Cyber Security—Reality and Perspectives

Universidad Carlos III-SPIN

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CERT® Coordination Center
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Outline of the Presentation

- Overview of the SEI
- The Threat of Cyberterrorism and Internet Attacks
- Cyberterrorism?
- The Cyber Environment
- Security and Survivability
- Statistics---Incident Trends
- The Administrative Overload because of the Incident Trends
- Intrusion Detection
- CERT (Computer Emergency Response Team) Advisories (Alerts)
- Cyberterror Vulnerabilities
- The Software Engineering Institute and Cyber Security
- CERT Centers
- CERT Coordination Center
- US-CERT
- AIRCERT (Automatic Incident Response CERT)
- CERT Analysis Center
- Survivable Systems Initiative
- OCTAVE (Operationally Critical Threat, Asset and Vulnerability Evaluation)
- CSIRT (Computer Security Incident Response Team) Development
- Training
- Survivable Systems Engineering
- Conclusions
Overview of the SEI

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Sponsored by the U.S. Department of Defense
Software Engineering Institute

Applied R&D laboratory, Federally Funded R&D Center, at Carnegie Mellon University, Pittsburgh PA

Mission is to provide leadership in software engineering and to transition new software engineering technology

Encouraged to support industry in precompetitive technology and in technology activities
SEI Organization Chart

Acting Director
Angel Jordan

Chief Operating Officer
Clyde Chittister

Technical Programs
- Networked Systems Survivability
  Rich Pethia
- Product Line Systems
  Linda Northrop
- Software Eng. Process Mgmt
  Bill Peterson
- Dynamic Systems
  Patricia Oberndorf
- Acquisition Support Program
  Brian Gallagher

Customer Service
- Technology Transition Directorate
  Sally Cunningham
- Program Integration Directorate
  Tom Brandt

Administration
- Financial & Business Operations
  Peter Menniti
- Human Resources
  Jill Diskin
- Information Technology
  Steve Huth
### SEI Technical Program

**The right software delivered**

defect free, on cost, on time, every time

<table>
<thead>
<tr>
<th>High confidence, evolvable, product lines</th>
<th>with predictable and improved cost, schedule, and quality</th>
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<tr>
<td>Integration</td>
<td>Capability Maturity Model Integration</td>
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<tr>
<td>Software Intensive Systems</td>
<td>Team Software Process</td>
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<tr>
<td>Survivable Systems</td>
<td>Product Line Practice</td>
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<td>Performance Critical Systems</td>
<td>Predictable Assembly with Certifiable Components</td>
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<tr>
<td>Architecture Tradeoff Analysis</td>
<td>Acquisition Support Systems</td>
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<tr>
<td></td>
<td>Team Software Engineering Measurement &amp; Analysis</td>
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</tbody>
</table>

#### Technical Practice Initiatives

- Capability Maturity Model Integration
- Team Software Process
- Survivable Systems
- Predictable Assembly with Certifiable Components

#### Management Practice Initiatives

- Integration
- Software Intensive Systems
- Product Line Practice
- Architecture Tradeoff Analysis
- Performance Critical Systems
- Technical Practice Initiatives
- Management Practice Initiatives
Visit Our Web Site

http://www.sei.cmu.edu

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Cyberterrorism?

Within the CERT Centers, we have no documented cases of cyber terror, however:

- Crime using Internet technologies is on the rise
- Cyber/Physical connectivity increases the threat
- Traditional terrorist attacks can have significant cyber impact
The Cyber Environment

Cyberspace
- Borderless
- Dynamic
- Anonymous
- Accessible

Not limited to the Internet
- Includes isolated networks
- Embedded systems
- Wireless technology
- Environment expanding to include new technologies
The Cyber Environment

“Urban Sprawl” in Cyberspace
  - Cyberspace has grown exponentially in recent years, now especially with wireless technologies

Expansion leads to increased threat
  - More people are aware of the capabilities of cyberspace (including criminals and terrorists)
  - The cyber and physical environments now overlap and are interdependent
  - Critical infrastructures now rely on the cyber environment
  - As networks, systems, and service multiply, so do vulnerabilities
The Environment – Old Structure

The Net Then – ARPANET 1971
The Old ’Net

ARPANET GEOGRAPHIC MAP, OCTOBER 1980

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The New Net-Still Growing

Source: http://cm.bell-labs.com/who/ches/map/gallery/index.html
Internet Integrated Infrastructure Threat Environment

- Terrorists
- Hackers
- Customers
- Nation States
- ASPs
- Other Systems
- Internet Support System
- Transportation Infrastructure X
- Banking and Finance
- Electric Power
- Business to Business
- Threats
The Threat - Reality

How real is the threat?

