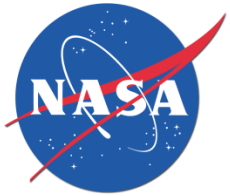
Federal Cyber Security Research Program



Federal Cyber Security Research Program

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Presented by Federal NITRD Program

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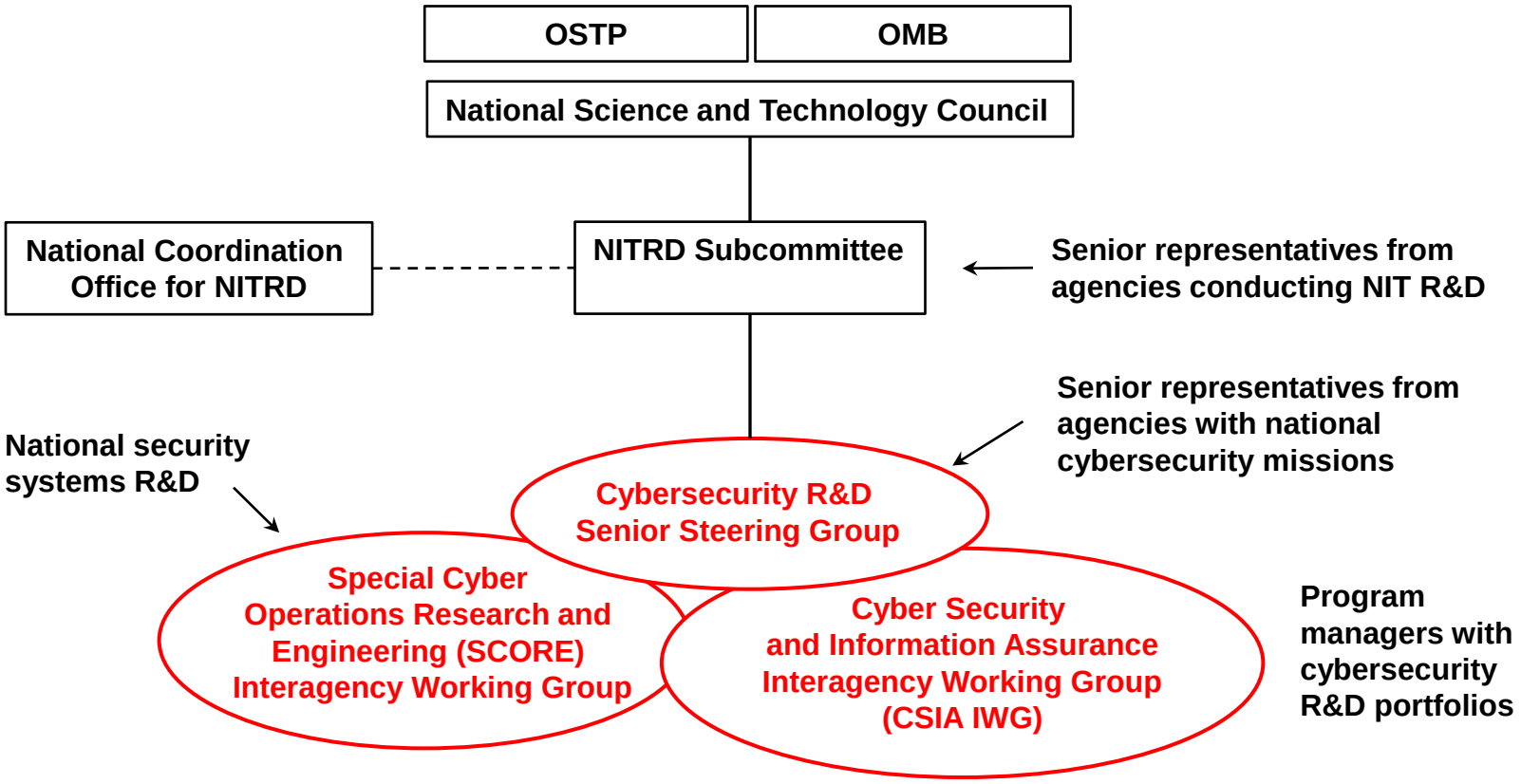
NITRD Structure for Cybersecurity R&D Coordination



