MULTIDISCIPLINARY EDUCATION AND RESEARCH AT CSI

IA/CD units in Non-IA courses

IA/CD units and modules are included in several of the Non IA tracks at UTD. In addition there are special tracks in Non-IA/CD areas that provide complementary skills required to carry out IA Research. We provide a sample. http://catalog.utdallas.edu/2013/graduate/programs/ecs/computer-science#computer-science-mscs

CS 6360 Database Design: Methods, principles, and concepts that are relevant to the practice of database software design. Database system architecture; conceptual database models; relational and object-oriented databases; database system implementation; query processing and optimization; transaction processing concepts, concurrency, and recovery; security. This course introduces students to the fundamental concept in relational databases. Students are introduced to: 1) Conceptual, logical and physical organization of data, 2) Use of both formal and commercial (e.g. SQL/PL-SQL) query languages, 3) Query optimization and 4) XML, XPath, and Xquereis. These concepts are exercised further by a number of assignments (homeworks) and two exams that involve design and implementation of services provided by a relational file system and semi-structured data models. Data security is also introduced as part of this course.

CS 6390 Advanced Computer Networks
In this class, we spend two lecture hours covering an overview of fundamental network security topics including symmetric and asymmetric key crypto and secure hash functions and their use in building secure remote authentication protocols as well as secure communication services for confidentiality, integrity and source authentication. We also cover KDCs and PKIs and SSL and its use for secure online commerce applications. The class also includes a hands-on homework exercise where students analyze network traffic captured from an operational network and infer application layer activities involved in the generation of the traffic. Finally, we use another hands-on homework exercise where students use various network debugging and diagnostic tools to query and learn configuration information about an operational network.

CS 6362 Advanced Software Architecture and Design Concepts
This course describes the methodologies for the development, evolution, and reuse of software architecture and design, with an emphasis on object-orientation. Identification, analysis, and synthesis of system data, process, communication, and control components. Decomposition, assignment, and composition of functionality to design elements and connectors. Use of non-functional requirements for analyzing trade-offs and selecting among design alternatives. Transition from requirements to software architecture, design, and to implementation. State of the practice and art. Aspects of security architecture are also introduced in this course.

CS 6367 Software Testing, Validation and Verification
Fundamental concepts of software testing. Functional testing. GUI based testing tools. Control flow based test adequacy criteria. Data flow based test adequacy criteria. White box based testing tools. Mutation testing and testing tools. Relationship between test adequacy criteria. Finite state machine based testing. Static and dynamic program slicing for testing and debugging. Software reliability. Formal verification of program correctness. Aspects of security testing are also introduced in this course.

CS 6375 Machine Learning
Computational limitations of learning machines. This course is extremely beneficial for our IA research in malware detection.

**CS 6371 Advanced Programming Languages**
Functional programming, Lambda calculus, logic programming, abstract syntax, denotational semantics of imperative languages, fixpoints semantics, verification of programs, partial evaluation, interpretation and automatic compilation, axiomatic semantics, applications of semantics to software engineering. This course also introduced students to secure programming languages.

**CS 6378 Advanced Operating Systems**
Concurrent processing, inter-process communication, process synchronization, deadlocks, introduction to queuing theory and operational analysis, topics in distributed systems and algorithms, checkpointing, recovery, multiprocessor operating systems. Security issues such as access control are also introduced in thus course.

**CS5333 Discrete Structures**
This course is about the Mathematical foundations of computer science. Topics include logic, sets, relations, graphs and algebraic structures. In addition, combinatorics and metrics for performance evaluation of algorithms will be covered. This course provides the foundations for understanding the foundations of cyber security needed for many of our IA/CD courses.

**EE/CE/CS 6304: Computer Architecture** (Spring 2012, Fall 2012 - 2013)
Trends in processor, memory, I/O and system design. Techniques for quantitative analysis and evaluation of computer systems to understand and compare alternative design choices in system design. Components in high performance processors and computers: pipelining, instruction level parallelism, memory hierarchies, and input/output. Students will undertake a major computing system analysis and design project. This course prepares students to take the hardware security course **Trusted and Secure Integrated Circuits and Systems.**

**Non-IA Tracks that enhance IA Research**
We have several programs, degrees and tracks both within the School of Engineering and Computer Science (ECS) as well as in other schools that enhance UTD’s IA Research. Due to these programs we have several interdisciplinary projects from NSF, AFOSR and ARO and have substantial number of publications. Below we list a sample of our programs. We also like a sample of our publications resulting from this interdisciplinary research. The names of professors at UTD outside of ECS are in bold.

