer across multiple banks, ranks and channels
  - For application developers and runtime system developers, our study can provide insights on which thread scheduling results in best overall performance

› What leverage does the research provide to industry member R&D plans?
  - Research project aligns with research on HBM, HMC or MCDRAMs in terms of their design and usage by applications
  - Our research can also aid in large organizations on how to schedule applications and threads within applications to benefit from different memory systems
Sponsorship and Collaboration

› **Efforts to involve multiple companies in project sponsorship:**
  - Currently collaborating with Advanced Micro Devices (AMD)
  - Actively seeking additional partners interested in the project

› **Efforts to involve multiple university collaborators in the project:**
  - None so far
## Project Quality Attributes

PI’s assessment of extent to which project demonstrates each QA.

<table>
<thead>
<tr>
<th>QA</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment w/Competencies</td>
<td>5</td>
<td>Have been working on next generation processors and memories</td>
</tr>
<tr>
<td>Sponsor-acknowledged Leverage for R&amp;D</td>
<td>4</td>
<td>Collaborated with AMD over the past 4 years</td>
</tr>
<tr>
<td>Multi-company Sponsorship</td>
<td>2</td>
<td>Although not successful, we communicated with other companies like Xceler Systems</td>
</tr>
<tr>
<td>Multi-PI Collaboration</td>
<td>3</td>
<td>Dr. Hui Zhao of UNT has been interested in this topic</td>
</tr>
<tr>
<td>Compliance with NSF Operations Requirements</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Objective Deliverables</td>
<td>4</td>
<td>Preliminary results were published</td>
</tr>
<tr>
<td>Innovation &amp; Technology Evolution</td>
<td>3</td>
<td>Could lead to hardware technologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Could also aid in scheduling applications on multicore systems</td>
</tr>
<tr>
<td>Potential for Derivative Services</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Commercialization Opportunities</td>
<td>3</td>
<td>Too early to evaluate</td>
</tr>
<tr>
<td>Past Performance</td>
<td>5</td>
<td>Active collaboration with AMD. Multiple research papers published on similar topic.</td>
</tr>
</tbody>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

HMA: Heterogeneous Memory Architecture Involving Emerging Memory Technologies

Project Lead: Dr. Krishna Kavi and Mahzabeen Islam (PhD student), UNT
Date: October 12, 2017
Project Overview

Tasks:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Application characterization</td>
</tr>
<tr>
<td>2</td>
<td>Development of flat-address-space management policies</td>
</tr>
<tr>
<td>3</td>
<td>Development of hierarchical organization optimization policies</td>
</tr>
<tr>
<td>4</td>
<td>Development of fusion organization optimization policies</td>
</tr>
<tr>
<td>5</td>
<td>Develop a framework to find the suitable combination of hierarchical and flat-address-space models depending on the application’s characteristics</td>
</tr>
</tbody>
</table>

Research Goals:

1. Explore different heterogeneous memory system architectures
2. Help understanding the applications’ perspective on designing future memory systems

Project Milestones:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>05/18</td>
<td>List of characterization features and mechanisms to gather them</td>
</tr>
<tr>
<td>2</td>
<td>12/17</td>
<td>Policies such as different types of prefetching, caching, and data migration for HMA</td>
</tr>
<tr>
<td>3</td>
<td>05/18</td>
<td>Framework to find the suitable HMA for any application</td>
</tr>
</tbody>
</table>

Benefits to Industry Partners:

1. Our findings may aid the active research on next generation memory systems being performed by industry partners

1 ■ Task has been approved by IAB sponsor(s)
■ Task is a deviation from the original sponsor-approved task (Why?)
(See notes section of this slide for more information.)

2 ■ Milestone complete or is on track for planned completion date
■ Milestone has changed from original sponsor-approved date (Why?)
Project Pictorial

Why we need Heterogeneous Memory Architecture (HMA)?

- Today different classes of computing (HPC, Big Data, in-memory databases etc.) 100s of GBs of main memory with competitive performance
- Conventional DRAM memory alone can not meet such demands due to power and scaling limitations

Figure: HMA
Completed Tasks

So far we have investigated:

• Different prefetching policies to prefetch pages from slower NVM to
  ➢ Processor resident SRAM buffer, provides 15% IPC improvement on average for a number of SPEC and HPC proxy workloads (a paper has been published in MEMSYS 2016)
  ➢ HBM resident buffer, provides 34% IPC improvement on average for a number of SPEC and HPC proxy workloads (a paper has been published in ARCS 2017)

• Different page transfer policies (limit, priority, priority-TLB policies) to migrate pages between faster and slower memories which provides substantial energy savings and improved performance over no-transfer baseline
  ➢ A report can be found here

Figure: HMA
Ongoing Tasks

Currently we are investigating prediction based page transfer policy
• We keep 2-bit counter per page (or per segment) which predicts whether or not the page migration will be useful
• We update this counter depending on whether the page was useful when it was last migrated
• This information helps us deciding should we migrate a page or not

Figure: State transition diagram for prediction counter
Ongoing Tasks

- Our preliminary experiments show that generally page migration with prediction works better than migration without prediction.

Relative IPC improvement (%) of prediction based migration over no-prediction migration

Important parameters: threshold = 32; usefulness count = 32; epoch length = 10 ms; page size = 2KB
Ongoing Tasks

- We are analyzing applications’ memory access behavior to find suitable thresholds and epoch lengths

![Steady increase](image1)
![Staircase](image2)
![Undefined](image3)

Figure: Page access behavior per 100 ms epoch

- Also access count histogram may suggest what will be an appropriate threshold for an application

![Normal curve](image4)
![Exponential curve](image5)
![Uniformly distributed](image6)
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Development of flat-address-space management policies.</td>
<td>🟢</td>
<td>Completed. New prediction based page migration policies have been investigated.</td>
</tr>
<tr>
<td>2. Development of hierarchical and fusion organization optimization policies.</td>
<td>🟢 🟡</td>
<td>Partially completed. We have investigated how to employ part of 3D-DRAM as prefetch buffer for slower PCM and results are reported on ARCS-2017 paper.</td>
</tr>
<tr>
<td>3. List of characterization features and mechanisms to gather them</td>
<td>🟡</td>
<td>In the initial stage of characterization, set of memory performance metrics to be quantified have been identified.</td>
</tr>
<tr>
<td>4. Framework to find the suitable HMA for any application</td>
<td>🟡</td>
<td></td>
</tr>
</tbody>
</table>

- 🟢 Significant Finding/Accomplishment
- 🟡 Task Complete
- 🟡 Task Partially Complete
- 🟡 Task Not Started
Efforts to Seek Additional Sponsorships and Collaborations

Were collaborations sought with researchers at other institutions to broaden research?

Were attempts made to leverage the research to obtain additional funding from companies or government agencies?

Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?

