A Scientific Research and Development **Approach to Transform Cyber Security**

A Report Prepared for the

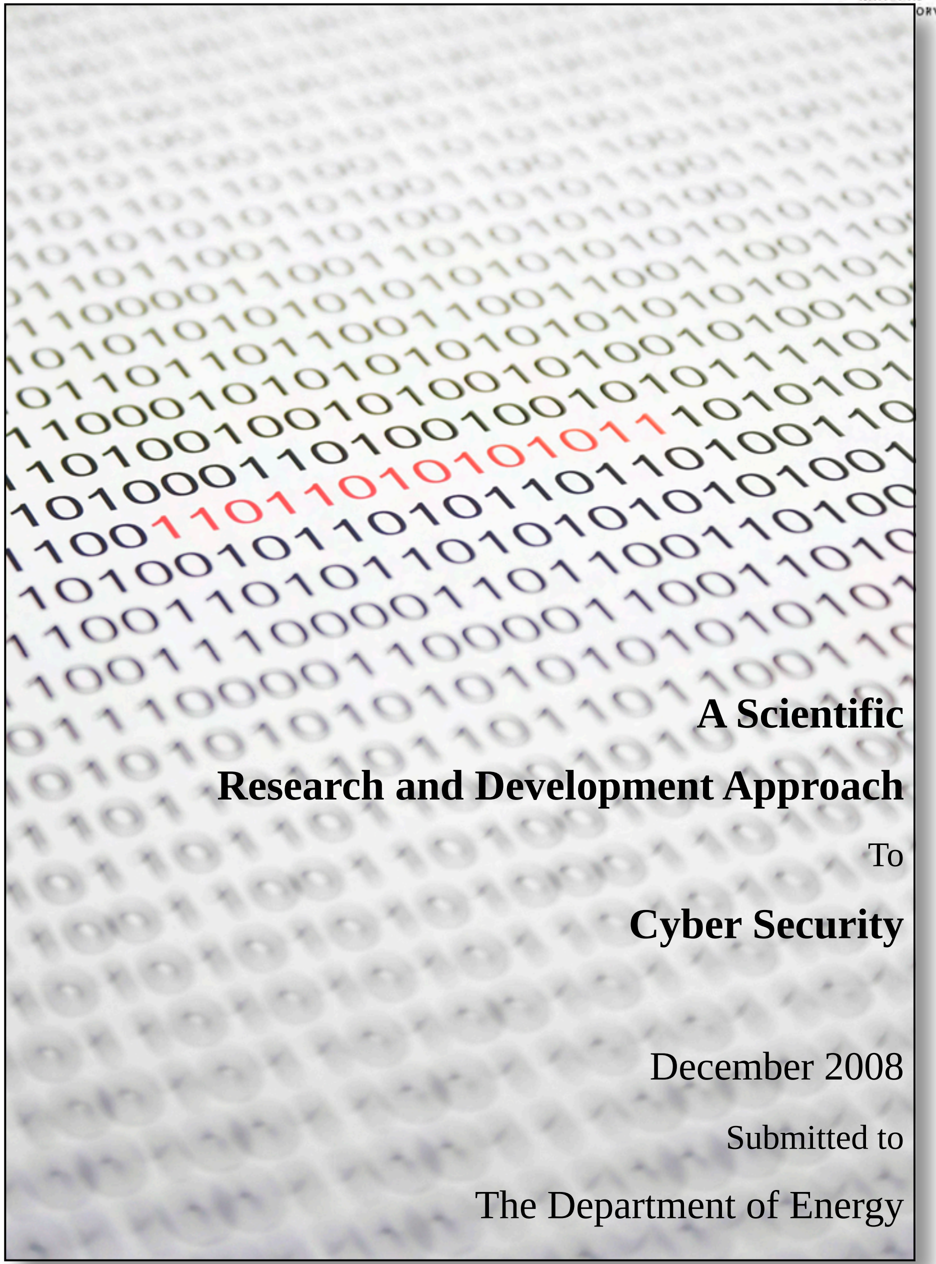
Department of Energy

Charlie Catlett, CIO, Argonne National Laboratory

On behalf of the Cyber Security Community

(DOE Laboratories, Universities, Industry participants)