**Non-IA Tracks in ECS (Engineering and Computer Science)**

**Data Science**
Massive amounts of structured and unstructured data is being generated continuously from sensor network and online user activities on e-commerce and social-media websites. **Big Data,** as this massive amount of data is called, leads to many challenges such as (a) How do companies manage and process this massive amount of data? (b) How do companies automatically learn hidden trends and patterns in this data? (c) How do companies gather actionable intelligence to improve their bottom line? This track covers tools and techniques that directly address these challenges. Students take a variety of courses including Big Data Analytics, Database Systems, Machine Learning and Statistical Methods. The track is relevant to IA as many of the data analytics tools are utilized in our research for malware detection.
Executive Masters in Software Engineering
UTD has initiated The Executive Master of Science in Computer Science - Software Engineering. The first batch of students is expected to graduate in Spring 2014. The program offers a number of courses including in software architectures, database systems and cyber security. It provides practical professional education to Dallas-area software professionals, preparing them for positions of increasing responsibility throughout their careers. The Cyber Security course which is being taught during Spring 2014 covers the CISSP (Certified Information Systems Security Professional) Modules as well as topics in Critical Infrastructure Protection among others. [http://cs.utdallas.edu/executiveMSSE/](http://cs.utdallas.edu/executiveMSSE/)

Systems Engineering
Systems Engineering is a department in the School of Engineering and Computer Science. It offers a Certificate in Cyber Security Systems (CCSS). This is a graduate level interdisciplinary certificate program in cyber security. The program is a joint program between the Engineering School (Computer Science department and Systems Engineering department) and School of Management (JSOM) at UTD. The program provides a common core for all students in the program and provides specialization in the computer science aspects or systems engineering aspects or management (risk and security audit) aspects of cyber security. The program was approved by the University senate in November 2013 and is now accepting applications for the Fall 2014 semester.

The Six Tracks in Computer Science at UTD
The CS department offers six concentration tracks at the graduate level including: (1) traditional CS, (2) networks and telecommunications, (3) intelligent systems, (4) systems, (5) software engineering, and (6) information assurance/cyber security. Most of these tracks include classes that provide students with the necessary skills to conduct research in IA. In addition, they include various classes where relevant IA topics are included in their syllabi (such as Advanced Computer Networks class in network and telecommunications track covers fundamentals of network security topics and software testing, validation and verification class covers security testing, etc). [http://catalog.utdallas.edu/now/graduate/programs/ecs/computer-science](http://catalog.utdallas.edu/now/graduate/programs/ecs/computer-science)

Non-IA Tracks in Other Schools at UTD
The Naveen Jindal School of Management (JSOM) offers a variety of Master of Science degrees as well as Certificates which includes concentration in Information Assurance.

(a) The Master of Science in Information Technology and Management (MS ITM) degree program requires a minimum of 36 semester credit hours consisting of basic business courses, IT foundation courses, IT elective courses and other electives. The business courses give students a better understanding of issues that occur at the interface between IT and business. The IT foundation courses cover the essentials of IT. The IT elective courses provide in-depth knowledge of technology and technology-management issues. In addition, students may select approved electives that maximize their goals. The program also offers opportunities for students with special interests to concentrate in a specific track within the IT area, such as business intelligence and analytics, enterprise systems, information security and assurance, IT consulting and management services, or healthcare systems.

(b) Obtaining certifications in specific areas of IT can enhance career prospects. Certifications relevant to IA/CD are in Business Intelligence and Data Mining. This is because we conduct extensive research on applying analytics for cyber security applications. The certificate program, which requires courses in business perspective, statistics, data preparation, and data mining,
demonstrates the working partnership between UT Dallas and SAS Institute, a leading provider of data mining and business intelligence software and services.

(c) The graduate certificate in Healthcare Information Technology (IT) emphasizes practical concepts in healthcare IT and hands-on experience gained using electronic medical records (EMR) software such as Epic. The learning outcomes for the program include the following: Identify and understand the key information requirements for managing and working with healthcare information systems; Understand analytics related to healthcare information to develop sound healthcare decisions; and Understand the core functionalities of a leading EMR software platform, including how it supports clinical information workflows in a paperless environment, and its interconnectivity with other clinical and business systems. We conduct extensive research in data privacy with funding from NIH. Therefore, exposure to healthcare IT-related issues will benefit our students a great deal.