Coordinated Effort on Game-Changers

- It's about trustworthiness of digital infrastructure
  - Security, reliability, resiliency, privacy, usability
  - How can we:
    - Enable risk-aware safe operations in compromised environments
    - Minimize critical system risk while increasing adversaries' costs and exposure
    - Support informed trust decisions, necessitating flexible security strategies, and allowing for effective risk/benefit analyses and implementations
- Strong commitment to focus on game-changing technologies for coordinated cybersecurity R&D agenda

Three-pronged Approach

- Themes
- Science of Cyber Security
- Transition to Practice

Coordination Through Themes

- Established through robust community discussion of what matters
- Recognizes that independent thinking is vital to good research
- Motivation not policing
- Provides shared vision of desired end state
- Enables focusing of efforts
- Avoids definitional issues
- Avoids information sharing obstacles caused by varying classification levels
- Results in coordinated activities, not a normalized inventory
- Provides an organizing overlay on existing topic taxonomies

Attributes of a Good Research Theme

- Compels a new way of operating or doing business
- Draws on a number of sciences and technologies (is not a single technology area)
- Is interdisciplinary
- Pokes at least one hard problem
- Requires a multi-year effort with measurable achievements
- Presents a logical path to transition, deployment, and to cooperation with the private sector
- Encourages research be conducted with an adversarial perspective

Ongoing Planning Process

- Annually re-examine themes
  - Enrich with new concepts
  - Provide further definition or decomposition

Initial Themes

- Tailored trustworthy spaces
  - Supporting context specific trust decisions
- Moving target
  - Providing resilience through agility
- Cyber economics
  - Providing incentives to good security

Remember: These are just starting points

Some Potential New Themes

- Design for Assurance (security engineering, practical verification, system architecture, usability)
- Understanding the Cyber Environment (situational awareness, systemic understanding of vulnerability)
- Nature-inspired Solutions (self-healing, evolving, growth)
- Mobility
- Borderless Security

Moving Target

- Controlled change across multiple system dimensions to:
  - Increase uncertainty and apparent complexity for attackers, reduce their windows of opportunity, and increase their costs in time and effort
  - Increase resiliency and fault tolerance within a system

Moving Target Paradigm

- All systems are compromised; perfect security is unattainable
- Objective is to continue safe operation in a compromised environment, to have systems that are defensible, rather than perfectly secure
- Cybersecurity is an adversarial science

Moving Target Challenges

- Managing moving target systems
- Smart movement
- Developing a cyber ecosystem to support agility

Tailored Trustworthy Spaces

In the physical world, we operate in many spaces with many characteristics

- Home, school, workplace, shopping mall, doctor's office, bank, theatre
- Different behaviors and controls are appropriate in different spaces

Yet we tend to treat the cyber world as a homogenous, undifferentiated space

The vision is of a flexible, distributed trust environment that can support functional, policy, and trustworthiness requirements arising from a wide spectrum of activities in the face of an evolving range of threats

TTS Paradigm

- Users can select/create different environments for different activities satisfying variety of operating capabilities
  - Confidentiality, anonymity, data and system integrity, provenance, availability, performance
- Users can negotiate with others to create new environments with mutually agreed characteristics and lifetimes

TTS Challenges

- Specifying a tailored trustworthy space
- Policy specification and management
- Validation of platform integrity
- Violation detection
- Verifiable separation

Cyber Economics & Incentives

- A focus on what impacts cyber economics and what incentives can be provided to enable ubiquitous security:
  - New theories and models of investments, markets, and the social dimensions of cyber economics
  - Data, data, and more data with measurement and analysis based on that data
  - Improved SW development models and support for “personal data ownership”

CEI Paradigm

- Promotion of science-based understanding of markets, decision-making and investment motivation
  - Security deployment decisions based on knowledge, metrics, and proper motivations
  - Promote the role of economics as part of that understanding
- Creation of environments where deployment of security technology is balanced
  - Incentives to engage in socially responsible behavior
  - Deterrence for those who participate in criminal and malicious behavior

CEI Challenges

- Data
  - Legal and ethical collection and distribution
  - Lack of appropriate data to support effective economic analysis
- Empowerment of critical infrastructure providers
  - Provide legal frameworks allowing service providers to be more active in defense of their systems/services
- Personal Info/Behavior
  - Educating/incentivizing users about the benefits of secure practices and acceptable cyber behavior
  - “Personal Data” – who’s accountable?