ASCAC - March 3, 2009

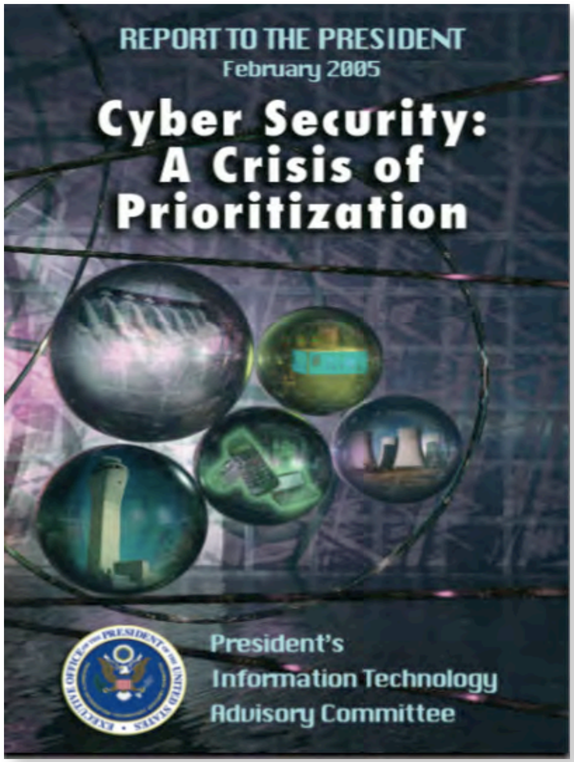


Background

- Summits
- Working Groups
- Open Workshops
- Report Vetted w/ Industry, Multiple Agencies

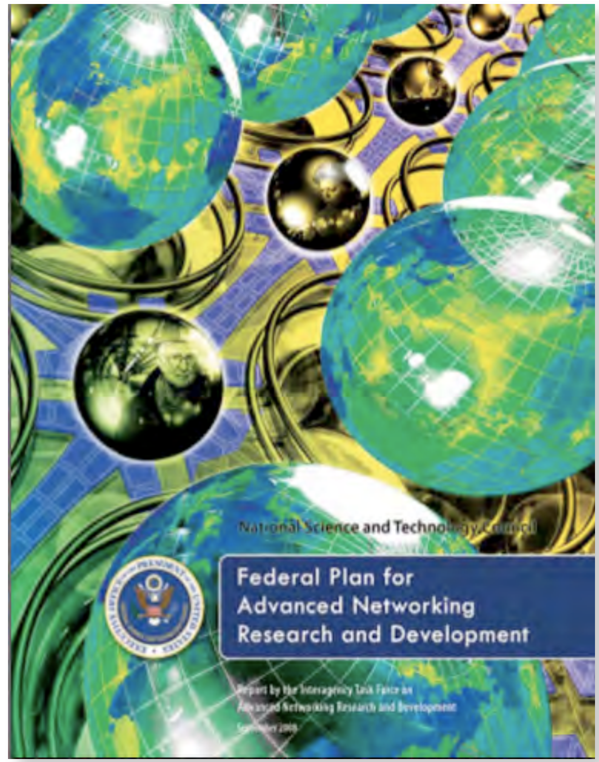
A National *Priority*

2005



"broad failure to invest" in "fundamental research in civilian cyber security."

2007



"The ability to design and develop secure… systems is a national priority."

2008

"special focus and prioritization are needed to respond to current national networking security concerns."