- We were unsuccessful in identifying potential faculty interested in this work at ASU or UTD. However we are exploring collaborations with SUNY-Stoneybrook
- We are exploring funding from sources such as AMD, JPL
# Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

Differentiated Levels of Security in IoT Devices

Project Lead: Dr. Krishna Kavi and Rohith Yanambaka Venkata (PhD Student), UNT
Date: October 12, 2017
Project Overview

Tasks:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1■</td>
<td>Literature survey and threat modelling for IoT.</td>
</tr>
<tr>
<td>2■</td>
<td>Developing a network device identification and auditing agent.</td>
</tr>
<tr>
<td>3■</td>
<td>Develop a hardware based integrity measurement mechanism. Better protection against side channel attacks and lower costs make this a viable alternative to Intel SGX.</td>
</tr>
<tr>
<td>4■</td>
<td>Developing an orchestration agent to enforce device-specific security policies.</td>
</tr>
<tr>
<td>5■</td>
<td>Optimizations and formal review with the sponsor.</td>
</tr>
</tbody>
</table>

Project Milestones:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1■</td>
<td>08/2017</td>
<td>A demonstration of the capabilities of the architecture through a proof of concept was made.</td>
</tr>
<tr>
<td>2■</td>
<td>03/2018</td>
<td>A comprehensive report on threat model for the IoT space will be delivered.</td>
</tr>
<tr>
<td>3■</td>
<td>06/2018</td>
<td>We are working on Incorporating a hardware based integrity measurement mechanism into CLIPS.</td>
</tr>
<tr>
<td>4■</td>
<td>12/2018</td>
<td>We plan to demonstrate an orchestration agent that enforces device-specific security policies.</td>
</tr>
</tbody>
</table>

Research Goals:

1. Leverage SDN, containers and NFV to secure the IoT.
2. Develop an orchestration agent to identify, monitor and protect devices in IoT.
3. Develop a robust data integrity measurement and verification mechanism that is optimized for IoTs.

Benefits to Industry Partners:

1. This will provide a greater level of security to the devices in the BYOD program.
2. Provides flexible control of security policies in an enterprise network.
3. Comply to Connect (C2C) provides a robust protection mechanism.

1 ■ Task has been approved by IAB sponsor(s)
   ■ Task is a deviation from the original sponsor-approved task (Why?)
   (See notes section of this slide for more information.)

2 ■ Milestone complete or is on track for planned completion date
   ■ Milestone has changed from original sponsor-approved date (Why?)
Project Pictorial

Untrusted External Network

Trusted Environment

Device Specific Security Function Containers
- Container 1
- Container 2
- Container N

Security Policy Manager

SDN Controller

IoT Arbitration Agent (Class 1 Devices)

IoT Arbitration Agent (Class 2 Devices)

IoT Arbitration Agent (Class N Devices)

Access granted
(Fully compliant devices)

Comply to Connect (C2C) network access control

Quarantine VLAN
Partially Non-compliant devices will be subject to remediation

Access Blocked:
Partially/Completely Non-Compliant devices

Class 1

Class 2

Class N
Project Pictorial (Mobile Device)

Sent from your Twilio trial account - 6078

2017-09-29 10:10:57.655 INFO [n.f.m.MACTracker] Mobile device identified
2017-09-29 10:10:57.655 INFO [n.f.m.MACTracker] Two Step Authentication required
2017-09-29 10:10:57.655 INFO [n.f.m.MACTracker] Please enter the password associated with your profile
2017-09-29 10:10:57.703 INFO [n.f.a.ACL] ACL rule(id:1) is added.
Project Pictorial (Tablet Devices)

2017-09-29 10:08:22.217 INFO [n.f.m.MACTracker] Tablet computer identified
2017-09-29 10:08:22.217 INFO [n.f.m.MACTracker] Authentication required
2017-09-29 10:08:22.218 INFO [n.f.m.MACTracker] Please enter the password associated with your profile
2017-09-29 10:08:22.267 INFO [n.f.a.ACL] ACL rule(id:1) is added.
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop top level system design.</td>
<td>●</td>
<td>Completed software architecture and design documents.</td>
</tr>
<tr>
<td>2. Develop a proof of concept.</td>
<td>●</td>
<td>A proof of concept using Netgear W3800, Open vSwitch and floodlight controller was demonstrated.</td>
</tr>
<tr>
<td>3. Develop an integrity measurement.</td>
<td>●</td>
<td>We are currently in the process of developing a hardware assisted integrity measurement architecture to augment the capabilities of CLIPS.</td>
</tr>
<tr>
<td>4. Designing an orchestration agent that enforces security policies.</td>
<td>●</td>
<td>Our objective is to develop a security orchestration agent. We have made significant progress in that regard by demonstrating a proof of concept. We are currently exploring optimizations to the architecture.</td>
</tr>
</tbody>
</table>

- **Significant Finding/Accomplishment**
- **Task Complete**
- **Task Partially Complete**
- **Task Not Started**
Efforts to Seek Additional Sponsorships and Collaborations

Were collaborations sought with researchers at other institutions to broaden research?

Were attempts made to leverage the research to obtain additional funding from companies or government agencies?

Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?

› This project is currently funded by Ashum® Corp. and Lockheed Martin MFC ®.

› We are currently exploring the possibility of additional collaborations with Toyota and Cisco.
## Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. A presentation was made at the “Security and Correctness in IoT” workshop that was held in Graz, Austria.</td>
</tr>
<tr>
<td></td>
<td>3. A demo was made at the NSF Biennial meeting held in Arlington, VA from July 26-28.</td>
</tr>
</tbody>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

Improving Throughput of Neural Network Architecture by Using Direct Memory Access and Deeply Pipelining Techniques

Project Lead: Dr. Krishna Kavi and Clement Cole (Masters Student), UNT
Date: October 12, 2017
Project Overview

Tasks¹:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Develop and Implementation of Software model.</td>
</tr>
<tr>
<td>2</td>
<td>Testing of simple software model.</td>
</tr>
<tr>
<td>3</td>
<td>Develop and Implementation of hardware model.</td>
</tr>
<tr>
<td>4</td>
<td>Testing of hardware model.</td>
</tr>
<tr>
<td>5</td>
<td>Optimization of hardware model.</td>
</tr>
</tbody>
</table>

Project Milestones²:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>08/2017</td>
<td>Completed a simple modification of neural network algorithm (Google tensor flow) for the purpose of MNIST numerical character recognition.</td>
</tr>
<tr>
<td>2</td>
<td>11/2017</td>
<td>Completed a single layer of cells on hardware for implementation of software’s implementation on an FPGA to test for better performance in throughput compared to software’s version.</td>
</tr>
<tr>
<td>3</td>
<td>01/2018</td>
<td>Complete with optimization of the neural network’s architecture on software with various modifications explained below followed by testing.</td>
</tr>
<tr>
<td>4</td>
<td>03/2018</td>
<td>Complete with optimization of the neural network’s architecture on hardware with various modifications explained below followed by testing (measuring speedups with previous versions).</td>
</tr>
</tbody>
</table>

Research Goals:

1. Enable easy conversion of software tools in machine learning into FPGA devices for speed and higher throughput.
2. Design designated FPGA devices that can easily be integrated into general computing systems.