(d) We carry out extensive research with JSOM’s International Center for Decision and Risk Analysis (ICDRiA) on several of our research projects in IA/CD funded by NSF, AFOSR, ARO and others. Risk Management is a growing and highly-relevant field of study. While probability and statistics are the primary quantitative techniques of Risk Management, there are many other techniques (such as optimization, decision theory, control theory, and game theory) which play an essential role in managing risk. The goal is to build both the knowledge and application of these techniques with specific attention to the interdisciplinary aspects. Our approach is to develop relevant models—validated by practitioners—to derive concepts and results which help to understand the impact of uncertainties. We provide useful, tested tools for mitigating risks and decision-making. We focus on the situation of several players, with various possibilities of rules of game. The Center also offers a number of courses in risk management. [http://jindal.utdallas.edu/centers-of-excellence/international-center-for-decision-and-risk-analysis/](http://jindal.utdallas.edu/centers-of-excellence/international-center-for-decision-and-risk-analysis/)

The School of Economic, Political and Policy Sciences (EPPS) offers two graduate certificates relevant to IA/CD. They are in Geospatial Intelligence (GEOINT) and Homeland Security. [http://www.utdallas.edu/dept/graddean/CAT2012/EPPS/PRE/certificates_epps.htm](http://www.utdallas.edu/dept/graddean/CAT2012/EPPS/PRE/certificates_epps.htm) In addition, EPPS also has one of the top criminology programs in the USA as well and a strong program in Economics and Public Policy. Knowledge of these topics is important for our research in (a) geospatial data security, (b) cyber operations, (c) digital forensics, (d) economics of cyber security and (e) policy-related aspects of security and privacy.

(a) The GEOINT certificate program produces graduates that have met the requirements for such professionals set forth by the United States Geospatial Intelligence Foundation (USGIF). The GEOINT is a rapidly evolving field that demands certain technical skill sets, the ability for individual rapid critical thinking and a global awareness of supporting information for national security and other intelligence activities.

(b) Strengthening the preparedness of the U.S requires a body of trained professionals in homeland security. The relative novelty of homeland security as a field of practice and study further strengthens the need for expanding the training and educational needs of both current homeland security professionals and other professionals with an interest in moving in to a career in homeland security. The graduate certificate in Homeland Security is directed to homeland security professionals and those aspiring to such employment in both government and business. [http://www.utdallas.edu/epps/public-affairs/dl/Homeland_Security_Certificate_Flyer.pdf](http://www.utdallas.edu/epps/public-affairs/dl/Homeland_Security_Certificate_Flyer.pdf)
(c) The Center for Crime and Justice Studies’ mission is to advance our understanding of crime and criminal justice through collaboration between criminal justice scholars and criminal justice professionals, to inform criminal justice policy makers and the public on "what works" in criminal justice through transparent scientific and objective research, and to help refine the criminal justice process to reduce the costs of justice while maintaining public safety and public demands for punishment. The Center provides a venue for faculty, graduate students, policy makers, and Criminal Justice practitioners to conduct scientific research pertaining to all things crime and justice. This surrounds human development, criminality, victimization, policing, courts, and reentry back into society. The Center will also offer professional training and certification programs for criminal justice professionals as well as publish newsletters for criminal justice scholars and practitioners on pressing justice related issues. http://www.utdallas.edu/epps/ccjs/

(d) EPPS offers a variety of programs in Economics including a Master of Science in Applied Economics. This degree provides an excellent graduate-level education in economics, with emphasis on the development of theoretical understanding of economic phenomena, quantitative skills that can be applied to economic problems and critical thinking to understand how to best apply economic theory and quantitative skills to real-world problems. The knowledge students gain in Game Theory is especially important for our research in adversarial modeling and mining. http://www.utdallas.edu/epps/economics/degrees.html

(e) EPPS offers a Masters degree in Public Policy (MPP). What makes a professional career in public policy unique is the emphasis on tackling "wicked problems" — the challenging issues that define the public agenda and require talented individuals to devote their energy to finding solutions. The MPP degree offers students an education to succeed in this dynamic, global workforce. Our interdisciplinary degree will teach students economic and statistical analyses as well as communication skills that will help them succeed. We conduct extensive research in data privacy and believe that students will benefit from exposure to policy related aspects.

The School of Brain and Behavioral Sciences (BBS) at UTD has graduate programs in cognitive neuroscience and psychology, among others. We conduct joint research with BBS to understand the minds of the hackers and therefore these programs are relevant to our research in IA/CD. http://bbs.utdallas.edu/graduate/

(a) The Master of Science degree in Applied Cognition and Neuroscience (ACN) program incorporates methodologies from such diverse fields as psychology, neuroscience and computer science. Students in the ACN program may choose to specialize in one or more of the following areas: Cognition and Neuroscience, Computational Modeling/Intelligent Systems, Human Computer Interaction, and Neurological Diagnosis and Monitoring. http://bbs.utdallas.edu/acn/

(b) The Master of Science in Psychological Sciences program provides advanced psychology training to prepare serious student scholars for nationally prominent doctoral programs in clinical and experimental psychology. Students will obtain research experience, advanced coursework and applied experience in psychology. This research-focused program requires students to work with a research mentor and to be actively involved in at least one research laboratory throughout the two-year training. Students also have the opportunity to gain additional applied experiences through the thriving internship program in the School of Behavioral and Brain Sciences. http://bbs.utdallas.edu/psycims/