Source: C. Catlett, c@anl.gov

The Department of Energy

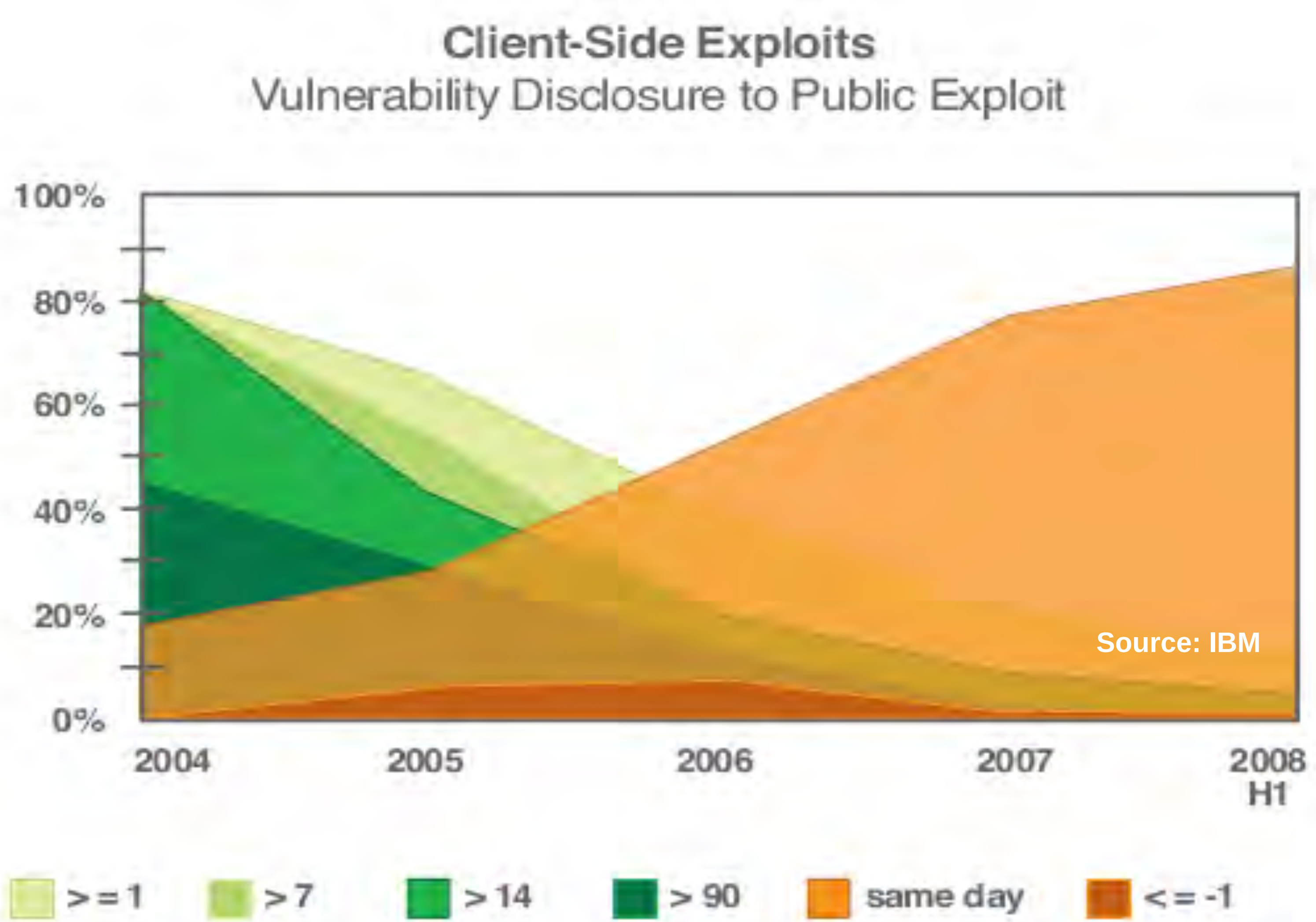
- Unique Requirements
  - National-scale civilian and classified infrastructure, assets, programs
  - International science communities
- Unique Strengths
  - National Laboratories with strong multi-disciplinary programs and rich academic and industry collaborations
  - Mathematics and Computational Science programs coupled with Leadership Class facilities.

Source: C. Catlett, c@anl.gov

Cyber Defense Today

- Mathematics & Computational Science Untapped
  - Mathematics-based Intrusion Detection
  - Limited use of modeling and simulation
- Architecture is Anachronistic
  - Inherent trust among components
  - Passive data
- Policy is Reactive and Tactical
  - Defense against specific, previous tactics
  - Underlying model (layered defense) awkward