Benefits to Industry Partners:

1. Enable industries interested in speeding computations and increased throughput of software implementations of machine learning applications.
2. A more specific use case in this design will be to enable conversion of handwritten documents into their digital counterparts.

Key:

- Task has been approved by IAB sponsor(s)
- Task is a deviation from the original sponsor-approved task (Why?)

(See notes section of this slide for more information.)
Project Pictorial
Current Progress In Increasing Processing Throughput Just from FPGA simulations

BEFORE DEEPLY PIPELINING EACH NEURAL CELL

AFTER DEEPLY PIPELINING EACH NEURAL CELL (especially functional units)
OPTIMIZATIONS DONE SO FAR ON EXISTING NUMERIC CHARACTER RECOGNITION.

TESTING ACCURACY OF ACTIVATION FUNCTIONS

<table>
<thead>
<tr>
<th>Activation[10.25]</th>
<th>0.999965</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activation[2.25]</td>
<td>0.904651</td>
</tr>
<tr>
<td>Activation[3.25]</td>
<td>0.962673</td>
</tr>
<tr>
<td>Activation[4.25]</td>
<td>0.985936</td>
</tr>
<tr>
<td>Activation[5.25]</td>
<td>0.99478</td>
</tr>
<tr>
<td>Activation[6.25]</td>
<td>0.998073</td>
</tr>
<tr>
<td>Activation[7.25]</td>
<td>0.99929</td>
</tr>
<tr>
<td>Activation[8.25]</td>
<td>0.999739</td>
</tr>
<tr>
<td>Activation[9.25]</td>
<td>0.999904</td>
</tr>
<tr>
<td>Activation[10.25]</td>
<td>0.999965</td>
</tr>
</tbody>
</table>

Verified result accuracy

TESTING LATENCY AS IT CORRESPONDS TO FIRST ITERATION OF PIPELINING

Increased throughput
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop and Implementation of Software model.</td>
<td></td>
<td>Completed the basic software implementation in C++ using the tensor flow C++ API tool cloned from “.</td>
</tr>
<tr>
<td>2. Optimization of the software model.</td>
<td></td>
<td>The software model was optimized after training to gather the weights of each neuron. The model was then fed into the Vivado HLS tool for synthesis. Further modifications were made to reduce the amount of black box components.</td>
</tr>
<tr>
<td>3. Converting the software model into a simple implementation on an FPGA</td>
<td></td>
<td>We are currently in the process of combining several neural cells after optimization to form the overall desired neural network architecture.</td>
</tr>
<tr>
<td>4. Testing performance of the FPGA implementation of simple computations.</td>
<td></td>
<td>Currently testing each individual component within each neural cell for better performance especially timing analysis to maintain synchronicity and accuracy.</td>
</tr>
</tbody>
</table>
Efforts to Seek Additional Sponsorships and Collaborations

Were collaborations sought with researchers at other institutions to broaden research?

Were attempts made to leverage the research to obtain additional funding from companies or government agencies?

Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?

› Currently this project is generally sponsored by the NSF but participants are open to any industrial interest in the funding of the project.
# Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Discoveries</td>
<td>1. Currently the project is at its early stages and we have not made any great discoveries.</td>
</tr>
</tbody>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

NEMESIS – Automated Architecture for Threat Modeling and Risk Assessment for Cloud Computing

**Project Lead:** Dr. Krishna Kavi and Patrick Kamongi (PhD Student), UNT

**Date:** October 12, 2017
Project Overview

Tasks:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Integrating Nemesis into our holistic toolchain (aka. Cockatoo)</td>
</tr>
<tr>
<td>2</td>
<td>Using our vulnerability OKB, design a generic framework for classifying vulnerabilities and attacks into entity/business specific emerging threat types</td>
</tr>
<tr>
<td>3</td>
<td>Symptoms ontology design and population</td>
</tr>
<tr>
<td>4</td>
<td>Vulnerability prediction at scale based on probability and machine learning techniques and their validation</td>
</tr>
<tr>
<td>5</td>
<td>Cockatoo use cases based on industry partners</td>
</tr>
</tbody>
</table>

Project Milestones:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11/2017</td>
<td>Detailed report on various potential use cases of our Cockatoo/Nemesis toolchain</td>
</tr>
<tr>
<td>2</td>
<td>12/2017</td>
<td>Adaptive models to score threat types probabilities</td>
</tr>
<tr>
<td>3</td>
<td>01/2017</td>
<td>Demonstrations of the generated Symptoms Ontology Knowledge Base (OKB) capabilities</td>
</tr>
<tr>
<td>4</td>
<td>02/2018</td>
<td>Report on the adoption of our Vulnerability prediction toolkit</td>
</tr>
<tr>
<td>5</td>
<td>03/2018</td>
<td>Detailed report on the value of our proposed Cockatoo/Nemesis</td>
</tr>
</tbody>
</table>

Research Goals:

1. To generate ontology knowledge bases of vulnerabilities, attacks, defenses, and symptoms facing any computer system.
2. To automatically evaluate the security threat level of any cloud system configurations.
3. To predict the number of unknown vulnerabilities in Software Products.

Benefits to Industry Partners:

1. Our framework can be utilized by small, medium and large corporations with an interest in creating private or hybrid cloud systems or migrating to public Cloud systems, to assess the potential security threats and risk levels.
2. Our vulnerability prediction model can be used to evaluate open-source software projects or internal ones.
3. Our Cockatoo toolchain can be used to orchestrate the lifecycle of cloud security threats assessment and mitigation.

1 Task has been approved by IAB sponsor(s)
2 Task is a deviation from the original sponsor-approved task (Why?)
(See notes section of this slide for more information.)
Project Pictorial – Nemesis Architecture
Project Integration – Cockatoo Toolchain

Dashboard
- Cockatoo
- Admin

Authentication
- User
- Nemesis

Tasking Interface
- Vulcan
- Sweep
- Prediction
- Use Case
- Maintenance

Knowledge Graph
- Cloud Computing Ontology Knowledge Base
- Semantic Query API
- Cyber Threat Data Ontology Knowledge Base

Job Queues
Job Execution
Result Analytic Engine

Tasking
Project Results

› Given any cloud system’s configurations for assessment, Nemesis leverages Vulcan framework API to assess the system vulnerability and generate a vulnerability index knowledge graph.

