Cyber Security Capabilities at The University of Texas at Dallas (UTD)

http://csi.utdallas.edu

Dr. Bhavani Thuraisingham
Founding Executive Director

September 2017

Outline

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- **Sponsors**
- **Collaborations**
- **Research Thrusts**
- **Education Programs, Research Prototypes and Tools, and Cyber Operations**
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Our Faculty

Founder

- Bhavani Thuraisingham, PhD, DEng (U of Wales, U of Bristol - UK)

Faculty from the School of Engineering and Computer Science

- Alvaro Cardenas, PhD (U of MD) Cyber Physical Systems Security
- Jorge Cobb, PhD (UTAustin) Cyber Security Outreach, Reliable Networks
- Yvo Desmedt, PhD (U. Leuven-Belgium) Cryptography
- Zygmunt Haas, PhD (Stanford) Wireless Network Security
- Kevin Hamlen, PhD (Cornell) Language and Software Security
- Shuang Hao, PhD (GATech) Network Security, Measurements and DNS Attacks
- Murat Kantarcioglu, PhD (Purdue) Data Security and Privacy
- Latifur Khan, PhD (U of Southern CA) Big Data Analytics for Security
- Zhiqiang Lin, PhD (Purdue) Systems Security and Forensics
- Yiorgos Makris, PhD (UC San Diego) Hardware Security
- J.V. Rajendran, PhD (NYU) Hardware Security (now at Texas A&M)
- Kamil Sarac, PhD (UC Santa Barbara) Cyber Security Education, Network Measurements

Several affiliated faculty from multiple schools at UTD (Sample)

- Michael Baron, PhD (U of MD) Statistical Methods for Security (currently at American University)
- Farokh Bastani, PhD (UC Berkeley), I/UCRC, Secure Software Engineering
- Alain Bensoussan, PhD (University of Paris) Risk Analysis for Security
- Nathan Berg, PhD (U of Kansas) Economics and Security (currently in New Zealand)
- Jennifer Holmes, PhD (U of MN) Cyber Security Policy
- Patrick Brandt, PhD (Ohio State) Political Science
- Daniel Krawczyk, PhD (UCLA) Psychosocial Aspects of Security
- Cong Liu, PhD (UNC Chapel Hill) Real-time Systems and Security

Our History and Accomplishments

- **NSA/DHS Center for Academic Excellence in Cyber Security Education, June 2004 (CAE)**
- **SAIAL (Security Analysis and Information Assurance Laboratory) July 2004**
- **NSA/DHS Center for Academic Excellence in Cyber Security Research, June 2008 (CAE-R)**
- **First NSF SFS Grant, 2010; Follow-on Grant 2014.**
- **Annual TexSAW (Texas Security Awareness Week) established in October 2011**
- **Hosted NIST Cyber Security Information Sharing Symposium, September 2013.**
- **NSA/DHS CAE and CAE-R certifications under the NSA's new requirements in June 2014**
- **Presentations at the National Privacy Research Strategy meeting on February 18-20, 2015 in Arlington VA, and assist in developing programs**
- **Member of NIST FFRDC in Cyber Security with MITRE and U of MD System**
- **NSA/DHS Center for Excellence in Cyber Operations in June 2015; first university in TX and 14th in the US**
- **Chaired Women in Cyber Security Conf. and Established Center for Engaging Women in Cyber Security, Sept. 2016**
- **Hosting ACM CCS (#1 Cyber Security Research Conference) in October 2017.**

