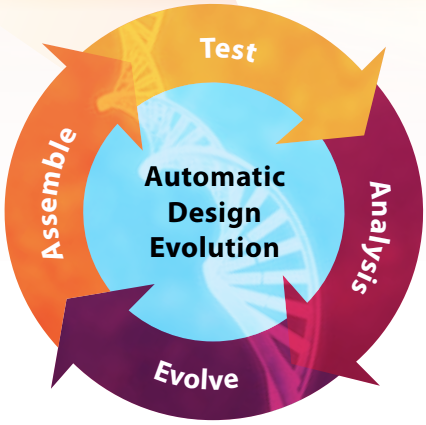
ASC
AUTONOMOUS SECURE COMMUNICATIONS

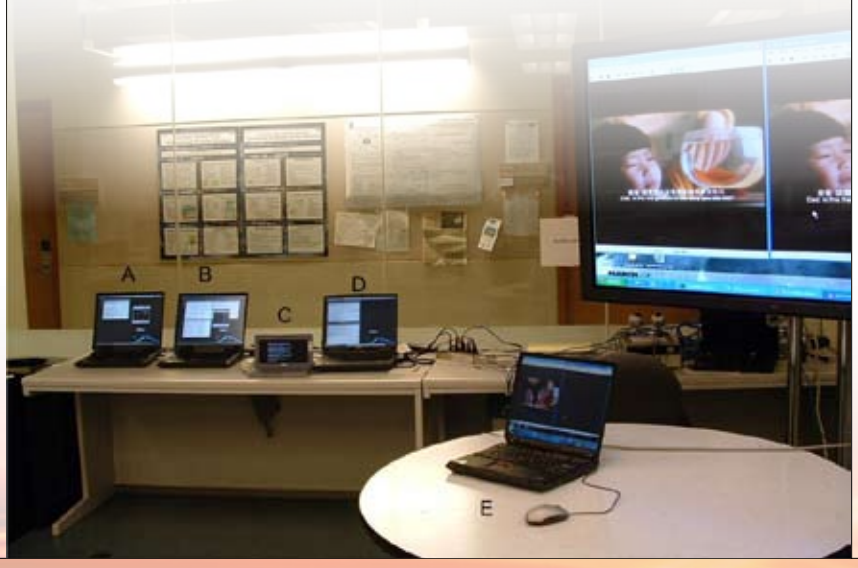
VirginiaTech
Invent the Future

An ICTAS Theme Area



The Need for Research

Modern data networks are complex distributed systems that promise to provide military and civilian users with network connectivity at any location and any time. However, without a robust and secure communication framework, the full potential of communication technology will not be fully realized. This is because the communication environments of data networks can vary dramatically due to changes in node mobility, radio interference, traffic pattern, and energy constraint. In addition, data networks are increasingly becoming the target of malicious attacks. A communication system that lacks robustness and security may crash miserably in these demanding operating environments. Hence, to fully realize the potential of data networks, the ASC team is building an autonomous and secure communication system that dynamically evolves the architecture design of a network according to its environment so that the survivability, availability, manageability, capacity, integrity, and confidentiality of the communication system can stay at its optimal level.



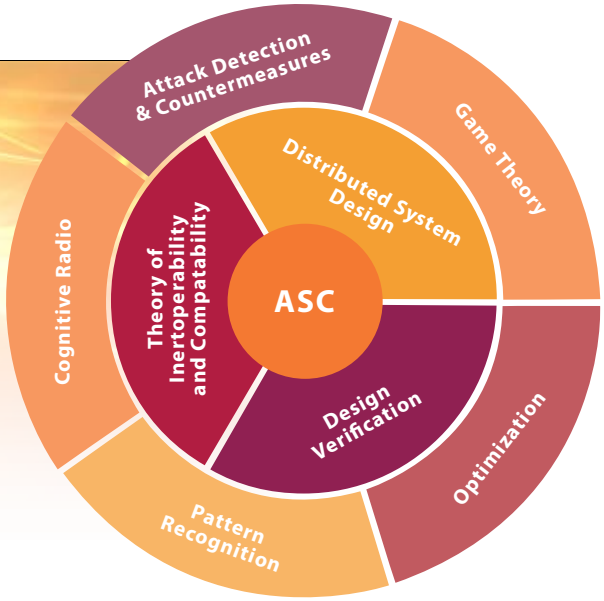
"The ASC team is building an autonomous and secure communication system that dynamically evolves."

Mission

The ASC team focuses on addressing critical challenges for building a self-adaptive communication system with great robustness and security. This multidisciplinary team integrates the most current research in a broad range of technical areas, including telecommunications, network interoperability and compatibility, network attack detection, network attack countermeasure, network abnormality diagnosis, network resource optimization, game theory, formal verification, and distributed system design.

Vision

The ASC team seeks to completely change the current ad hoc and manual ways of network engineering and bring the entire network design field into the new era of automatic system design and adaptation. This evolutionary change will greatly accelerate the advances of communication technologies.



Accomplishments

The members of the ASC team have been leaders in the area of network attack detection, design verification, routing theory, cognitive radio research, signal processing, and network optimization. Funding agencies, including the National Science Foundation, Department of Defense, and Office of Naval Research have given the ASC team members multiple grants and contracts, averaging about $1 million per year over the past several years. Faculty members and researchers in this team have published numerous technical papers and book chapters in these areas. Part of the preliminary research results of ASC won third place in the Grand Final of ACM student research competition, whose award ceremony was jointly held with the ACM Turing award. These past achievements have enabled us to develop the tools, techniques, algorithms, and theories for building this new focus area of ASC systems.

The Technical Approach

Traditional network systems have been designed by network engineers based on complex collections of objectives, policies, principles, and past experiences. The design process is top-down in nature and begins with a set of over-simplified assumptions about the operation environments and performance objectives. Then, using past design experiences, the network engineers come up with a new system design that they believe will be robust and secure for the assumed operation environments. But limited human experience and capability mean this manual process cannot fully evaluate and exploit all possible design space solutions for network systems, resulting in extreme challenges in identifying the best designs and promptly responding to network environment changes.

The aim of the ASC team is to bring revolutionary changes to the current ad hoc and inefficient network design and adaptation situation. The concept of evolution, which has produced extraordinarily complex, diversified, adaptable, and efficient living creatures, will be introduced to the area of network system design. This automatic evolution design starts as a large set of reusable "genes" supplied by network engineers all over the world. Each gene is a small piece of computer code that implements a particular design for a small part of a network component. A new combination of a group of related genes results in a novel design for one component of a network system, such as an intrusion detection system, a routing protocol, or a transmit power adaptation strategy. The adaptability, efficiency, and security of a system design can be seen as a process of assembling a larger system from a number of component parts and then testing the system in the environment in which it finds itself. The selection of genes in the automatic design process is based on the performance analysis and is guided by evolution principles that are derived from interoperability and compatibility theory, optimization theory, and game theory. With the evolution process, not only can the entire design space can be searched for the optimal design, the adaptability of a network system can also be realized by evolving the system design based on the changes in the environment.

The ASC system is made possible by the collaboration of team members with a variety of expertise. The design of ASC integrates technologies from a diversified research disciplines, including attack detection, signal processing, pattern recognition, formal design verification, system compatibility and interoperability theory, game theory, optimization theory, adaptive radio designs, localization theory, and distributed system design.

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