Source: C. Catlett, c@anl.gov



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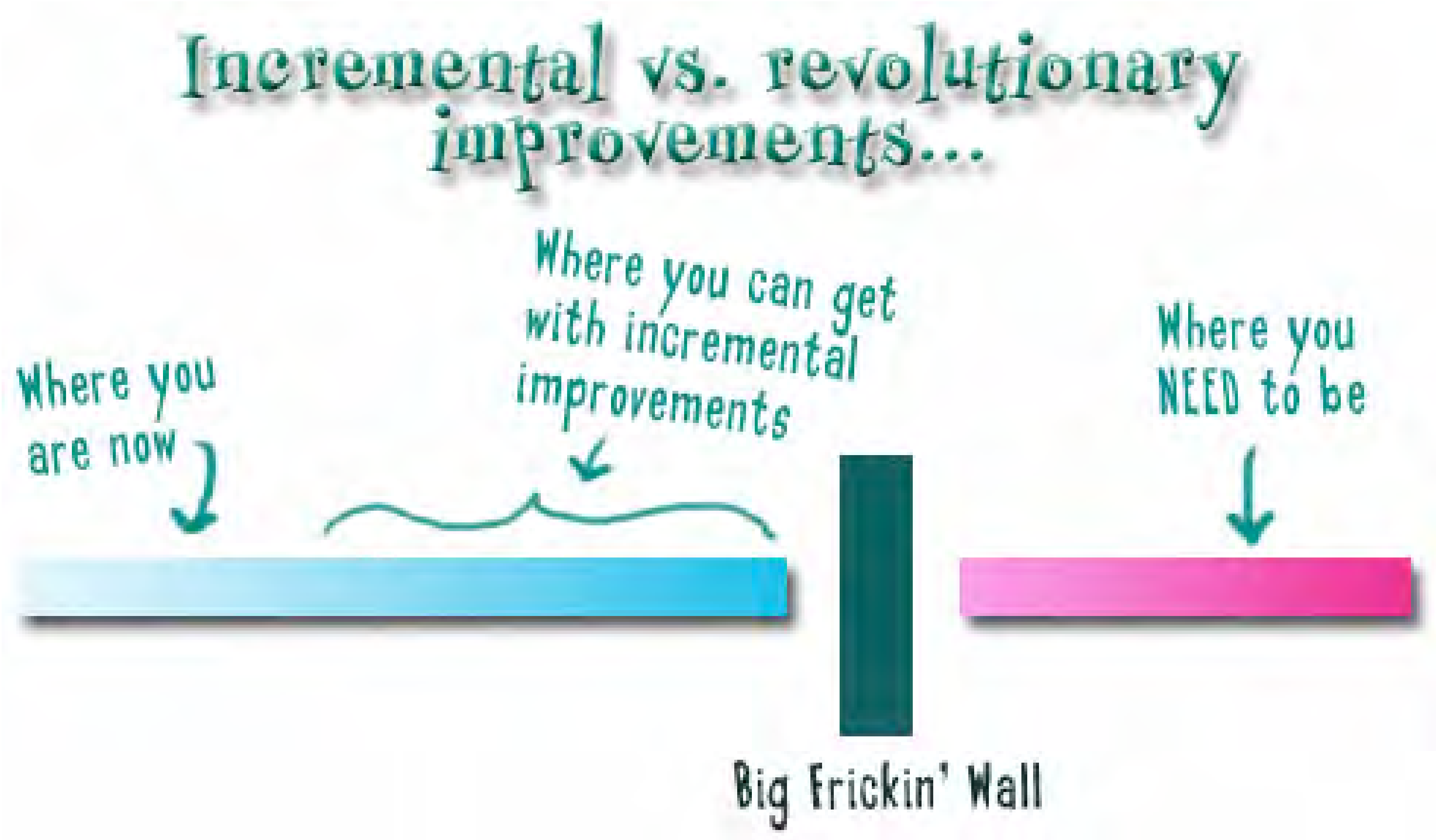
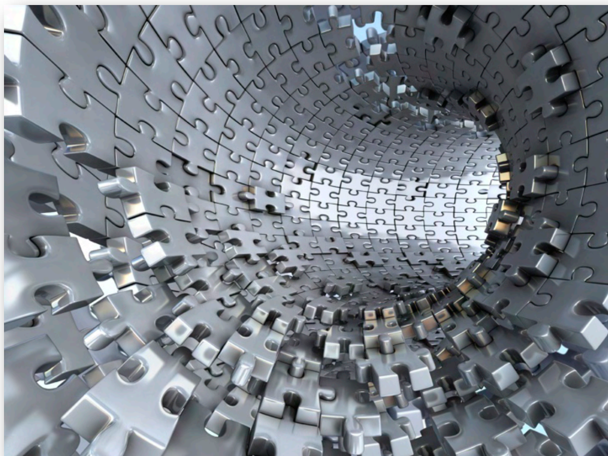
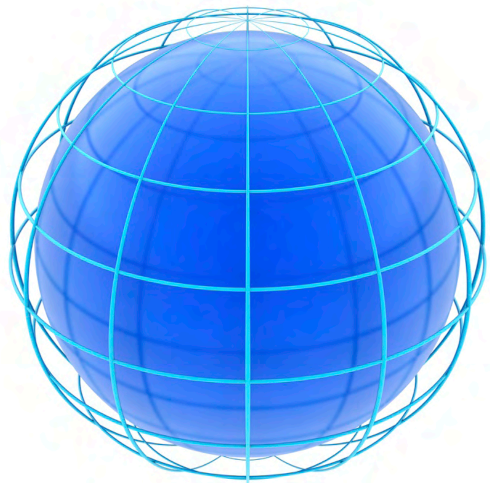