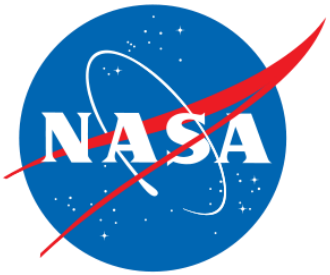
Our History and Accomplishments

- **Over $36M in research funding and $8M in education funding in 12 years from federal agencies**
- **Prestigious grants and contracts including the following:**
  - **Multiple NSF CAREER (100% success for NSF CAREER 5/5)**
  - **Multiple AFOSR YIP**
  - **DoD MURI and several Mini-MURIs ($1-2M+ grants).**
  - **NSF Large SatC and multiple Medium SatC**
  - **NSF MRI (Major Research Instrumentation)**
  - **NSA Research Grant Competition held in 2015**
  - **Highly Competitive and Prestigious NSF/VMware Partnership Research Grant (Small center scale award).**
  - **UT System National Security Network Grant.**
- **Fellowships and Awards:**
  - **IEEE, AAAS, IACR Fellowships, IBM Faculty Award, IEEE and ACM Awards**
  - **e.g., IEEE CS Technical Achievement, ACM SIGSAC Outstanding Contributions Award, IEEE SMC/Homeland Security Technical Achievement, ACM CODASPY Research Award, IEEE CS Services Computing Research Innovation Award, AFCEA Medal of Merit**

Our History and Accomplishments

- **Numerous keynote addresses, top-tier journal and conference publications (e.g., IEEE S&P, ACM CCS, ACM KDD, ACM SIGMOD, Usenix Security, NDSS), open source tools, multiple patents, books.**
- **Affiliated I/UCRC (Industry University Cooperative Research Center)**
- **Student Placements (SFS students and PhD students):**
  - **Government: NSA, CIA, NAVAIR, Federal Reserve, …**
  - **FFRDC and Labs: MITRE, MIT Lincoln, Applied Physics Lab, Sandia, Los Alamos, …**
  - **Industry: IBM TJ Watson, Google, Microsoft, Amazon, E-Bay, Yahoo, Raytheon, L-3, TI, HP, VCE, Ericsson, AT&T, Blue Cross Blue Shield, Cisco, Facebook, Intel, Linkedin, …**
  - **Academia: UNCC, Clemson, UCSD Medical School, Vanderbilt Medical School, UT Southwestern Medical Center, US Military Academy at West Point…**

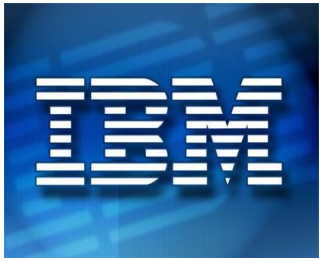
Our Sponsors (Sample)