Three-pronged Approach

- Themes
- ⇨Science of Cyber Security
- Transition to Practice

What is the Science Of Security

- A body of laws that are predictive…
  - Transcend specific systems, attacks, and defenses
- Expectation in 10 years:
  - Applicable in real settings
  - Provide explanatory value
    - Abstractions and models
    - Connections and relationships
  - Not necessarily quantitative, could assert properties or relationships
    - Cannot enforce this policy with that mechanism

Thanks to Fred B. Schneider, Cornell University

Scientific Methods

- Not limited to formal, mathematical model of science
  - This is an important aspect, but perhaps not the most important
- Includes experimental science, field studies, social and behavioral science, principles of engineering which use the Scientific Method
  - Benefits from a hypothesis driven analytical approach with well designed experiments
  - Considerations of shared data set, test methods and facilities
- Aimed at providing repeatability, robust scientific discourse, grounding for research decisions, ability to guide new research efforts

New Government Emphasis Area: Science of Cyber Security

- A major research initiative on the *science of security* that
  - Investigates fundamental laws
  - Will result in a cohesive understanding of underlying principles to enable investigations that impact large-scale systems.
  - Enables repeatable experimentation vice ad hoc test and evaluation
  - Is aggressive in nature
  - Supports high-risk explorations is needed to establish such a scientific basis
  - Public-private partnership of government agencies, universities and industry

Some Potential Science of Security Research Topics

- Methods to model adversaries
- Techniques for component, policy and system composition
- A control theory for maintaining security in the presence of partially successful attacks
- Sound methods for integrating the human in the system: usability and security
- Quantifiable, forward-looking, security metrics (using formal and stochastic modeling methods)
- Measurement methodologies and testbeds for security properties
- Development of comprehensive, open, and anonymized data repositories

What Are Some Scientific Approaches to These Topics?

- Develop constructs that enable us to draw general conclusions or develop solutions that work over a class of problems
  - E.g., Characterize classes of attacks
    - Identify attack classes with class of defenses for prevention
    - Determine classes of properties (confidentiality, integrity, …) affected by attack
- Posit laws that would provide scientific basis for engineered solutions and prove/disprove them or validate/invalidate them through experimentation
  - E.g., Posited: Dynamic defense increases the differential cost of attack

Thanks to Fred B. Schneider, Cornell University

Transition to Practice

- Concerted effort to get results of federally funded research into broad use
  - Integrated demos
  - Conferences and workshops
  - “Matchmaking” efforts
    - Among Agencies
    - Between research and product
  - Potential funding for last mile

Technology Discovery

- Information Technology Security Entrepreneur Forum (ITSEF) – March 2011
- Security Innovation Network (SINET) Showcase – October 2011
- DOD/DHS SBIR Conference – July 2011
- More coordinated Principal Investigator (PI) Meetings
- National Lab Technology Exposition
- Suggestions??

Test & Eval / Exp Deployment

- Partner with operational Dep's/Agencies
- Candidates
  - DREN (DOD Research and Engineering Network)
  - NSF Office of Cyber Infrastructure (OCI)
  - NSA – R2 Living Lab
- Outputs
  - Evaluation in realistic settings
  - Lessons Learned
  - Adoption, Integration, and Use Scenarios

Transition / Commercialization

- DHS S&T System Integration Forum (SIF)
  - VCs, System Integrators, government operational network managers
- DOD Venture Catalyst Initiative (DeVenCI)
- DDRE Open Business Cell (OBC)

- Suggestions??