› Then Nemesis automatically analyze the given vulnerability index and produces:
  - An aggregated estimated risk value
  - Threat types ranking
  - Critical facing vulnerabilities
  - Recommended configurations to minimize the perceived risk
  - An integration API into our holistic Cockatoo toolchain

› Using our designed vulnerability prediction model
  - We can predict the number of unknown vulnerabilities for various open-source software projects with a high coefficient of determination
  - We can extend Nemesis architecture risk estimation capabilities
  - Offer our vulnerability prediction model as a standalone service
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop a scalable framework to model and represent the knowledge about cyber and cloud domains of interest.</td>
<td></td>
<td>Designed and developed an automated toolkit and an extensible semantic search API as a result of this task, codename “IkawaFarm”.</td>
</tr>
<tr>
<td>2. Develop an approach to collect telemetry data of any complex computer system.</td>
<td></td>
<td>Designed and developed an automated tool as a result of this task, codename “Legos”.</td>
</tr>
<tr>
<td>3. Develop a prototype application of our contribution work on Vulcan framework that is integral part of Nemesis Architecture.</td>
<td></td>
<td>Designed and developed an automated user friendly web application for “Vulcan” framework.</td>
</tr>
<tr>
<td>4. Design and develop software tools to support core features of Nemesis Architecture.</td>
<td></td>
<td>Developed a tool codename “Sweep” to automate the generation of large datasets to experiment with vulnerability prediction models.</td>
</tr>
<tr>
<td>5. Integrating all these above tools and applications into an integrated toolchain, centered around our Nemesis Architecture.</td>
<td></td>
<td>Designed a toolchain codename “Cockatoo”, and currently developing a cloud service prototype version.</td>
</tr>
</tbody>
</table>

- Significant Finding/Accomplishment
- Task Complete
- Task Partially Complete
- Task Not Started
Efforts to Seek Additional Sponsorships and Collaborations

- Were collaborations sought with researchers at other institutions to broaden research?
- Were attempts made to leverage the research to obtain additional funding from companies or government agencies?
- Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?

- Collaborations sought with UTD

- Attempted to get connected with companies such as: Armor, Raytheon, & Bell Helicopter
## Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
</table>
 IkawaFarm: Ontology engineering toolkit for cloud and cyber domains  
 Vulcan: Web application for vulnerability assessment for cloud systems  
 Sweep: Tool for software vulnerability timeline and complexity analysis metrics dataset generation for machine learning experiments  
 Nemesis: Architecture design & proof of concept software  
 Cockatoo: A toolchain for risk assessment and mitigation for any computer system – prototype software |
Net-Centric and Cloud Software and Systems I/UCRC

Optimization for Massive MIMO Systems

Project Lead: Dr. Robert Akl and Robin Chataut (University of North Texas)
Date: October 12, 2017
Project Description

Area throughput = Spectral Efficiency * Cell density * Bandwidth

What is Massive MIMO?
- Tens of users are served simultaneously by hundreds of antenna
- Huge multiplexing gains allowing an order of magnitude higher data rates

Advantages:
- use of low power components
- reduced latency
- robustness to interference and internal jamming
- scalability
- simplicity

What is the specific problem to be solved?
- Highly complex precoding and decoding algorithms
- Pilot contamination problem

Image source: Department of Electrical Engineering, Linkoping University
## Project Overview

### Tasks:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conduct literature survey to understand current model and determine gaps in existing models and techniques</td>
</tr>
<tr>
<td>2</td>
<td>Derive the mathematical model of proposed model</td>
</tr>
<tr>
<td>3</td>
<td>Build a prototype of proposed model and do simulations</td>
</tr>
<tr>
<td>4</td>
<td>Review result and explore optimizations</td>
</tr>
</tbody>
</table>

### Project Milestones:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>05/2017</td>
<td>Detailed report on current framework and techniques</td>
</tr>
<tr>
<td>2</td>
<td>10/2017</td>
<td>Complete mathematical model of the proposed design</td>
</tr>
<tr>
<td>3</td>
<td>03/2018</td>
<td>Obtain performance expression and results from simulations</td>
</tr>
<tr>
<td>4</td>
<td>08/2018</td>
<td>Review results and obtain final report of the project after optimizations</td>
</tr>
</tbody>
</table>

### Research Goals:

1. To build low complexity and spectrally efficient algorithm
2. To increase area throughput without increasing bandwidth and cell density
3. To find optimal pilot reuse factor value to always run system at maximum spectral efficiency

### Benefits to Industry Partners:

1. Our algorithm can be beneficial for industry member in achieving goals of 5G communication
2. With low bandwidth and high spectral efficiency, this will certainly help in implementing IOT
3. Our model may help in implementing Machine-to-Machine (M2M) communication

---

1. Task has been approved by IAB sponsor(s)
2. Task is a deviation from the original sponsor-approved task (Why?)
(See notes section of this slide for more information.)

2. Milestone complete or is on track for planned completion date
   - Milestone has changed from original sponsor-approved date (Why?)
Expected Results

Goal is to increase Spectral Efficiency

We are hoping to make 100 fold improvement in Spectral efficiency (requirement for 4G is 3 bit/s/Hz, International Mobile Telecommunications standard)

- Low-complexity and spectrally efficient precoding and decoding algorithm for Massive MIMO systems

- Determine the optimal value for pilot reuse factor in different environments according to number of active users in a cell

- Energy-efficient signal processing schemes for massive MIMO systems
Preliminary Results

› We have obtained optimal value of pilot reuse factor by doing simulations at six different environments.

› Spectral efficiency of 60 bits/s/Hz have been obtained till now.
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Conduct literature survey to understand current model and determine gaps in existing models and techniques</td>
<td>![ ]</td>
<td>We completed the study of currently used system model and precoding/decoding algorithms in Massive MIMO systems.</td>
</tr>
<tr>
<td>2. Derive the mathematical model of proposed model</td>
<td>![ ]</td>
<td>We have developed few equations for our new algorithm.</td>
</tr>
<tr>
<td>3. Build a prototype of proposed model and do simulations</td>
<td>![ ]</td>
<td>System model has been designed and some results have been obtained. We have found optimal value of pilot reuse factor at different environment to achieve maximal spectral efficiency.</td>
</tr>
<tr>
<td>4. Review result and explore optimizations</td>
<td>![ ]</td>
<td>Preliminary results have been obtained.</td>
</tr>
</tbody>
</table>
Efforts to Seek Additional Sponsorships and Collaborations

*Were collaborations sought with researchers at other institutions to broaden research?*

*Were attempts made to leverage the research to obtain additional funding from companies or government agencies?*

*Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?*

› We are exploring collaborations with other universities.

› We are attempting to get connected with companies such as: Motorola and Ericsson.
Net-Centric and Cloud Software and Systems I/UCRC

Cyber Defensive and Offensive Software Diversification (UTD-2016-10-1)

Project Lead: Dr. Kevin Hamlen, UTD
Date: October 12, 2017
# Project Overview

## Tasks:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Formulate foundational science of automated software synthesis for diversity.</td>
</tr>
<tr>
<td>2</td>
<td>Implement proof-of-concept prototype using program-sketching synthesis approach.</td>
</tr>
<tr>
<td>3</td>
<td>Expand prototype to diversify realistic test binaries.</td>
</tr>
<tr>
<td>4</td>
<td>Evaluate diversified software communities for attack resilience.</td>
</tr>
</tbody>
</table>

## Research Goals:

1. Establish a scientific basis for designing, implementing, and evaluating secure software diversification based on automated program synthesis.
2. Evaluate effectiveness of technique for defending software communities against exploits of known vulnerabilities.
3. Evaluate effectiveness against exploits of vulnerabilities unknown to defenders (0-days).