Source: Kathy Sierra

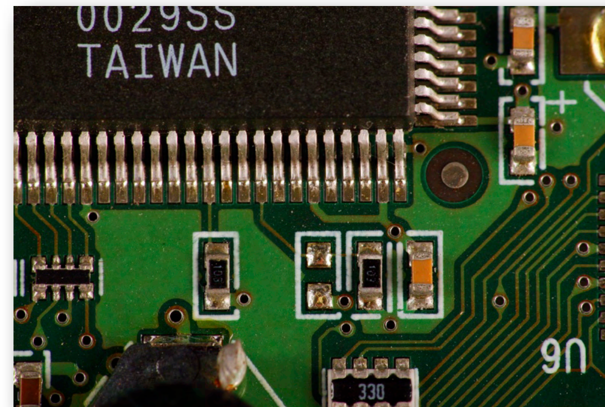
Three Focus Areas



Mathematics
Predictive Awareness for Secure Systems



Information
Self-Protective Data and Software



Platforms
Trustworthy Systems from Untrusted Components

Source: C. Catlett, c@anl.gov

Focus Areas in Context

Argonne NATIONAL LABORATORY

PITAC (2005)

- Authentication Technologies
- Secure Fundamental Protocols
- Secure Software Engineering & Software Assurance
- Holistic System Security
- Monitoring & Detection
- Mitigation & Recovery Methodologies
- Cyber Forensics: Catching & Deterring Criminal Activities
- Modeling & Testbeds for New Technologies
- Metrics, Benchmarks, & Best Practices
- Non-Technology Issues that Compromise Cyber Security

Mathematics
Predictive Awareness for Secure Systems

Information
Self-Protective Data and Software

Platforms
Trustworthy Systems from Untrusted Components

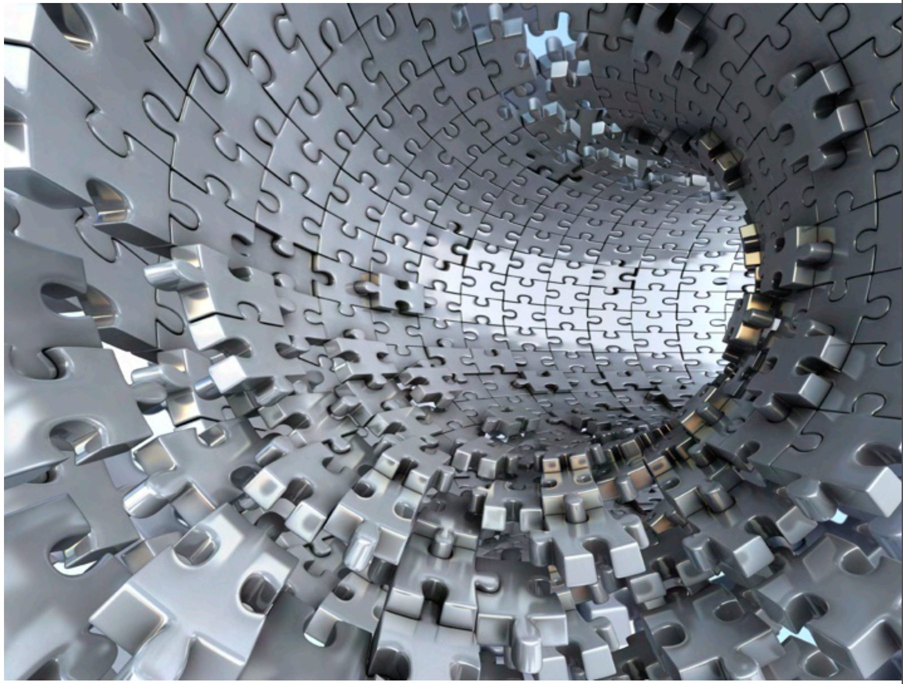
PCAST (2007)