IARPA
BE THE FUTURE

Sandia National Laboratories

MITRE



Raytheon

Tektronix®

vmware®

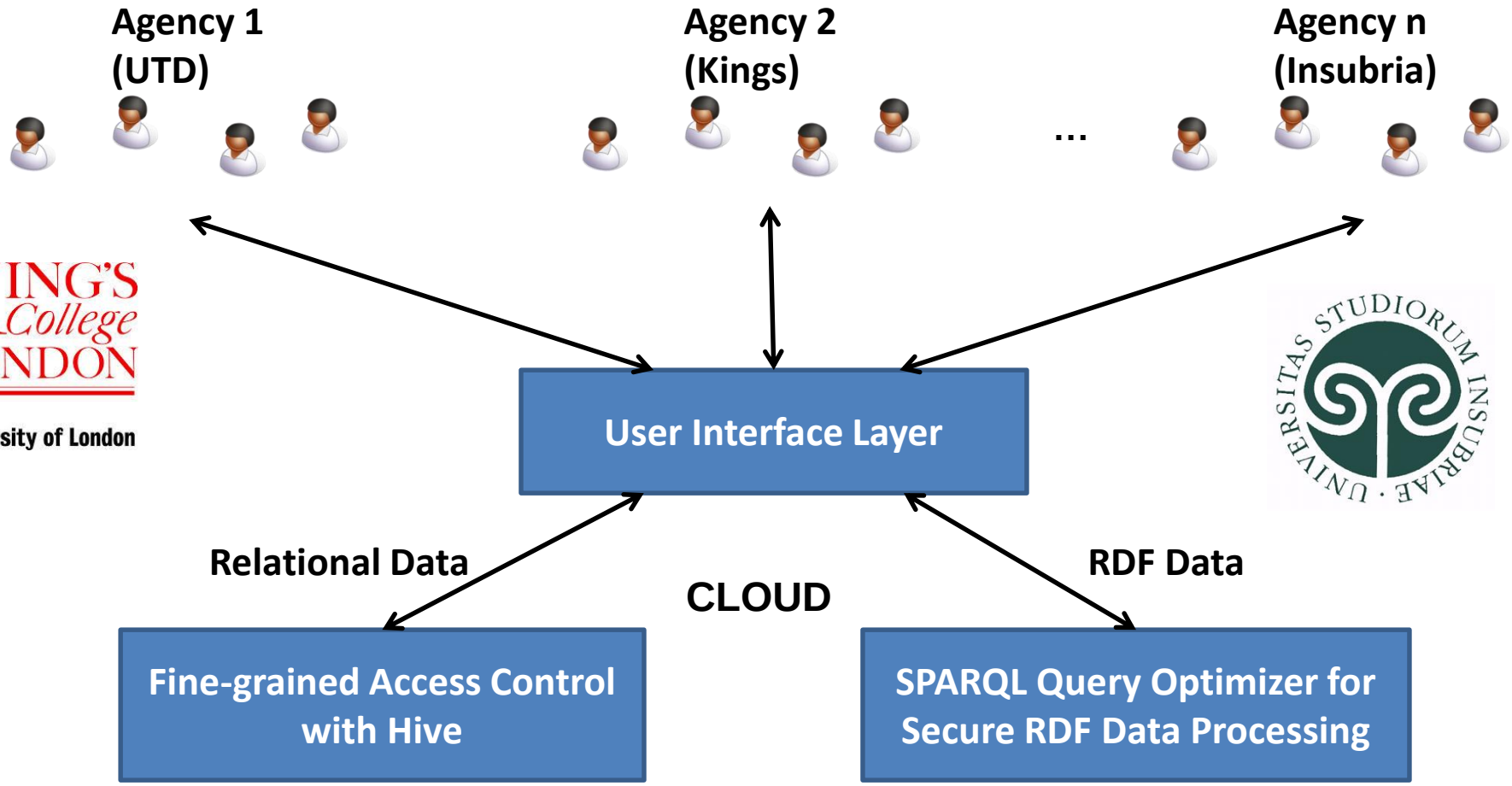
NOKIA

Our Academic Collaborators (Funded Research)

UTD/Kings College, London/U of Insubria, Italy Collaboration sponsored by AFOSR/EOARD

Cloud-based Assured Information Sharing

http://www.wpafb.af.mil/News/Article-Display/Article/400150/afosr-funded-initiative-creates-more-secure-environment-for-cloud-computing/



Initial List of Nine Collaborators on Funded INSuRE NSA/NSF Project

Other Collaborations (Sample)

- **ARL South: Research on Adversarial Machine Learning**
  - **UTD focus on Computer Sciences; ARL focus on Behavioral Sciences**
  - **UTD support from ARO**
  - **Participated in ARL Planning Workshop on Cyber Fogginess (January 2016)**
- **AFRL: UTD faculty have participated as visiting scientist**
  - **Cloud Computing Security**
- **Collaboration with NIST**
  - **Member of the Academic Advisory Council for NIST FFRDC**
  - **Research Collaboration wish NIST on Cyber Physical Systems Security**
  - **Participating in NIST Big Data Security and Privacy Working Group**
- **Collaboration with NSA TX Planned**
  - **NSA TX visiting us on August 23, 24 2017 to discuss collaborations**
  - **Preparing two Science of Security Proposals to be submitted on August 21 (one team with Purdue, other with Vanderbilt)**