UTD’s School of Arts and Humanities provides one of the top and fastest growing programs in the world in Arts and Technology. This program is carried out jointly with the School of Engineering and Computer
Science (ECS). The undergraduate Arts and Technology program will offer a focused, rigorous, interdisciplinary education emphasizing the creation, application and implications of interactive digital content. The program will emphasize the fusion of creative with critical thinking and theory with practice. Students will gain both practical skills and conceptual understanding. In addition to the basic understanding of the interaction of technology with the creative arts, students may choose from elective possibilities to focus on either Digital Arts and Design, which will emphasize the role and potential of computer-generated visual images, or Games and Interactive Narrative, which will emphasize the nature and potential of interactive games. Arts and Technology majors at UT Dallas will be prepared to make use of their academic training in a wide range of occupations in industries such as advertising, communications, education and entertainment. UTD’s Cyber Security Institute Faculty is having discussions with the Arts and Technology Program director on how to incorporate security and privacy aspects into their program.

http://www.utdallas.edu/ah/students/degrees.html

Sample Publications Resulting from the Interdisciplinary Research with names of professors in JSOM, EPPS and BBS in bold.

- Murat Kantarcioğlu, Alain Bensoussan, SingRu Celine Hoe: Investment in Privacy-Preserving Technologies under Uncertainty. GameSec 2011:219-238 (with JSOM)
- Daniel C. Krawczyk, James Bartlett, Murat Kantarcioğlu, Kevin W. Hamlen, Bhavani M. Thuraisingham: Measuring expertise and bias in cyber security using cognitive and neuroscience approaches. ISI 2013:364-367 (with BBS)

Item 4 Part b
b. Non-IA courses encourage papers in IA topics or projects. Provide links to 5 to 10 best thesis, dissertation, or projects in IA within 3 years of application. Link to actual papers required – not a subscription service.
Points: 1 point per paper/only 2 papers per course/up to 5 points.

Prof. Latifur Khan
While Prof. Khan is a member of the Core IA Faculty due to his extensive research in Data Mining for Malware Detection, he is a renowned expert in data analytics. Below are his student’s thesis and papers that include aspects of IA/CD. For example, his student Dr, Farhan’s thesis was on Cloud Query Processing. One chapter of this thesis is on access control for the cloud where query rewriting techniques are developed in accordance with the security policies (Chapter 7 of Thesis). Similarly Dr. Neda's thesis also has a chapter on privacy preserving federated query processing (Chapter 7). Furthermore, Dr. Sunitha’s thesis deserves extensive applications of formal methods for data model interoperability (Appendix), and Dr. Abrol’s thesis work has been expanded into a system for homeland security applications with a patent pending.

PhD Thesis

Sunita Ramanujam (PhD. 2011), Towards an Integrated Semantic Web: Interoperability Between Data Models Ph.D. Thesis (Advisors: Latifur Khan and Kevin Hamlen), The University of Texas at Dallas, Richardson, Texas, December 2011. [BibTeX].

Student Papers

Tahseen Al-Khateeb, Mohammad M. Masud, Latifur Khan, Bhavani M. Thuraisingham: Cloud Guided Stream Classification Using Class-Based Ensemble. IEEE CLOUD 2012: 694-701


Tahseen Al-Khateeb, Mohammad M. Masud, Latifur Khan, Charu C. Aggarwal, Jiawei Han, Bhavani M. Thuraisingham: Stream Classification with Recurring and Novel Class Detection Using Class-Based Ensemble. ICDM 2012: 31-40, 2011


Dr. Bhavani Thuraisingham
While IA/CD is Dr. Thuraisingham’s main focus, she is also involved in data analytics for counter-terrorism applications (she has a certificate in Terrorism Studies in St. Andrews University Scotland.). Below is a sample of her papers that are mainly involved with data analytics.

Neda Alipanah, Pallabi Parveen, Latifur Khan, Bhavani M. Thuraisingham: Ontology-Driven Query Expansion Using Map/Reduce Framework to Facilitate Federated Queries. ICWS 2011: 712-713


Prof. I-Ling Yen
Prof. Yen conducts research in dependable systems that has included secure dependable systems research. Sample of her papers with her students are listed below.

- **Panfeng Xue, I-Ling Yen, Kendra M. L. Cooper**: QoS-driven dynamic adaptation in media intensive systems. *SOCA 2011*: 1-8

**Prof. Neeraj Mittal**

Prof. Mittal conducts research in distributed systems that has included secure distributed systems research. Sample of his papers with his students are listed below.