- Al Qaeda regularly uses computer technology to pass operational plans & training materials

- Osama bin Laden has stated that the Information and Financial Infrastructures of the U.S. are targets for terrorist action

- The attack on the World Trade Center had a serious cyber impact on the Financial Infrastructure even though it was not the target of the attack

- The Information Infrastructure is designed for efficiency and functionality, not for security or survivability
How Real is the Threat – the stats

- Incidents and Vulnerabilities reported by the CERT C/C
  - CERT/CC Incident Reports
    - 1988-2000: 47,711
    - 1999: 9,859
    - 2000: 21,756
    - 2001: 52,658
    - 2002: 82,094
  - Vulnerabilities Discovered
    - 1995-2000: 2,596
    - 1999: 417
    - 2000: 1,090
    - 2001: 2,437
    - 2002: 4,129
Increasing Vulnerability $\Rightarrow$ Increasing Threat

Total vulnerabilities reported (1995-2002): 9,162
Vulnerabilities Reported to the CERT/CC

Total vulnerabilities reported (1995 - 2003): 12,946
More Vulnerabilities =>
More Incidents

Total incidents reported (1988-2002): 182,463
Incidents Reported to the CERT/CC

Total incidents reported

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Incident Trends are Toward Higher Sophistication

- Email propagation of malicious code
- "Stealth"/advanced scanning techniques
- Widespread attacks using NNTP to distribute attack
- Widespread attacks on DNS infrastructure
- Executable code attacks (against browsers)
- Automated widespread attacks
- GUI intruder tools
- Hijacking sessions
- Internet social engineering attacks
- Packet spoofing
- Automated probes/scans
- DDoS attacks
- Increase in worms
- Sophisticated command & control
- Anti-forensic techniques
- Home users targeted
- Distributed attack tools
- Increase in wide-scale Trojan horse distribution
- Windows-based remote controllable Trojans (-back orifice)
- Techniques to analyze code for vuls without source
- Widespread denial-of-service attacks

Intruder Knowledge


High

Attack Sophistication

Low
Should We Be Concerned?

The Development and growth of cyber technologies has changed the threat environment forever.

Adoption of technology creates dependencies that evolve to interdependency.
- A significant attack on one can directly impact others (Cascade effect).

Pervasiveness of cyber technologies redefines security.
- Physical attacks have cyber consequences and Cyber attacks have physical consequences.
Should We Be Concerned?

Attackers well aware of the potential impact of using cyberspace

- Nations adding Computer Network Warfare to strategy and doctrine
- Terrorist groups developing cyber capabilities (Al Qaeda)
- Criminal groups have been using cyberspace for years
- Critical Infrastructures prime targets (exploitation and compromise)

We are our own worst enemy

- Websites great source of intelligence
Your Administrative Responsibilities

- Monitoring
- Incident response
- Damage assessment and recovery
- Analysis
- System life-cycle management
- Backups, fault tolerance
Security Patches and Workarounds

- Stay up-to-date regarding vendor patches and workarounds to address security vulnerabilities
- Verify the integrity and authenticity of all downloaded software before applying it to your systems
- Test patches and workarounds in an isolated, physically secure test environment before deployment
- Deploy security patches and workarounds as soon as possible to reduce exposure to attacks
- Maintain a thorough, up-to-date record of security patches and workarounds that you have applied
Why Care About Patches

of intrusions result from exploitation of known vulnerabilities or configuration errors where countermeasures were available.
Virus Scanning

Even the most conscientious users can receive a virus
- Files and media exchanged between employees and with customers or other external contacts
- Data downloaded from remote systems
- E-mail attachments

Measures
- Install and regularly use current virus scanning software
- Keep virus scanners data up-to-date on all systems
- Raise awareness of current and emerging virus threats
- Train users to scan all data received for viruses before use
Host-based Firewalls

Another layer of Defense
• Becoming commonplace,
yet still under-utilized
OS specific
• Free and commercial
• Some have IDS too
Examples:
  - Zone Alarm
  - Black Ice Defender
  - Tiny Personal Firewall
  - Linux Firewalls
  - Windows XP Firewall
  - Mac OSX Host Firewall
    (on by default)
Network Firewalls

One or more components placed at gateways between networks to enforce information security policy

- Filtering routers
- Bastion hosts and application/service proxies
- Network switches
- Network monitors

Ensure secure administration of firewall components
Reinforce perimeter defenses with host security
What is an Intrusion Detection System?