## Project Milestones:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12/16</td>
<td>Publication of technical approach and literature review</td>
</tr>
<tr>
<td>2</td>
<td>01/17</td>
<td>Initial prototype implementation completed</td>
</tr>
<tr>
<td>3</td>
<td>12/17</td>
<td>Second revision prototype with realistic test samples working</td>
</tr>
<tr>
<td>4</td>
<td>03/18</td>
<td>Publication of evaluation results</td>
</tr>
</tbody>
</table>

## Benefits to Industry Partners:

1. Increase robustness of software communities against malicious attack even when adversaries manage to discover and exploit vulnerabilities despite all other defenses.
2. Provide new capabilities for surgical strikes and long-term covert missions in offensive cyberwarfare (for military applications).
3. Anticipate and train malware defenses against next-generation malware attacks.

---

1 Task has been approved by IAB sponsor(s)  
2 Task is a deviation from the original sponsor-approved task (Why?)  
2 Milestone complete or is on track for planned completion date  
2 Milestone has changed from original sponsor-approved date (Why?)
Project Pictorial

Code Synthesis

- Gadget Discovery
- Non-deterministic Compilation
- Gadget Assignment

Executable Synthesis

- Program Sketch
- PE Template
- Code Injector

Frankenstein

Benign Binaries

Diversified Software
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Publish scientific approach</td>
<td>■</td>
<td>Published in New Security Paradigms Workshop, 2016</td>
</tr>
<tr>
<td>2. Complete initial prototype implementation</td>
<td>■</td>
<td>Implementation in Racket/Rosette program synthesis language</td>
</tr>
<tr>
<td>3. Extend prototype to support real-world test samples</td>
<td>■</td>
<td>In-progress: Currently working on diversification strategy for Java runtime APIs</td>
</tr>
<tr>
<td>4. Evaluate security robustness</td>
<td>■</td>
<td>Task will begin once prototype extensions are complete (see above).</td>
</tr>
</tbody>
</table>

- **Significant Finding/Accomplishment**
- **Task Complete**
- **Task Partially Complete**
- **Task Not Started**
Efforts to Seek Additional Sponsorships and Collaborations

› Successful collaboration with U.C. Irvine (Dr. Michael Franz’s group) and M.I.T. (Dr. Mathias Payer’s group)
  – Award: NSF Trustworthy Computing Collaborative Research Grant, “ENCORE: Enhanced program protection through Compiler-Rewriter cooperation”
  – $1.2M total ($177K for UTD)

› Successful research collaboration with Google (Android Security team, Dr. Vishwath Mohan)

› Ongoing joint research agreement with IBM (Dr. Frederico Araujo, previously Prof. Hamlen’s student)
## Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papers, Publications, Presentations/Venue</td>
<td>1. Two recent significant publications: NDSS’15 (16.9% acceptance rate), NSPW’16 (46% acceptance rate)</td>
</tr>
<tr>
<td></td>
<td>2. Numerous prior significant publications (e.g., ISI’13, WOOT’12, PAKDD’14)</td>
</tr>
<tr>
<td>Products (Software, Hardware, Data, Designs,  etc.)</td>
<td>1. Frankenstein Software Mutation System</td>
</tr>
<tr>
<td></td>
<td>2. Opaque Control-flow Integrity Defense System</td>
</tr>
<tr>
<td>Student Placements</td>
<td>1. Vishwath Mohan (Google Android Security)</td>
</tr>
<tr>
<td></td>
<td>2. Frederico Araujo (IBM T.J. Watson)</td>
</tr>
<tr>
<td>Other</td>
<td>1. Fred Araujo won the 2016-2017 Erik Jonsson Best Dissertation Award for his work on Cyber-deceptive Software Engineering.</td>
</tr>
</tbody>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

Angle Estimation Study (UTD-2014-10-5)

Project Lead: M. Saquib, UTD
Date: October 2017
# Project Overview

## Tasks:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Compare multiple advanced angle estimation methods to standard monopulse for a uniform linear array (ULA)</td>
</tr>
<tr>
<td>2</td>
<td>Calculate the Cramer Rao Lower Bound (CRLB) for an N-element linear array</td>
</tr>
<tr>
<td>3</td>
<td>Explore how different angle estimators approach the CRLB including monopulse, maximum likelihood estimator (MLE), multiple-input multiple output (MIMO), etc.</td>
</tr>
</tbody>
</table>

## Research Goals:

1. Compare the theoretical accuracy of various angle estimation techniques applicable to a uniform linear array (ULA)
2. Enable a trade study of accuracy versus complexity

## Project Milestones:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td>5/2017</td>
<td>Derived the CRLB expressions for different array configurations including single-input multiple-output (SIMO) array, phased array and MIMO array</td>
</tr>
<tr>
<td>1,2,3</td>
<td>7/2017</td>
<td>MATLAB based simulations were performed to compare the angle estimation accuracy among multiple direction finding algorithms</td>
</tr>
<tr>
<td>1,2,3</td>
<td>3/2018</td>
<td>Submit a comprehensive report documenting all findings and achievements</td>
</tr>
</tbody>
</table>

## Benefits to Industry Partners:

1. Meeting the interest of our sponsors to have an overview of the theoretical accuracy of various angle estimation methods
2. Allowing our sponsor to perform a trade-off when implementing these angle estimation methods into hardware

---

1 Task has been approved by IAB sponsor(s)
2 Task is a deviation from the original sponsor-approved task (Why?)
(See notes section of this slide for more information.)
Project Pictorial

- Deriving the expressions of various angle estimation methods
- Deriving the expressions of CRLB of different array set-ups
- Performing extensive MATLAB based simulation
- Conducting numerical analysis of the studied algorithms and comparing them with monopulse method
- Documenting all the findings in a comprehensive report
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Compare multiple advanced angle estimation methods to standard monopulse for a uniform linear array (ULA)</td>
<td>■</td>
<td>MATLAB simulation figures that compare the angle estimation accuracy have been generated and shown to our sponsor in a PowerPoint presentation</td>
</tr>
<tr>
<td>2. Calculate the Cramer Rao Lower Bound (CRLB) for an N-element linear array</td>
<td>■</td>
<td>Expressions of CRLB have been derived and key findings have been presented in the PowerPoint slides</td>
</tr>
<tr>
<td>3. Explore how different angle estimators approach the CRLB including monopulse, maximum likelihood estimator (MLE), multiple-input multiple output (MIMO), etc.</td>
<td>■</td>
<td>Performance differences of multiple angle estimation techniques are illustrated numerically through MATLAB simulation</td>
</tr>
</tbody>
</table>

- **Significant Finding/Accomplishment**
- **Task Complete**
- **Task Partially Complete**
- **Task Not Started**
Efforts to Seek Additional Sponsorships and Collaborations

Were collaborations sought with researchers at other institutions to broaden research?
Were attempts made to leverage the research to obtain additional funding from companies or government agencies?
Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?