Research Thrust - 1

- **Active Malware Defense (Hamlen et al)**
  - **Sponsors: AFOSR, NSF, NSA, NASA, Sandia, ONR, DARPA, Raytheon**
    - **Reactively Adaptive Malware and Frankenstein; Reverse Engineering for Malware Detection; Android Malware Detection; Host Health Management; Author Attribution**
  - Frederico Araujo**, Kevin W. Hamlen**, Sebastian Biedermann, Stefan Katzenbeisser: From Patches to Honey-Patches: Lightweight Attacker Misdirection, Deception, and Disinformation. ACM Conference on Computer and Communications Security 2014: 942-53
  - Richard Wartell, Vishwath Mohan, **Kevin W. Hamlen**, **Zhiqiang Lin**: Binary stirring: self-randomizing instruction addresses of legacy x86 binary code. ACM Conference on Computer and Communications Security 2012: 157-168
  - David Sounthiraraj, Justin Sahs, Garret Greenwood, **Zhiqiang Lin**, **Latifur Kha**n: SMV-Hunter: Large Scale, Automated Detection of SSL/TLS Man-in-the-Middle Vulnerabilities in Android Apps. NDSS 2014
  - Yangchun Fu, **Zhiqiang Lin**, **Kevin W. Hamlen**: Subverting system authentication with context-aware, reactive virtual machine introspection. ACSAC 2013: 229-238
  - Vishwath Mohan, **Kevin W. Hamlen**: Frankenstein: Stitching Malware from Benign Binaries. WOOT 2012: 77-84

Research Thrust - 2

- **Data Security and Privacy (Kantarcioglu et al)**
  - **Sponsors: AFOSR, NSF, NIH, ARO**
    - **Privacy Preserving Record Linkage and Mining; Adversarial Machine Learning; Secure Data Provenance; Policy and Incentive-based Assured Information Sharing; Security and Privacy for Social Networks; Inference Control; Risk-aware Data Security and Privacy**

- Yan Zhou, **Murat Kantarcioglu**, **Bhavani M. Thuraisingham**, Bowei Xi: Adversarial support vector machine learning. KDD 2012: 1059-1067
- Mohammad Saiful Islam, Mehmet Kuzu, **Murat Kantarcioglu**: Inference attack against encrypted range queries on outsourced databases. CODASPY 2014: 235-246
- Mehmet Kuzu, **Murat Kantarcioglu**, Elizabeth Ashley Durham, Csaba Tóth, Bradley Malin: A practical approach to achieve private medical record linkage in light of public resources. JAMIA 20(2): 285-292 (2013)
- Raymond Heatherly, **Murat Kantarcioglu**, **Bhavani M. Thuraisingham**: Preventing Private Information Inference Attacks on Social Networks. IEEE Trans. Knowl. Data Eng. 25(8): 1849-1862 (2013)
- Hyo-Sang Lim, Gabriel Ghinita, Elisa Bertino, **Murat Kantarcioglu**: A Game-Theoretic Approach for High-Assurance of Data Trustworthiness in Sensor Networks. ICDE 2012: 1192-1203

Research Thrust - 3

- **Secure Cloud Computing (Lin et al)**
  - **Sponsors: NSF, AFOSR, VMware**
    - **Virtual Machine Introspection and VM Space Traveler; Secure Virtualization; Hybrid Cloud Security; Secure Cloud Data Storage; Secure Cloud Query Processing; Assured Information Sharing in the Cloud**

- Yangchun Fu, **Zhiqiang Lin**: Space Traveling across VM: Automatically Bridging the Semantic Gap in Virtual Machine Introspection via Online Kernel Data Redirection. IEEE Symposium on Security and Privacy 2012: 586-600
- Alireza Saberi, Yangchun Fu, **Zhiqiang Lin**: Hybrid-Bridge: Efficiently Bridging the Semantic-Gap in VMI via Decoupled Execution and Training Memoization. NDSS 2014
- Erman Pattuk, **Murat Kantarcioglu**, **Zhiqiang Lin**, Huseyin Ulusoy: Preventing Cryptographic Key Leakage in Cloud Virtual Machines. USENIX Security 2014: 703-718
- Safwan Mahmud Khan, **Kevin W. Hamlen**: Hatman: Intra-cloud Trust Management for Hadoop. IEEE CLOUD 2012: 494-501
- Kerim Yasin Oktay, Vaibhav Khadilkar, Bijit Hore, **Murat Kantarcioglu**, Sharad Mehrotra, Bhavani M. Thuraisingham: Risk-Aware Workload Distribution in Hybrid Clouds. IEEE CLOUD 2012: 229-236

Research Thrust - 4

- **Cyber Physical Systems Security, IoT Security (Cardenas, Haas, Liu, et al)**
  - **Sponsors: NSF, MITRE, NIST, Intel, AFOSR**
    - **Control Systems Security, Integrating Secure Systems with Real-time Systems, Policy-related Security**

