Research Relationship to Unifying Theme

Faculty: Pramod Varshney

My current research deals with information fusion in large-scale complex systems. With an extensive amount of information being generated by multiple sources and sensors, it is imperative that the information be integrated and assimilated to generate a consistent and accurate picture of underlying phenomena. While my main focus has been the development of information fusion algorithms thus far, there are two aspects of trust and assurance that need to be looked at. One, we need to be able to assure that the data fusion result is trustworthy and that information sources or fusion devices have not been tampered with. We are currently developing approaches for assured data fusion with specific emphasis on ad hoc mobile networks and distributed sensor networks. Second, the human user should have trust in the fused result being generated and presented. Many times, the human simply turns off the system due to information overload or a lack of trust in the result. One needs to develop approaches to enhance human trust of automated information processing systems and the results generated by it.

Research Relationship to Unifying Theme

Faculty: Jeffrey Stanton

The most complex systems existing in our society today typically comprise both human and technological elements that are intricately linked (e.g., air traffic control systems). For these systems to work effectively and reliably, the people involved must have a clear understanding of the capabilities and limitations of the technology. Armed with this knowledge, people must also have the skill and motivation to exploit the capabilities of the technology effectively and work around its limitations creatively in pursuit of the system's established goals. These three human elements -- knowledge, skill, and motivation -- are essential to the proper functioning of any complex system that includes human beings. By examining human behavior at the individual, small group, and organizational levels, my research provides insights into the conditions that support optimal functioning of the complex system. For example, my research on a behavioral information security examines the role of employee motivation in the provision of effective information security in work organizations. In particular, my work in this area examines the antecedents of motivation, such as organizational commitment, and the consequences of motivation that manifest in particular types of security-related behavior.

Research Relationship to Unifying Theme

Faculty: Scott Bernard

Developing an overall picture of a complex system and its environment is important to establishing trust and security. This type of overall picture is referred to as "enterprise architecture" (EA). EA provides a multi-dimensional, hierarchical view of an organization and the systems contained therein. EA provides current and future views of an organization's business processes, information flows, and supporting technologies. EA also provides standards and planning to manage the ongoing transition from current to future system environments. These EA views and products support the development of an effective assurance and trust strategy for complex systems that address physical security; information authentication, storage, and access; and human factor issues. Without an EA view of complex systems, new development efforts are analogous to adding a room to the house without consulting blueprints.

Research Relationship to Unifying Theme

Faculty: Howard Blair

I am interested in constructing heterogeneous and hybrid complex systems that can be guaranteed to meet rigorous specifications and be controlled. A heterogeneous complex system involves the co-evolution of time-dependent values of large ensembles of variables, where some of them are discrete-valued and some continuous-valued. The evolution of the system through time is also usually dependent on highly structured interdependencies between the variables. The heterogeneous/hybrid distinction is essentially based on the granularity and hierarchical nature of the interdependency relationship among the variables. To investigate such complex systems, I have extended systems of differential equations to incorporate discrete-valued variables that may change value in a fractal manner. These extensions depend upon being able to map continuously and differentiably from a continuous domain of values to a structured domain of discrete values. This work is being applied as a component of a project to model molecular processes in biological systems having to do with gene regulatory networks. The work is also being applied to unify a variety of models of classical and quantum computation in order to rigorously reason about their behavior.

Research Relationship to Unifying Theme

Faculty: Joon Park

To support trust in complex systems, we need to approach not only from technical area but also non-technical areas. Those non-technical areas may include personnel, environmental, and operational disciplines. Although we use the same trust technologies for the same complex system, the level of trust can vary based on the system's environment, users, and operations. Therefore, we need interdisciplinary approaches for trust in complex systems. In this context, I believe the Systems Assurance Institute (SAI) at Syracuse University has a high potential to lead this effort.

Research Relationship to Unifying Theme

SAI Faculty: Shiu-Kai Chin and Susan Older

A common thread throughout our research and educational activities is an emphasis on the mathematical foundations that are necessary for establishing trust in the correctness of hardware and software systems.

Pedagogically, we want students to be able (1) to think critically about the software and systems they create, and (2) to use logic and other mathematical tools effectively to describe, predict, and analyze the behavior of such systems. In our research, we are interested in the construction and application of mathematical models that support reasoning about complex program behavior, such as concurrency and information security. Common themes in my work include the emphasis on notions of composition (i.e., syntax-directed reasoning and component-based construction) and on understanding the relationship between different models and different abstractions.

In past work, we developed a general framework for incorporating fairness assumptions (such as ``every sufficiently enabled entity makes progress'') into a compositional setting, concentrating on a language of imperative, synchronously communicating processes. More recently, we have focused on aspects of security and how formal models and logic can support reasoning about integrity, confidentiality, authentication, and distributed access control.

Research Relationship to Unifying Theme

SAI Faculty: Patricia Longstaff

I have been integrating the work done on complex systems (in the hard sciences and economics) into all my work since I attended the summer program at the Santa Fe Institute in 1995. I have used it extensively to analyze the changes in the communications sector after the introduction of increased competition. It has been a valuable tool for both public policy analysis and strategic management decisions. I am currently using these ideas in a monograph for Harvard on management and public policy responses to concentration in this sector. As part of SAI, I plan to develop complex systems analysis tools that can be used for organizational responses to security issues.

Research Relationship to Unifying Theme

SAI Faculty: Wenliang (Kevin) Du

My research follows three threads. The first thread concentrates on establishing trust in distributed computing, especially, in the area of distributed data mining, distributed knowledge discovery, and distributed information processing. I am interested in applying security techniques (e.g. cryptography, security protocols) to protect private information in distributed computing settings.

The second thread of my research focuses on establishing trust in wireless network environments, especially, in wireless ad hoc networks and wireless sensor networks. I have been working with people in wireless networks area, trying to combine my security background with their wireless network background. Our goal is to develop security services that are secure, energy-efficient and fault tolerant in wireless networks.

I believe computer science/engineering students who graduate from our system assurance program should have solid hand-on experience designing, building, and analyzing secure systems. The third thread of my research aims at this goal. I adopted a pedagogical practice commonly used by operating system and network courses to our computer and network security courses. I have been developing an instructional computer system for these security courses. Based on this system, students can conduct security operations, understand and modify the existing security mechanisms, add new security features, analyze the system's security properties, and detect the system's vulnerabilities.