› Experimental findings were shared with L3 Mustang Technology
› We are waiting for our collaborator’s feedback
› Additional funding was requested for next year
# Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
</table>
2. Joint MIMO Radar-Communications beamforming design, to be submitted to 2018 IEEE Radar Conference |
| Products (Software, Hardware, Data, Designs, etc.) | 1. Findings based on simulation using MATLAB  
2. Comprehensive report |
| Student Placements               | N/A                                                                                 |
Net-Centric Cloud Software and Systems I/UCRC

Nanopore Sensors and Signal Processing Algorithms for Health Monitoring

Project Lead: Andreas Spanias, Michael Goryll, Trevor Thornton
Date: October 12, 2017
Project Overview

Tasks¹:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Denoising</td>
</tr>
<tr>
<td>2</td>
<td>Identify Nanopore Signature Events</td>
</tr>
<tr>
<td>3</td>
<td>Explore additional</td>
</tr>
<tr>
<td>4</td>
<td>Test on real datasets</td>
</tr>
</tbody>
</table>

Research Goals:
1. Denoising algorithm working with real data.
2. Distinguish binding events from noise.
3. Produce report for detection with simulants.

Project Milestones²:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/2018</td>
<td>Report on Denoising with simulation data</td>
</tr>
<tr>
<td>2</td>
<td>4/2018</td>
<td>Obtain real data from nanopore sensor</td>
</tr>
<tr>
<td>3</td>
<td>06/2018</td>
<td>Distinguish binding events from noise</td>
</tr>
<tr>
<td>4</td>
<td>10/2018</td>
<td>Report 1st year</td>
</tr>
</tbody>
</table>

Benefits to Industry Partners:
1. Potential for creating new nanosensor.
3. Tools and software for detecting events.
Project Pictorial

Figure | Signal processing of Nanopore-Nanobead data.
Progress to Date and Accomplishments (Project just Started)

<table>
<thead>
<tr>
<th>Task# / Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Experiments with synthetic data</td>
<td></td>
<td>Created synthetic data.</td>
</tr>
<tr>
<td>2. Algorithm development for denoising</td>
<td></td>
<td>Starting soon</td>
</tr>
<tr>
<td>3. Algorithm Development for distinguishing events from noise</td>
<td></td>
<td>Staring in 2018</td>
</tr>
</tbody>
</table>

- **Significant Finding/Accomplishment**
- **Task Complete**
- **Task Partially Complete**
- **Task Not Started**
Efforts to Seek Additional Sponsorships and Collaborations

› Project just Started

› Presentation given by Michael Goryll to several potential sponsors June 2017

› Possibly NXP could explore new sensor

› Project started August 2018. By Spring 2018 we will have results
## Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papers, Publications, Presentations/Venue</td>
<td>In preparation for Conferences and Report to NCSS in 2018</td>
</tr>
<tr>
<td>Products (Software, Hardware, Data, Designs, etc.)</td>
<td>Algorithms in 2018</td>
</tr>
<tr>
<td>Student Placements</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

Synergy of Machine Learning, Deep Learning and Software Engineering
-- for Intelligence Software Development and Evolution

Project Lead: Dr. LiGuo Huang, SMU
Presenter: Simin Wang, SMU
Date: October 12, 2017
Project Overview

Tasks1:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preliminary filtering of the related academic literatures in 7 premier Software Engineering conferences within the past 3 years</td>
</tr>
<tr>
<td>2</td>
<td>Overview of application domains and methodologies for all process areas</td>
</tr>
<tr>
<td>3</td>
<td>Detailed empirical analysis on three top priority process areas: defect analysis, code optimization and testing</td>
</tr>
<tr>
<td>4</td>
<td>Recommendation of process areas and intelligent methodologies based on maturity level evaluation</td>
</tr>
<tr>
<td>5</td>
<td>Presentation of empirical analysis results and discussion of future collaborations</td>
</tr>
</tbody>
</table>

Research Goals:

1. To investigate how Machine Learning (ML), Deep Learning (DL) and Natural Language Processing (NLP) methodologies support the intelligent software system development and evolution.
2. To evaluate the maturity levels of academic research results in real-world applications.
3. To recommend the potential areas where “intelligence” can be built in.

Benefits to Industry Partners:

1. The empirical analysis results will help Futurewei and Huawei in identifying the promising process areas where “intelligent” data analytics can be explored.
2. Provide the guideline for Futurewei and Huawei to develop their Intelligent Software System Development System.
3. The maturity level evaluation results help identify the methodologies that are ready to be extended for industrial applications.

Project Milestones2:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>02/17</td>
<td>List of selected literatures</td>
</tr>
<tr>
<td>2</td>
<td>04/17</td>
<td>Overview (Introduction) chapter</td>
</tr>
<tr>
<td>3</td>
<td>05/17</td>
<td>Detailed analysis chapters on three process areas</td>
</tr>
<tr>
<td>4</td>
<td>07/17</td>
<td>Final report and presentation slides</td>
</tr>
<tr>
<td>5</td>
<td>09/17</td>
<td>Presentation and discussion</td>
</tr>
</tbody>
</table>

1 Task has been approved by IAB sponsor(s)
2 Task is a deviation from the original sponsor-approved task (Why?)
(See notes section of this slide for more information.)
Project Pictorial

**Classification**
Align methodologies with 9 software engineering process areas

**Analysis**
Multi-dimensional analysis covering methodologies, maturity levels, application domains, etc.

**Researcher Social Networks**
Identify top 10 leading researchers, publications, research topics and motivations of studies, etc.

**Empirical Study**
Conduct a comprehensive systemic literature review on the application of MC/DL/NLP methodologies in Software Engineering

**Detailed Investigation**
Investigate further on three process areas (defect analysis, code optimization and test case generation)

**Discovery**
Identify methodologies ready for extension to industrial applications

**Recommendations**
Recommend potential process areas where “intelligence” can be integrated and methodologies can be employed
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Preliminary filtering of the related academic</td>
<td>■</td>
<td>Completed the selection of literatures</td>
</tr>
<tr>
<td>2. Overview of application domains and methodologies for all process areas</td>
<td>■</td>
<td>Completed the overview chapter</td>
</tr>
<tr>
<td>3. Detailed empirical analysis on three top priority process areas</td>
<td>■</td>
<td>Completed the chapters of three top priority process areas: code optimization, test case generation, defect analysis</td>
</tr>
<tr>
<td>4. Recommendation of process areas and intelligent methodologies</td>
<td>■</td>
<td>Completed the final report and final presentation slides that include recommendation of process areas and intelligent methodologies</td>
</tr>
<tr>
<td>5. Presentation of empirical analysis results and discussion of future collaborations</td>
<td>■</td>
<td>Presented empirical analysis results to Futurewei/Huawei. Both report and presentation have been accepted by Futurewei/Huawei.</td>
</tr>
</tbody>
</table>

- Significant Finding/Accomplishment
- Task Complete
- Task Partially Complete
- Task Not Started
Efforts to Seek Additional Sponsorships and Collaborations

Were collaborations sought with researchers at other institutions to broaden research?