- Comprehensive analysis of potential system-level vulnerabilities to inform the design of inherently secure NIT systems
- Generation of the fundamental building blocks for the development of secure NIT systems
- Usability and related social sciences, because progress in improving the security of NIT systems also involves altering user behavior."

Source: C. Catlett, c@anl.gov

Mathematics: Predictive Awareness for Secure Systems

- **Create** capabilities to examine system or network behavior to anticipate failure or attack, including real-time detection of anomalous activity and adaptive "immune system" response.
- **Requires** a deeper understanding of complex applications and systems, appropriate architectures, techniques, and processes – using data-driven modeling, analysis, and simulation.
- **Leverages** DOE programs in mathematics and computational science, and leadership computing expertise and facilities.

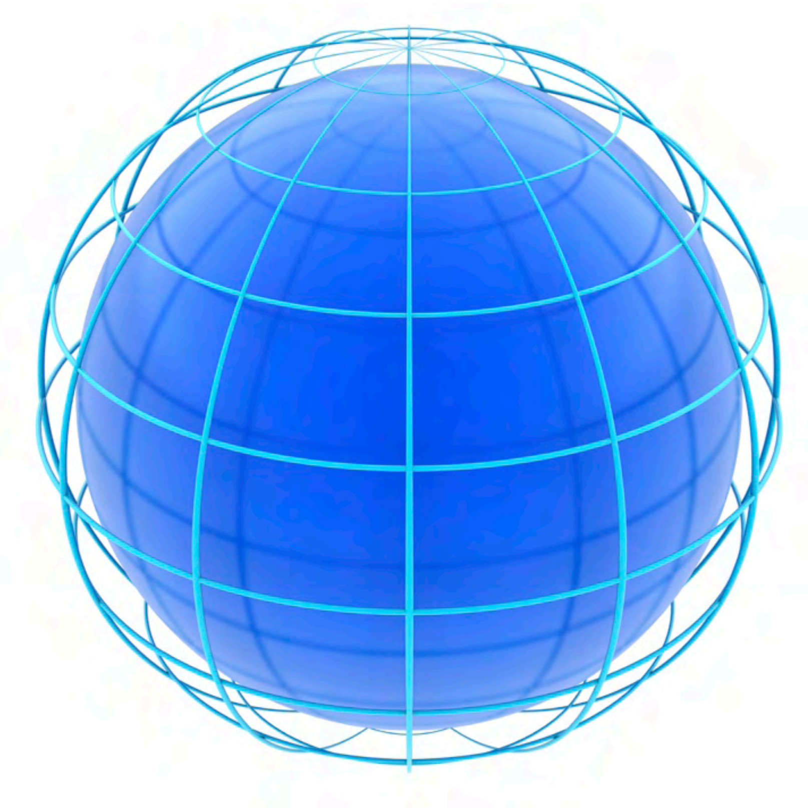


"…meteorology provides proof that complex, evolving, large-scale systems are amenable to mathematical analysis and that the network-security community need not necessarily restrict itself to the (probably oversimplified) models now in the literature." *Workshop on Scalable Cyber-Security Challenges in Large-Scale Networks: Deployment Obstacles, Interagency Working Group for IT R&D, March 2003.*

Source: C. Catlett, c@anl.gov

Information: Self-Protective Data and Software

- **Create** “active” data systems and protocols to enable self-protective, self-advocating, and self-healing digital objects.
- **Requires** data provenance and related research to provide information integrity, awareness of attributes such as source, modification, trace back, and actors; and mechanisms to enforce policy concerning data confidentiality and access.
- **Leverages** DOE leadership in, and mission requirements for, protection of classified and/or controlled information (data, software) and analysis and stewardship of large-scale scientific data sets for international experiments.