- Carlos Barreto, Jairo Alonso Giraldo, **Alvaro A. Cárdenas**, Eduardo Mojica-Nava, Nicanor Quijano: Control Systems for the Power Grid and Their Resiliency to Attacks. IEEE Security & Privacy 12(6): 15-23 (2014)
- Carlos Barreto, **Alvaro A. Cárdenas**, Nicanor Quijano, Eduardo Mojica-Nava: CPS: market analysis of attacks against demand response in the smart grid. ACSAC 2014.
- Junia Valente, **Alvaro A. Cárdenas**: Using Visual Challenges to Verify the Integrity of Security Cameras. ACSAC 2015: 141-150
- Carlos Barreto, **Alvaro A. Cárdenas**: Incentives for demand-response programs with nonlinear, piece-wise continuous electricity cost functions. ACC 2015: 4327-4332
- **Cong Liu**, Jian-Jia Chen: Bursty-Interference Analysis Techniques for Analyzing Complex Real-Time Task Models.RTSS 2014: 173-183
- Jian-Jia Chen, Wen-Hung Huang, **Cong Liu**: k2U: A General Framework from k-Point Effective Schedulability Analysis to Utilization-Based Tests. RTSS 2015: 107-118

Research Thrust - 5

- **Hardware Security (Makris, Rajendran et al)**
  - **Sponsors: NSF, ARO, Intel, TI, SRC**
    - **Hardware Trojans, Counterfeiting, IP Piracy, Reverse Eng., Security Verification and Validation, EDA Tools for Security**

- Yu Liu, Ke Huang, **Yiorgos Makris**: Hardware Trojan Detection through Golden Chip-Free Statistical Side-Channel Fingerprinting. DAC 2014: 1-6
- Ke Huang, Yu Liu, Nenad Korolija, John M. Carulli, **Yiorgos Makris**: Recycled IC Detection Based on Statistical Methods. IEEE Trans. on CAD of Integrated Circuits and Systems 34(6): 947-960 (2015)
- Ujjwal Guin, Ke Huang, Daniel DiMase, John M. Carulli, Mohammad Tehranipoor, **Yiorgos Makris**: Counterfeit Integrated Circuits: A Rising Threat in the Global Semiconductor Supply Chain. Proceedings of the IEEE 102(8): 1207-1228 (2014)
- **Jeyavijayan Rajendran**, Ramesh Karri, James Bradley Wendt, Miodrag Potkonjak, Nathan R. McDonald, Garrett S. Rose, Bryant T. Wysocki: Nano Meets Security: Exploring Nanoelectronic Devices for Security Applications. Proceedings of the IEEE 103(5): 829-849 (2015)
- **Jeyavijayan Rajendran**, Ozgur Sinanoglu, Ramesh Karri: Regaining Trust in VLSI Design: Design-for-Trust Techniques. Proceedings of the IEEE 102(8): 1266-1282 (2014)

Research Thrust - 6

- **Data/Security Analytics (Khan et al)**
  - **Sponsors: IARPA, NASA, NGA, AFOSR, Raytheon, Tektronix, Nokia**
    - **Security integrated with Semantic Web Data Management, Geospatial Data Management; Stream-based Novel Class Detection; Social Network Data Analytics; Big Data Management and Analytics.**

- Mohammad M. Masud, Qing Chen**, Latifur Khan**, Charu C. Aggarwal, Jing Gao, Jiawei Han, Ashok N. Srivastava, Nikunj C. Oza: Classification and Adaptive Novel Class Detection of Feature-Evolving Data Streams. IEEE Trans. Knowl. Data Eng. 25(7), 2013\
- Pallabi Parveen, Nate McDaniel, Varun S. Hariharan**, Bhavani M. Thuraisingham**, **Latifur Khan**: Unsupervised Ensemble Based Learning for Insider Threat Detection. SocialCom/PASSAT 2012: 718-727
- Ahsanul Haque, Swarup Chandra, **Latifur Khan**, Charu Aggarwal: Distributed Adaptive Importance Sampling on graphical models using MapReduce. IEEE BigData Conference 2014: 597-602
- Ahsanul Haque, Brandon Parker**, Latifur Khan**, **Bhavani M. Thuraisingham**: Evolving Big Data Stream Classification with MapReduce. IEEE CLOUD 2014: 570-577