Selected Current Activities

- NSF's Workshop on the Future of Trustworthy Computing
- DARPA's CRASH program
- IARPA's STONESOUP
- Workshop on Cyber Security Data for Experimentation
- DHS's Cyber Security Industry Day

NSF Workshop on the Future of Trustworthy Computing

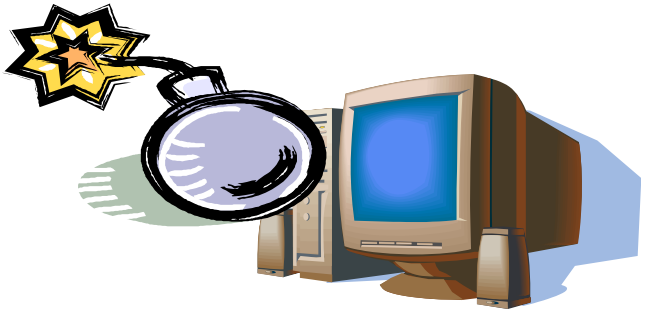
- Goals:
  - Introduce and stimulate ideas about NITRD cybersecurity R&D themes in research community
  - Assist newer researchers in finding productive research directions
- Occurred Oct. 27-29th
  - ~100 attendees in-person, mix of new and experienced
  - Recorded online: http://tc2010.cse.psu.edu/index.html
- Keynotes from
  - David Reed, *SAP Labs*
  - Virgil Gligor, *Carnegie-Mellon University, CyLab*
  - Daniel Geer, *In-Q-Tel*
  - Patrick Lincoln, *SRI International*

NSF Workshop: Panels

- **Tailored Trustworthy Spaces**
  - Chair: Joshua Guttman, *Worchester Polytechnic Institute*
  - William Arbaugh, *University of Maryland,* Carl Gunter, *University of Illinois, Urbana-Champaign,* Ruby Lee, *Princeton University*
- **Moving Targets**
  - Chair: Sal Stolfo, *Columbia University*
  - Anup Ghosh, *George Mason University,* John Knight, *University of Virginia*, Tal Rabin, *IBM Research*
- **Cyber-economics**
  - Chair: Rebecca Wright, *Rutgers University*
  - Matt Blaze, *University of Pennsylvania,* Jens Grossklags, *Princeton University,* Rafael Pass, *Cornell University*
- **Science of Cybersecurity**
  - Chair: Mike Reiter, *University of North Carolina*
  - Andrew Appel, *Princeton University*, Amit Sahai, *University of California, Los Angeles,* Peter Weinberger, *Google*
- NITRD panel
  - Bill Newhouse, *NIST Information Technology Lab,* Douglas Maughan, *DHS S&T,* Steven E. King, *Office of the Director, Defense Research & Engineering,* Sandy Landsberg, *DoE*
- Breakout sessions on each theme

DARPA's CRASH Program

Clean-slate design of **R**esilient, **A**daptive, **S**ecure **H**osts

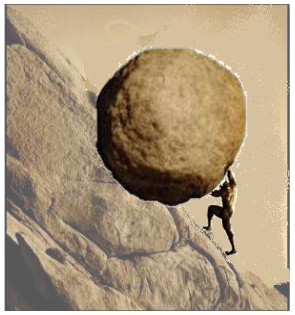


Blow off the Legacy Computational Base
Inspired by biological mechanisms for resilience

- Provably removes whole classes of vulnerabilities
- Learns how to respond to new threats
- Defense in depth
- Diversity, randomization, variability
- Diagnosis, adaptation & self-regeneration

Make The Enemy Push the Rock

Innate immunity rules out all the standard attacks using hardware mechanisms that cannot be bypassed. There are at least two reasons why any attack won't work, both of which would need to be subverted for the attacker to make progress. Even if an attacker gains some access, his ability to exploit the penetration is limited by the hardware enforced access rules.



Adaptive immunity learns to recognize the footprints of novel techniques used by the attacker, catches him earlier in the exploit, prevents him from achieving his goals, and facilitates quicker recovery and regeneration. Inmate immunity buys us time for adaptive immunity to take over and increase the attacker's work factor yet further. As time goes on we know more and more about the attacker and how to stop him.