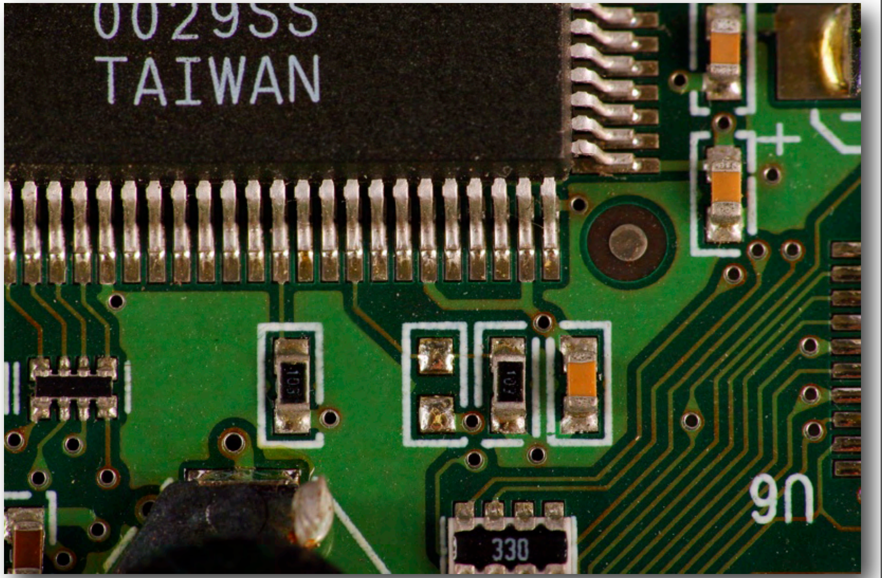


Self-Protective Data and Software

Source: C. Catlett, c@anl.gov

Platforms: Trustworthy Systems from Untrusted Components

- **Create** mechanisms for specifying and maintaining overall trust properties for operating environments and platforms.
- **Requires** techniques for quantifying and bounding security and protection, integrity, confidentiality, and access in the context of a "system" comprised of individual components for which there are varying degrees of trust.
- **Leverages** DOE expertise in hardware and software systems architecture, operating systems, and secure build and test facilities.