Research Thrust - 7

- **Network Security/Cryptography (Haas, Sarac, Desmedt, Cobb, Mittal, et al)**
  - **Sponsors: NSF, CISCO**
    - **Wireless Network Security, Network Measurements, Network Protocol Security, Key Management and Group Communication**

- **Zygmunt J. Haas**: Keynote: Information Assurance in sensor networks. PerCom Workshops 2011
- S. M. Nazrul Alam, **Zygmunt J. Haas**: Coverage and connectivity in three-dimensional networks with random node deployment. Ad Hoc Networks 34: 157-169 (2015)
- Milen Nikolov, **Zygmunt J. Haas**: Towards Optimal Broadcast in Wireless Networks. IEEE Trans. Mob. Comput. 14(7): 1530-1544 (2015)
- **Yvo Desmedt**, Josef Pieprzyk, Ron Steinfeld, Xiaoming Sun, Christophe Tartary, Huaxiong Wang, Andrew Chi-Chih Yao: Graph Coloring Applied to Secure Computation in Non-Abelian Groups. J. Cryptology 25(4): 557-600 (2012)
- Ramon Novales, **Neeraj Mittal**, **Kamil Saraç**: SKAIT: A parameterized key assignment scheme for confidential communication in resource constrained ad hoc wireless networks. Ad Hoc Networks 20: 163-181 (2014)

Cyber Security Education (Sarac et al)

- **Sponsors: NSF, DoD, IBM, NSA**
  - **NSF SFS Scholarship for Service**
    - **Started in Fall 2010 and would have graduated 50+ US Citizen students by 2020 and placed them with Federal Government.**
  - **DoD IA Scholarship**
    - **Participated in the DoD IASP Program for Capacity Building and Student Education in the mid to late 2000s.**
  - **NSA GenCyber 2016**
    - **Summer camp for Junior and Senior High School students in practical cyber security education and experimentation.**
  - **NSF Capacity Development**
    - **Assured Cloud Computing, Secure Mobile System (smart phones), Planning for Big Data Security and Privacy.**
    - **Developing labs and practical programs for students**
  - **Experimental Research Project INSuRE**
    - **Participating in INSuRE program for five straight semesters since January 2015.**

Cyber Security Education (Sarac et al)

- **Sponsors: NSF, DoD, IBM, NSA**
  - **TexSAW: Annual cyber security exercises and competitions**
    - **Modeled after NYU's CSAW.**
    - **Held since 2011; Around 40-80 students participate from TX and neighboring states in practical cyber security exercises and workshops.**
  - **Professional Education**
    - **Offering courses on Cyber Security Essentials that cover the CISSP modules as well as additional topics in Cyber Security for the Local Industry and Students (especially non Computer Science students).**
    - **Have also taught for AF Bases via AFCEA as well as to the DoD and the Intelligence Community.**
  - **Cyber Security Outreach**
    - **Talks at High Schools, DFW Public Libraries to make the students and public aware of Cyber Security**

Cyber Security Education (Sarac et al)