Device on a network that monitors traffic and/or host activity looking for the following:

- Malicious traffic, such as attempts to circumvent identification & authorization or other access controls
- Reconnaissance traffic, such as port scans
- Unusual traffic: type, level, source, etc.
- Activity on host systems that is outside of known patterns

Device then logs and reports activity in prescribed manner
Types of IDS

- **Host-based**
- **Signature-based**
- **Anomaly-based**
- **Network-based**
CERT® Advisories alert you to vulnerabilities for which you should take immediate action

- Description of the vulnerability and its scope
- Potential impact should the vulnerability be exploited
- Solutions or workarounds
- Appendices contain details and vendor information
- Revision history
- PGP signature
Cyberterror Vulnerabilities

Most Infrastructures are Scale-free networks
- Able to survive random attacks, but susceptible to targeted attack
  › Super Hubs (Financial)
  › Considerable redundancy within the system but not of the system

Database Compromise
- Ability to Destroy, Disrupt, or Distort critical data
- Information as essential as physical infrastructure

Physical Attack
- Loss of facilities
- Redundancy becomes critical

Physical Security in Cyberspace
- Most physical access is now controlled with Internet technology
- Generation of keys, cards, identity, etc. controlled in cyberspace
Strategies & Tactics

Key Points
• Good security administration is all about good systems administration
• Take a conservative approach in configuration management
• Separate, isolate and simplify system and network services
• You’re only ever as secure as your weakest link
• Practice vigilance and be prepared for change
• Apply appropriate tactics to sustain and improve security
• Keep systems and network components up-to-date regarding patches and workarounds for security
• Maintain secure backups
Software Engineering Institute

Applied research and development laboratory situated as an integral unit at Carnegie Mellon University

Mission is to provide leadership in software engineering and to transition new software engineering technology

Encouraged to support industry in pre-competitive technology research and development and in technology transition activities
CERT was formed in 1988 in response to the Internet Worm

CERT added research, training, and analysis as the Internet matured

September 15, 2003 CERT Centers is named the US CERT (www.us-cert.gov) in partnership with DHS
<table>
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<tr>
<th>CERT® Coordination Center</th>
<th>Artifact Analysis</th>
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<tr>
<td><strong>Solving today’s security problems</strong></td>
<td></td>
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<tr>
<td>Study intruder code to develop defenses</td>
<td></td>
</tr>
<tr>
<td>Developing new techniques for analysis</td>
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| **Vulnerability Handling** |
| Analyze flaws in Internet systems |
| 4,000 vulnerabilities handled each year |
| Publications available at http://kb.cert.org/vuls/ |

| **Incident Handling** |
| Respond to security emergencies on the Internet |
| Measure exploitation of flaws |
| 100,000 incidents handled each year |
| Publications available at http://www.cert.org |
US-CERT

US-CERT is a partnership of

- The National Cyber Security Division (NCSD) of the Department of Homeland Security (DHS)

- The CERT Coordination Center
CERT’s Areas of Expertise

• Vulnerability analysis
• Artifact analysis
• Insider threats
• Survivable Architectures
• Function abstraction/extraction
• Modeling and simulation
• Dependency and critical infrastructure analysis
• Best practices and methodologies for testing software
• R&D
US-CERT Working Relationships

US-CERT will work with organizations involved in watch, warning, and response, including:

• Private, public, and academic organizations that operate computer security incident response teams (CSIRTs)
• Managed security service providers
• ISACs
• Infrastructure owners/operators
• Technology developers
US-CERT Focus

Prevent and mitigate cyber attacks and reduce cyber vulnerabilities by concentrating on four areas:

• Improving warning of and response to incidents
• Increasing coordination of response information
• Reducing vulnerabilities
• Enhancing prevention and protection efforts
US-CERT: Coordinated Response

- Provide tools and capabilities to share information in a secure manner
- Contact partners regularly and exchange information and make this situational awareness information available to partners
- Facilitate coordination and cooperation in major Internet security events
- Work with vulnerability reporters, partners, and vendors to resolve vulnerabilities
- Provide direct support to response and recovery operations following major cyber failures in national infrastructure
AirCERT (Automatic Incident Response CERT)

Technology needed to handle exponential growth in incidents & develop systems of indications and warnings

Key Ideas

Open-source infrastructure to automatically gather & report security events from Internet sites to the CERT/CC

Reduce the burden on security analysts by automatically handling well-understood attacks

Spot problems not visible from a local perspective

Use and Status

Gather structured, security incident data for analysis to identify current trends, scope of a specific widespread incident, & predictive indicators for attacks

Completed proof-of-concept prototype; some components being tested by the Internet community, piloting with GSA & agencies
US-CERT: Sharing Incident and Sensor Data