Were attempts made to leverage the research to obtain additional funding from companies or government agencies?

Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?

› Future collaborations between Futurewei/Huawei and Dr. LiGuo Huang’s research team will be discussed based on the empirical study results.

› NSF I-Corps proposal will be submitted

› Ph.D. students will have the opportunity to acquire the internship at Futurewei.
## Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papers, Publications, Presentations/Venue</td>
<td>1. Empirical study report and slides finished</td>
</tr>
<tr>
<td>Products (Software, Hardware, Data, Designs, etc.)</td>
<td>1. Empirical data collected to evaluate the maturity levels of ML, DL and NLP applications in Software Engineering</td>
</tr>
<tr>
<td>Student Placements</td>
<td>1. One fresh Ph.D. student involved in the study and will be involved in future collaboration with Huawei</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>
Net-Centric and Cloud Software and Systems I/UCRC

Running SAPPHIRE at Hospitals in China

Project Lead: Dr. JungHwan Oh, UNT
Presenter: ABM Rezbaul Islam (PhD Student), UNT
Date: October 12, 2017
Problem Statement

› Why this research is needed:
  - Some hospitals in China would like to use SAPPHIRE to measure the quality of their Colonoscopy procedures performed by their physicians

› Specific problem to be solved:
  - A colonoscopy quality measure software, SAPPHIRE (Semi-Automated Parallel Programming Heterogeneous Intelligent Reconfigurable Environment) made by Endometric (endometric.com) has been developed by the videos collected from the hospitals in US
  - The colonoscopy machines used by the hospitals in China are different from the ones in US, and the generated videos are also different from the ones in US
  - We need to check that the outputs of SAPPHIRE using the videos from China are reasonable
  - If not, we need to revise some modules
We developed SAPPHIRE (Semi-Automated Parallel Programming Heterogeneous Intelligent Reconfigurable Environment).

SAPPHIRE is a general purpose, real-time, modular, task-parallel middleware and SDK for writing task-parallel stream programs.

It is generic enough to support any language that can be compiled to binary code.

Primary goals are modularity, scalability, extensibility, configurability, collaboration among multiple developers, and ease of use.

The primary focus of our middleware is the processing of stream data which can be from medical videos, surveillance videos, military videos and many others.
SAPPHIRE (Contd...) 

› **Semi-Automated:** Automate most of the redundant work 
› **Parallel Programming:** Implicit multi-threaded environment 
› **Heterogeneous:** 
  – Take advantage of various types of processors on a system (multi-core CPUs with accelerators such as GPUs)
› **Intelligent Reconfigurable Environment:** 
  – Build a stream program from modules 
  – Maximize throughput (or minimize delay) given constraints 
    › Heterogeneous choice: Choose whether to use CPU dominant code, GPU dominant code, or a combination for each module
Current Outputs of SAPPHIRE using the videos from China

- Among many modules,
  - Blurry frame detection module is working correctly
  - Stool frame detection module is not working correctly since the videos from China have a rainbow color effect, so there is a tendency that more non-stool frames are detected as stool frames
  - The module distinguishing colonoscopy videos from EGD (Esophagogastroduodenoscopy) videos is not working since different color bite-blocks are used in China
STOOL Frames of different Colonoscopy

Frames from USA colonoscopy Video

Frames from CHINA colonoscopy Video

- The frames are different (i.e., rainbow effect) since the equipment used in CHINA is different from USA
Stool Module for SAPPHIRE contd..

- The current STOOL module uses a model based on RGB color values of each pixel in an image.

- We have been considering a different approach.
  - Instead of RGB value, we are using HSV (Hue, Saturation, and Value) values of each pixel.
    - The hue (H) describes the shade of color and where that color is found in the color spectrum.
    - The saturation (S) describes colorfulness in proportion to its brightness. A pure red is fully saturated, with a saturation of 1.
    - The value (V), also called its brightness, describes how dark the color is. A value of 0 is black, with increasing brightness moving away from black.
Stool Module for SAPPHIRE contd..

† We calculate the HSV values of only STOOL part of an image

[Image: Only STOOL part was cropped]

→ Calculate the HSV values of stool area

† We use this HSV value to define the threshold to detect stool pixels
† Modify the current stool detection logic with HSV values
# Experimental Results

<table>
<thead>
<tr>
<th>Video name</th>
<th>BBPS (Insertion)</th>
<th>BBPS (Insertion)</th>
<th>BBPS (Withdrawal)</th>
<th>BBPS (Withdrawal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20170418_111745_192.168.100.165_P05.mpg</td>
<td>8.98</td>
<td>8.99</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>20170418_120201_192.168.100.165_P06.mpg</td>
<td>7.5</td>
<td>8.58</td>
<td>8.63</td>
<td>8.96</td>
</tr>
<tr>
<td>20170419_083305_192.168.100.165_P02.mpg</td>
<td>6.17</td>
<td>8.19</td>
<td>7.02</td>
<td>7.81</td>
</tr>
<tr>
<td>20170419_112833_192.168.100.165_P02.mpg</td>
<td>5.22</td>
<td>7.43</td>
<td>6.39</td>
<td>7.58</td>
</tr>
<tr>
<td>20170419_115731_192.168.100.165_P04.mpg</td>
<td>4.94</td>
<td>8.05</td>
<td>7.24</td>
<td>8.61</td>
</tr>
<tr>
<td>20170419_121556_192.168.100.165_P05.mpg</td>
<td>7.4</td>
<td>8.56</td>
<td>7.05</td>
<td>8</td>
</tr>
<tr>
<td>20170424_084653_192.168.100.165_P01.mpg</td>
<td>6.2</td>
<td>7.82</td>
<td>6.05</td>
<td>7.33</td>
</tr>
</tbody>
</table>
# Project Overview

## Tasks:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check Blurry frame detection module, and revise it if necessary</td>
</tr>
<tr>
<td>2</td>
<td>Check Stool frame detection module, and revise it if necessary</td>
</tr>
<tr>
<td>3</td>
<td>Check EGD (bite-block detection) module, and revise it if necessary</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

## Research Goals:

1. To get an stool module which detects efficiently stool images

## Project Milestones:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>A new Stool frame detection module</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>A new EGD (bite-block detection) module</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Benefits to Industry Partners:

1. All hospitals in the world using Olympus CV-290 Colonoscope can have benefit of this research.

---

1. Task has been approved by IAB sponsor(s)
2. Task is a deviation from the original sponsor-approved task (Why?)
   (See notes section of this slide for more information.)
3. Milestone complete or is on track for planned completion date
4. Milestone has changed from original sponsor-approved date (Why?)
# Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Check Blurry frame detection module, and revise it if necessary</td>
<td>Completed</td>
<td></td>
</tr>
<tr>
<td>2. Check Stool frame detection module, and revise it if necessary</td>
<td>Completed</td>
<td></td>
</tr>
<tr>
<td>3. Check EGD (bite-block detection) module, and revise it if necessary</td>
<td>On-going</td>
<td></td>
</tr>
</tbody>
</table>

- **Significant Finding/Accomplishment**
- **Task Complete**
- **Task Partially Complete**
- **Task Not Started**
Efforts to Seek Additional Sponsorships and Collaborations

Were collaborations sought with researchers at other institutions to broaden research?