Trustworthy Systems from Untrusted Components

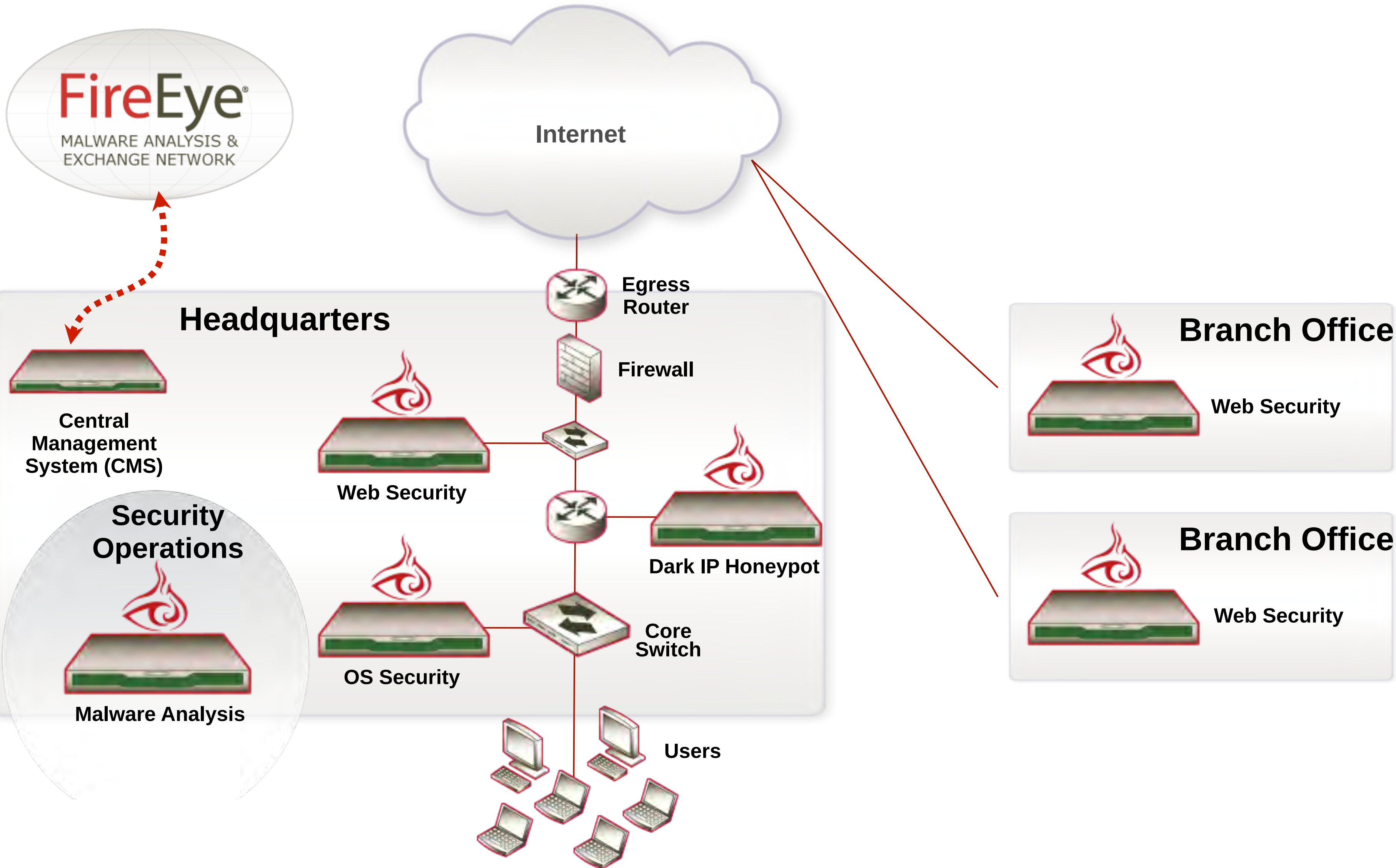
Source: C. Catlett, c@anl.gov

DOE: Uniquely Positioned

	DOE	DARPA	NSF	DOD Labs	NSA, IARPA	NIH	DHS
Programmatic Orientation	Vision & Project	Project	Project	Vision	Project	Vision & Project	Project
“Customer”	Society; Energy	DOD	Society	DOD	Intelligence Community	Society; Medical Community	National Infra.
National Laboratory Assets	✔			✔	✔	✔	
Research Horizon	Near Mid Long	- Mid -	- - Long	- - Long	Near Mid Long	Near Mid Long	Near Mid Long
Typical Performers	Gov Academia Industry	Gov Academia Industry	- Academia -	Gov Academia -	Gov Academia Industry	- Academia Industry	- Academia Industry
Cyber Security Expertise	✔	✔	some	some	✔		✔
Primary Results Applicability	***Flexible***	**Classified**	Open	**Classified**	**Classified**	Open	**Classified**

Source: C. Catlett, c@anl.gov

Example of Industry Work



Source: Ashar Aziz, FireEye Inc.

Recommendations (1 of 2)

- Focus Areas to Harness DOE Strengths
  - Mathematics: Predictive Awareness for Secure Systems
    - Leadership computing, mathematics, and computational science programs – cyber security as a computational science and engineering challenge leveraging INCITE.
  - Information: Self-Protective Data and Software
    - Computer science, computer architecture programs to explore novel approaches to *active* data.
  - Platforms: Trustworthy Systems from Untrusted Components
    - System software and architecture programs to pursue new operating system, distributed application, and platform architectures harnessing state-of-the-art such as multicore.

Recommendations (2 of 2)

- Programmatic Considerations
  - SciDAC-scale multidisciplinary teams
  - “X-Prize” style – clear targets, broad competition
    - Engage Industry
    - Facilitate many “failures” to find diamonds in the rough (aggressive program leadership/management)
  - Proactive research collaboration with industry, other agencies (NSF, DHS) and DOE programs.
  - Harness Leadership Computing, data analysis, and related infrastructure.
    - Support computational science (modeling and simulation) as well as nearer term needs such as sensor data analysis and intensive software vulnerability testing (e.g. “a software wind tunnel”)