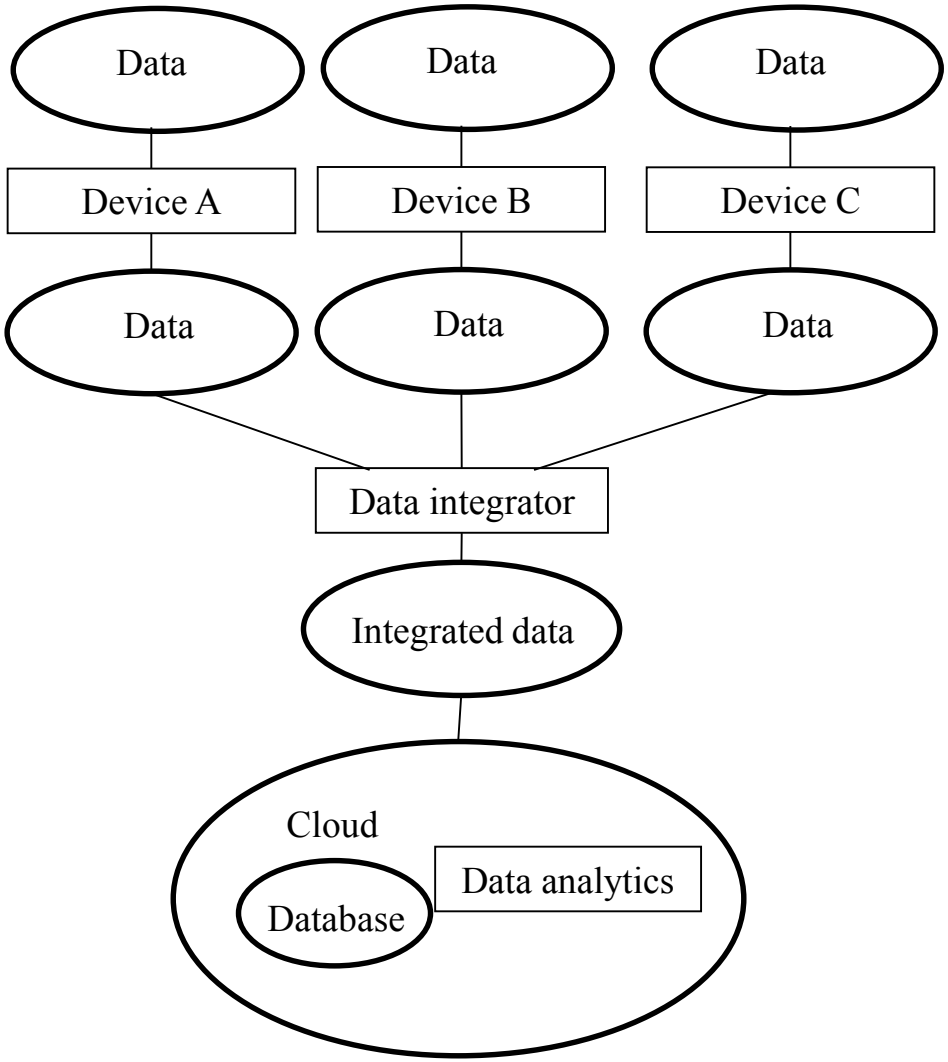
- **Sponsors: NSF, DoD, IBM, NSA**
  - **Degrees and Certificates**
    - **Masters degrees in Cyber Security (special track), Certificates for Undergraduate students, Around 40+ PhD students working on their Theses in Cyber Security at any one time.**
  - **Courses Offered**
    - **Computer and Information Security, Network Security, Data and Applications Security and Privacy, Digital Forensics, Cryptography, Secure Web Services, Secure Cloud Computing (with support from IBM and NSF), Hardware Security, CISSP Modules as part of Cyber Security Essentials, Secure Social Networks, Machine Learning for Security, Big Data Analytics, Critical Infrastructure Protection, Biometrics, Security Engineering, Software Reverse Engineering, Control Systems Security, Cyber Physical Systems Security, Binary Code Analysis.**
    - **Planned: Cyber Operations, Mobile System Security, Reverse Engineering for Malware.**

Sample Systems, Prototypes and Tools Developed from Research, Education and Experimentation

- Data Analytics Tools for Malware Detection (Khan)
  - Botnet detection, Email worm detection, Buffer overflow detection
- Cyber Deception Tools and Experimentation with Malware(Hamlen)
  - Honeypatching, Frankenstein
- Secure Cloud Data Storage System (Kantarcioglu)
  - Currently being commercialized with NSF SBIR
- Social Media Analytics System (Thuraisingham)
  - Two patents and exploring commercialization
- Reverse Engineering and Binary Code Analysis Tools (Lin)
  - Multiple systems including smart phone malware analysis
- Other Tools and Systems
  - Hardware Trojan Detection (Makris)
  - Tools for IoT Security (Cardenas)
  - Network Measurements (Sarac)