Were attempts made to leverage the research to obtain additional funding from companies or government agencies?

Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?

› We are trying to contact some hospitals in China.
## Objective Evidence Supporting NCSS Value Proposition

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papers, Publications, Presentations/Venue</td>
<td>1. Many conference and journal papers</td>
</tr>
</tbody>
</table>
| Products (Software, Hardware, Data, Designs, etc.) | 1. EM (EndoMetric)-Automated-RT (Real-Time)  
2. SAPPHIRE (Semi-Automated Parallel Programming Heterogeneous Intelligent Reconfigurable Environment) |
| Student Placements                | 1. Two PhD                                                                          |
Conclusion

› Revised STOOL model detects more accurate stool pixels

› We are working on EGD module.
Net-Centric and Cloud Software and Systems I/UCRC


Project Lead: Lawrence Chung, UTD
Date: October 12, 2017
Project Overview

Tasks:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design and build a estimating tool</td>
</tr>
<tr>
<td>2</td>
<td>Design and build a recommendation tool</td>
</tr>
<tr>
<td>3</td>
<td>Design and build a risk navigation tool</td>
</tr>
<tr>
<td>4</td>
<td>Extend the requirements engineering tool</td>
</tr>
<tr>
<td>5</td>
<td>Test extensions to the HP beacon indoor location app</td>
</tr>
</tbody>
</table>

Project Milestones:

<table>
<thead>
<tr>
<th>Task#</th>
<th>Planned Completion</th>
<th>Milestone (Deliverable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10/17</td>
<td>Demonstrate the POC estimating tool</td>
</tr>
<tr>
<td>2</td>
<td>11/17</td>
<td>Demonstrate the POC recommendation tool</td>
</tr>
<tr>
<td>3</td>
<td>1/18</td>
<td>Demonstrate the POC risk navigation tool</td>
</tr>
<tr>
<td>4</td>
<td>3/18</td>
<td>Demonstrate the POC RE tool</td>
</tr>
<tr>
<td>5</td>
<td>5/18</td>
<td>Integrated beacon app demonstration</td>
</tr>
</tbody>
</table>

Research Goals:

1. Become a resource to help CIOs estimate performance and cost of cloud applications
2. Build graduate researchers capable of benchmarking, emulating and simulating cloud applications
3. Help cloud providers [NTT Data and other partners] use tools to provide effective solutions

Benefits to Industry Partners:

1. Members can use the lab to easily verify the impact of their cloud solutions
2. Members can use the lab benchmark and simulation students to construct unique benchmarks and simulation models
3. Members can view posted results of cloud benchmarks, simulations, emulations

1 Task has been approved by IAB sponsor(s)
2 Task is a deviation from the original sponsor-approved task (Why?)
   (See notes section of this slide for more information.)
Goal-Oriented Modeling and Analytics Using Big Data

• Business: Value

• Big Data 4Vs: Volume, Velocity, Variety, Veracity

• Too much gap between Big Data 4V’s and Business Value

*We want to find and use hidden insights that can be turned into business value to help business decision-making with Big Data.*

• Goal-Oriented Approach to Big Data Analytics

• Developing a tool as a proof of concept
Estimating Performance and Cost of Cloud-based Systems using Big Data

Refinements on our ontological approach by using Big Data and Machine Learning, and extension of NFR Framework and RE Tool for estimating performance and cost of cloud-based systems in a reliable, fast, and inexpensive manner.

< Softgoal Interdependency Graph for reasoning ontologies >

< Ontology Diagram and Ontological Mapping >

< Previous research: assuring high level of fidelity of cloud simulation model complemented by cloud benchmark model using ontological mapping >

< Refinement of our idea using Big Data and Machine Learning: Ontological Concepts act as features that are needed in using Machine Learning techniques and a criteria for reasoning, designing and evaluating good feature sets >

< Extension of NFR Framework and RE Tool: Helps capturing, mapping, and representing the ontologies, and the execution of cloud simulations >

< Refinements on our ontological approach and development of a supporting tool by extending the NFR Framework >
Goal-Oriented Recommendation Systems using Big Data

Using a recommendation system does not imply satisfactory recommendations—even the best algorithms might be inadequate.

Properties Manager
- Preferences
  - Accuracy: ★★★★★
  - Robustness: ★★★★★
  - Privacy: ★★★★★

Analyzer
- Non-functional properties
- Trade-off Analysis
  - Accuracy, robustness, privacy, diversity, serendipity, etc.
- Relevance filtering
- Importance redefinition

Our work intends to strengthen existing recommendation systems
- A different user should have a different recommendation
A good approach is to use the trade-off between relevant non-functional properties as the goal of the recommendation system.
Comprehensive and Deep risk analysis using a Scenario-driven approach

Murphy’s Law: Any thing that can go wrong will go wrong

How do we know if our scenario analysis is deep, comprehensive and complete??

We perform Scenario analysis by asking questions and going deep down the scenario tree for the depth

R: Theia asks Stevie to walk 10 steps and turn

Ontology of Theia

List of Scenarios obtained by asking questions

Compare

Scenarios obtained from ontology

All Scenarios from questions matching with scenarios in ontology??

Prototyping and experimentation, deep and comprehensive risk analysis, ontology based approach, developing a tool for verification
## Progress to Date and Accomplishments

<table>
<thead>
<tr>
<th>Task#/Description</th>
<th>Status</th>
<th>Progress and Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. NTT Data UTD Joint Development Lab build</td>
<td>![ ]</td>
<td>UTD cloud used to provide resources</td>
</tr>
<tr>
<td>3. NTT Data UTD Joint Development Lab integration test</td>
<td>![ ]</td>
<td>First integrated test completed</td>
</tr>
<tr>
<td>4. HP Beacon Android App Proof of Concept assignment</td>
<td>![ ]</td>
<td>Initial PoC designed and coded; location precision problems remain</td>
</tr>
</tbody>
</table>
Efforts to Seek Additional Sponsorships and Collaborations

Were collaborations sought with researchers at other institutions to broaden research?

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Were student researchers subsequently employed or given internships with a sponsor as a result of their work on the project?

- NTT DATA sponsorship of NTT DATA Cloud benchmarking
- NTT DATA sponsorship of NTT DATA Joint Development Lab
- Industry-experienced graduate students added to the lab
## Objective Evidence Supporting NCSS Value Proposition

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</thead>
<tbody>
<tr>
<td>Products (Software, Hardware, Data, Designs, etc.)</td>
<td>1. UTD and NTT Data Joint Lab Development Environment built on UTD Cloud</td>
</tr>
</tbody>
</table>
| Student Placements                          | 1. ROKAF  
                                           | 2. IBM  
                                           | 3. TI |