Dynamic Diversity guarantees that even if an attacker gets past both innate and adaptive immunity, he still has more work to do because what he thought he knew about us is no longer true. As time goes on we know more and more about the attacker while he knows less about us.

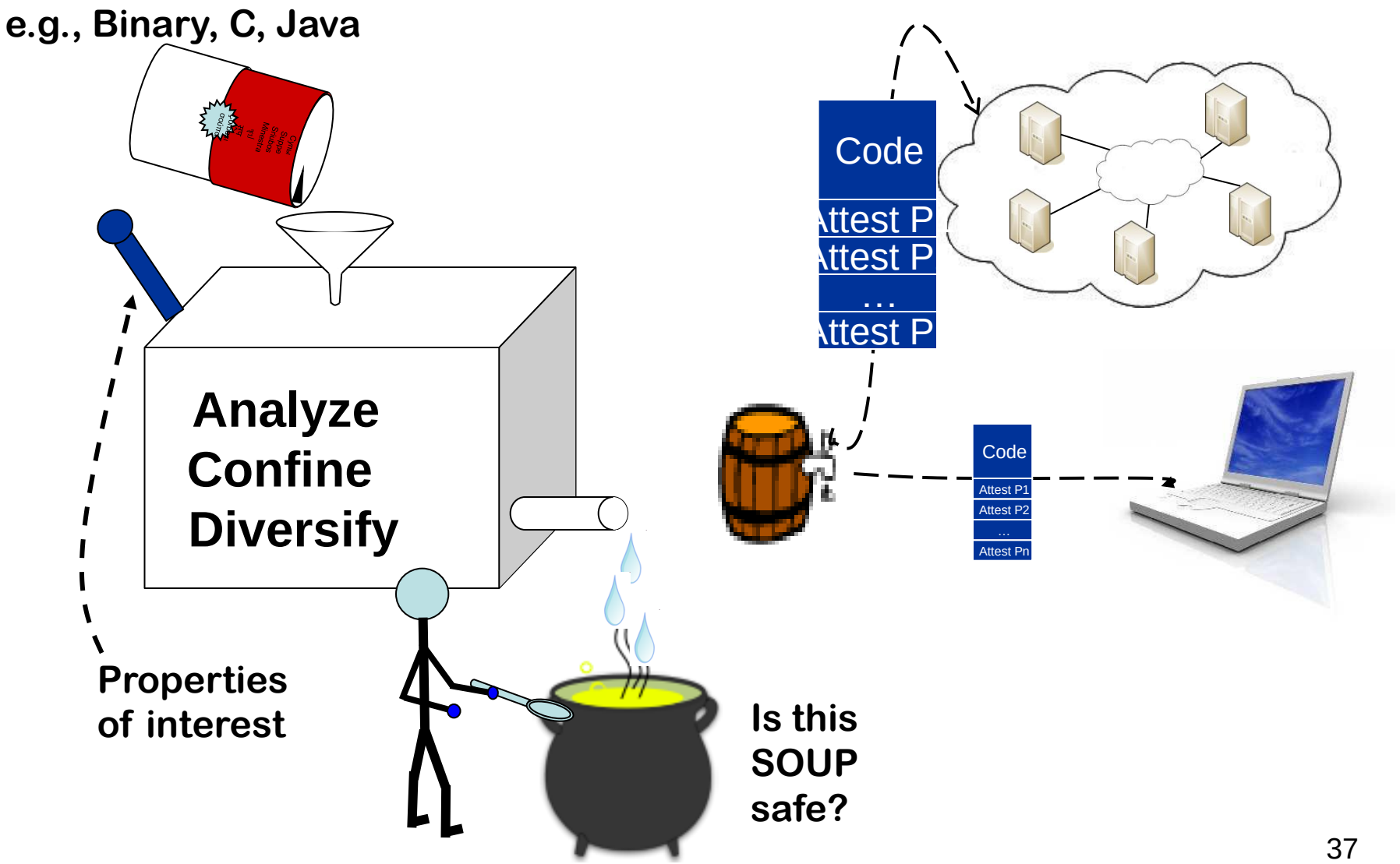
Program Structure

Program Area	Topics
New Processor Design	**Innate immunity** Type & memory safety, Meta-data processing
New OS and Language System Design	**Innate & Adaptive Immunity, Diversification** Decomposition, separation, least privilege, complete mediation, separation of privilege, information flow management
Application middleware	**Adaptive Immunity & Diversification** System modeling & machine learning, self monitoring and diagnosis, self-adaptive software frameworks, automatic patching, memory and instruction set randomization
Formal methods & analysis techniques	Assessing resilience, metrics, co-design of hardware, languages, OS and formal methods, information flow proofs, verification of security properties
Application demonstrators	New demo min-apps built to exploit, demo, & test full framework
Red teaming	Red-teams help design & test from the beginning
Incentives and market analysis	Workshops and analyses of opportunities & incentives for transitioning technologies into DoD & mainstream

IARPA's STONESOUP

- "Securely Taking on New Executable Software of Uncertain Provenance"
- Develop technology that will allow end users to invoke:
  - advanced automated software analysis techniques to identify vulnerabilities or to assure their absence
  - *tailored confinement* of software execution so that identified weaknesses cannot be exploited
  - *diversification* of software components so residual vulnerabilities will be more difficult for attackers to discover or exploit
- High-risk, high-reward: putting tools in the hand of end-users
  - Opportunity to provide feedback to software vendors

STONESOUP Vision



Workshop on Cyber Security Data for Experimentation

- Goal: Bring together academics, companies and government agencies to discuss
  - models of engagement to allow the research community to conduct experiments with real-world data sets
  - how to share research results
  - how funding agencies can facilitate the process
- Sponsored by NSF, DHS, ONR, Treasury, and others
- http://www.gtisc.gatech.edu/nsf_workshop10.html