Cyber Operations Lab: Initial Stage

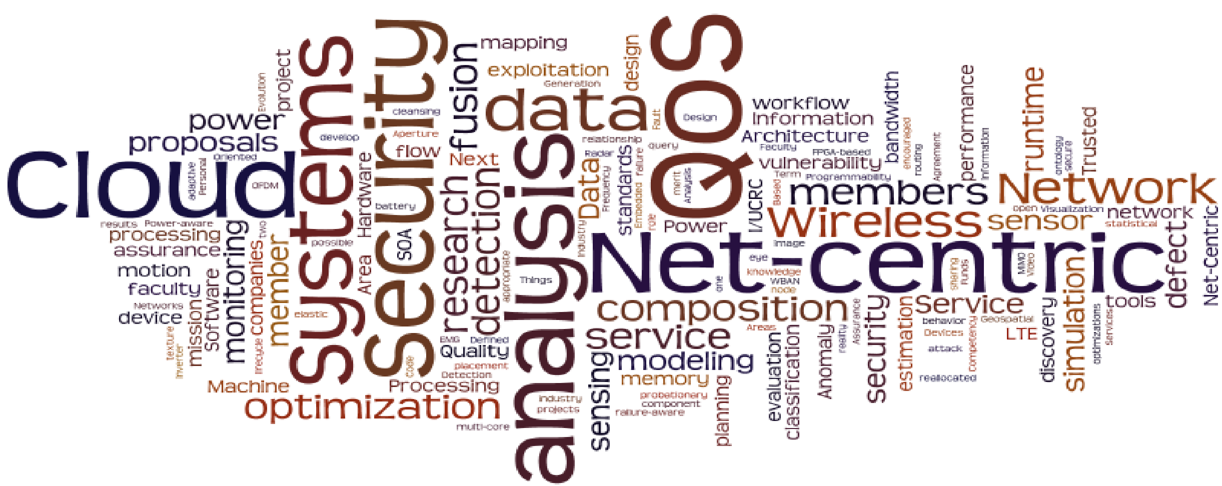
- **SAIAL Lab being converted into a Secure IoT Systems Lab**
  - **Layered Architecture (Hardware, Network, System, Database, Applications such as smart phones)**
  - **Student projects (BS, MS, PhD) to carry out attacks at different levels (ethical hacking) and develop security solutions.**
  - **Will be made available to our partners in government, industry and academia.**



Affiliated I/UCRC: Net-Centric and Cloud Software Systems (NCSS):

Dr. Farokh Bastani et al

- Independent Center affiliated with the Cyber Security Institute
- Net-Centric and Cloud Software & Systems
  - Develop net-centric applications
    - Integrate communication systems, networked sensor systems, command and control systems, etc.
  - Service-based and component-based technologies
    - Compose services into applications dynamically; Verification, validation, and reliability assessment of the composed system in real-time
    - Incorporate security services to assure overall system security
  - Leverage cloud computing for deployment of composite systems
    - Resource management, SLA compliance, workload modeling



Some NCSS I/UCRC Members

UNT
UNIVERSITY OF NORTH TEXAS

UT DALLAS

SMU

ASU ARIZONA STATE UNIVERSITY

MISSOURI S&T
University of Science & Technology

Summary and Directions

- **Summary**
  - **NSA/DHS Certifications in CAE, CAE-R, and Cyber Operations**
  - **Award Winning Faculty with Research in all aspects of Cyber Security with Publications in Top Tier Journals and Conferences.**
  - **Strong Cyber Security Education Program with multiple NSF SFS grants.**
  - **Collaborations with Academia, Industry and Government Labs**
  - **Multiple Patents and Commercialization Activities**
  - **Prestigious Grants including NSF CAREERs, AFOSR YIPs, MURI, NSA/VMWare Research Partnership.**
- **Directions**
  - **Establish an Industry Consortium**
  - **Fully Functional Cyber Operations Lab**
  - **Large Center Grant ($10M+)**
  - **UT System-wide Collaboration Project Possibly via UT System National Security Network**

Contact

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