- Work to improve capabilities to share incident and sensor data, and monitor and improve the health of the Internet
- Advance standards for incident data exchange
- Encourage vendors to adopt these standards
- Share incident and network sensor data among partners with appropriate sanitization
- Develop better analysis capabilities for analyzing collected data
US-CERT: Vulnerability Discovery and Reduction (1)

- Work with partners and the private sector to significantly reduce vulnerabilities in:
  - commercial off-the-shelf software
  - software used by critical infrastructures

- Identify, develop, and promote use of tools that are effective in reducing vulnerabilities in software

- Assemble collection of existing/emerging tools that can strengthen current software quality evaluation schemes

- Test key technologies currently in use, or planned for use, in our critical infrastructures
US-CERT: Vulnerability Discovery and Reduction (2)

• Share best practices for secure programming with software development managers

• Establish a vulnerability discovery lab
  - demonstrate the effectiveness of methods and tools
  - identify latent vulnerabilities in deployed technologies
  - identify vulnerabilities in products under development
### Need

Attacks occur at Internet speed and cause major damage within reaction cycles; we need predictive and preventative capability.

### Key Ideas

- Augment existing, inadequate, IDS technology
- Dynamically adjust for rapid changes in environment
- Protection against new threats

### Use and Status

- Studying feasibility of data collection, reduction & fusion processes
- Initial pilot successful at identifying severe operational anomalies & previously undetected probes
A major initiative of the SEI as a Federally Funded Research and Development Center (FFRDC) funded by DOD

An important component of this initiative is:

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Survivability

The ability of a system to fulfill its mission, in a timely manner, in the presence of attacks, accidents, and failures
Initiative Goal

Ensure that appropriate technology, systems management practices, and supporting infrastructures are used to limit damage and to ensure continuity of critical services in the presence of attacks, accidents, and failures.
Critical Need for Better Engineering Methods

Sophisticated intruders target
- distributed user workflows
- trust relationships among distributed systems
- limited visibility into and control of remote systems
- people and the meaning they assign to content
- work resources that people rely on

Many organizations rely solely on insufficient boundary control and “bolt-on” mechanisms as defense

Resistance, recognition, and response must be integrated into the system and application architecture
CERT/CC Field of Vision
Effective security management programs must be sensitive to mission and overall objectives.

Information security must be linked to an organization’s mission & business objectives for effective planning

Enable interdisciplinary teams to perform information security risk evaluations & act as a focal point for improvement efforts

Actively piloting in DoD, government, & industry sectors

Created first derivative method: OCTAVE-S for small organizations

Offering training

Seeking transition opportunities
Security Practices

Need

Pervasive understanding of security policy, management practices and technical practices

Key Ideas

Organizations can improve the security & survivability of networked systems by adopting CERT® security practices

Use and Status

Practices are published on the web & taught in training courses

Working on certification standards

Seeking DoD pilot sites & transition opportunities
CSIRT (Computer Security Incident Response Team)

Development

Need

Organizations need teams to respond to computer security incidents

Key Ideas

Develop a community of CSIRTs to share resources and respond to global incidents

Engage organizations as partners depending on the maturity of their CSIRT capability

Use and Status

Assisting DoD and other sectors to develop a certification and accreditation process for CSIRTs

Using CSIRT training courses as a transition mechanism for our knowledge and experience
Training

Need
Improve the information security skills of technical staff and managers to address the increasing gap between core competencies required and number of qualified personnel

Key Ideas
Approaches exist to protect critical information assets and systems
All levels of staff need training to facilitate adoption of security practices

Use and Status
Offering public and customer deliveries
Seeking transition and licensing partners
Survivable System Engineering

**Need**

Structured, repeatable methods to identify architectural & design changes that enhance a system’s survivability

**Key Ideas**

Focus on survivable architectures for loosely coupled & unbounded systems

Support evolution of survivable architectures as requirements & technologies change

**Use and Status**

Understand survivability risks to a system architecture & identify mitigating strategies

SSE version 1.0 documented; short tutorial developed; pilots ongoing

Seeking transition opportunities
Let’s Draw Some Conclusions

• The Internet is growing in an uncontrolled way
• Vulnerabilities and incidents are growing
• Cyberterrorism could happen
• The Overload of System Administrators is growing
• Intrusion Detection Systems are mandatory
• The use of Patches and Workarounds is essential
• CERT Centers play a key role in Cyber Security
• US CERT initiatives promise to play a key role in Cyber Security and in the combat of Cyberterrorism
• Education in Cyber Security is essential
• Systems Survivability has emerged as a new Engineering Discipline
How To Contact Us

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CERT/CC Incident Handling

Email: cert@cert.org
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CERT personnel answer 8:30 AM - 5:00 PM EST (GMT-5)/EDT (GMT-4) Mon.-Fri.
On call for emergencies during other hours.