- Industry involvement
  - Symantec, McAfee, Verisign, Microsoft, Cisco
- NSF plans to support industry/academic data sharing as result of workshop

DHS Cyber Security Industry Day

- Industry Day Session
  - Nov. 17, in Washington DC
  - https://www.fbo.gov/spg/DHS/OCPO/DHS-OCPO/Cyber_Security_Industry_Day/listing.html
  - DHS S&T Cybersecurity R&D BAA upcoming
- Goals:
  - Provide the tools necessary to increase resilience to cyber threats and operational disruptions and the forensic tools to identify perpetrators
  - Engage industry, government, and academia to ensure that the core functions of the internet develop securely and benefit all owners, operators, and users
  - Address economic assessment, risk analysis, and modeling requirements to implement and deploy cyber security technologies
  - Accelerate transition of new cyber security technologies into products and services for end users including DHS, first responders, critical infrastructure providers and sectors, private industry, and government

Other Agency Activities

- DoD
  - ARO: Workshop on Moving Target Defense, GMU, Oct. 25-26
  - AFOSR: Fall 2010 MURI topic on Science of (Cyber) Security
- NIST
  - Active areas include: virtualization and cloud, key management, usability of security, identity management, health IT, Smart grid
  - Recent activity: Second Cloud Computing Forum & Workshop Nov. 4-5 2010; see: http://www.nist.gov/itl/cloud/cloudworkshopii.cfm
- Treasury
  - Sept. 2010 workshop on Financial Services Explained: An Operational Overview
- DoEnergy
  - $30M in cyber security project awards announced Sept. 23, 2010: http://www.energy.gov/news/documents/Cybersecurity-Selections.pdf
  - Office of Electricity Delivery and Energy Reliability: joint funding with DHS of Trustworthy Cyber Infrastructure for the Power Grid (TCIPG) , spring 2010
  - Office of Science: basic research in mathematics of cybersecurity and complex interconnected systems underway

Conclusions

- Coordinated effort among government agencies
- Focus on game-changing themes
  - Encourages research collaborations based on tangible topics
    - Common vocabulary to relate different research activities
  - Will be aware of and reactive to new research directions
- Open to new collaborations, especially between government, industry and academia

For More Information

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