Systems Security

Threats, Vulnerabilities, and Risks

Ed Crowley CISSP, NSA-IAM/IEM

Fall '05

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What is Security?

- How can you tell if you have it?
- How much is enough?
- What are the basic security primitives?
  - How can you evaluate them?
- Who defines them?

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System Security:
Threats, Risks, and Vulnerabilities

- Who/what wants to break into your computer?
- How do they break into computers?
  - Case Studies
- What can you do?

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Outline

- Introduction
  - The Big Picture
    - Trends
    - Definitions
- Primitives, Vulnerabilities, Threats, and Risk
  - Attacks and Attackers
- Current Environment
  - Context
- Vulnerabilities
  - Systemic
- Threats
  - Social Engineering
  - Password Guessing
  - Buffer Overflow
  - System Flaws
  - Exploits
- Risk and Risk Management
  - Assessment and evaluation
- Security Models

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Who am I?

- Certified Information System Security Professional (CISSP)
  - Information System Security Association (ISSA)
  - InfraGard
  - University of Houston Security Council
- NSA Certified INFOSEC Assessment Methodology (IAM), and INFOSEC Evaluation Methodology (IEM)
- Developed NSTISSC Certified IT Security Specialization
  - 4, three credit hour courses, UH, College of Technology
- Former IS Director, Network Admin, Web Master
  - www.tbe.uh.edu
  - ProfessorCrowley.com (coming soon!)
- CompTIA Security +, Net+, Cisco CCNA, Msoft MCSE …
- Graduate Military Police Academy, USARPAC Basic Sentry Dog School, former Security Clearance Holder

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Trends, *One*

Over time:

- Cyber incidents are increasing in:
  - Number
  - Sophistication
  - Severity
  - Cost.
- The nation's economy is increasingly dependent on cyberspace
  - Unknown interdependencies and single points of failure.
  - A digital disaster strikes some enterprise every day.
- Infrastructure disruptions have cascading impacts, multiplying their cyber and physical effects.

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Trends, Two

- Fixing vulnerabilities before threats emerge reduces risk.
- It is a mistake to think that past levels of cyber damage are accurate indicators of the future.
  - Much worse can happen.
- Common defense of cyberspace depends on a public-private partnership.
- Everyone must act to secure their parts of cyberspace.

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Who are the Attackers?

- Here
  - Adrian Lamo
  - Kevin Mitnick
  - Kevin Poulsen
- Later we may also look at:
  - Robert Morris
  - Alexey Ivanov and Vasiliy Gorshkov
  - Others …

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Who are the Defenders?

Last Spring's Security Panel

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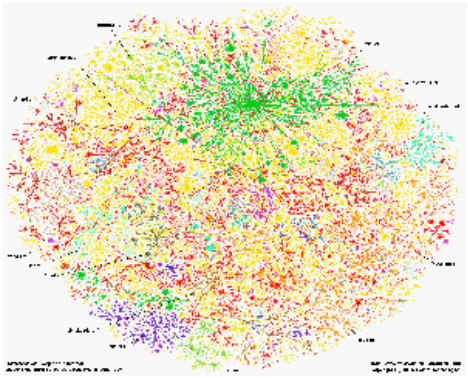
The Big Picture Internet Map

- Internet Traffic Map



- Where are the national boundaries?
- Where are the police?

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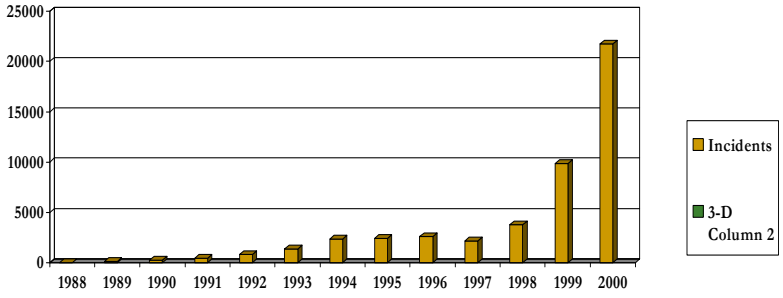
The Big Picture *CERT.org*

- Computer Emergency Reaction Team Incident Statistics



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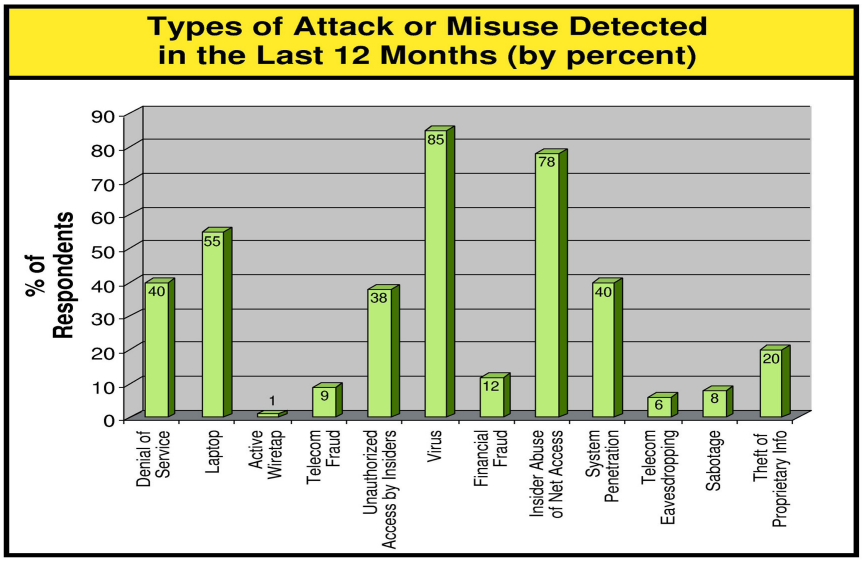
The Big Picture *Computer Security Institute*



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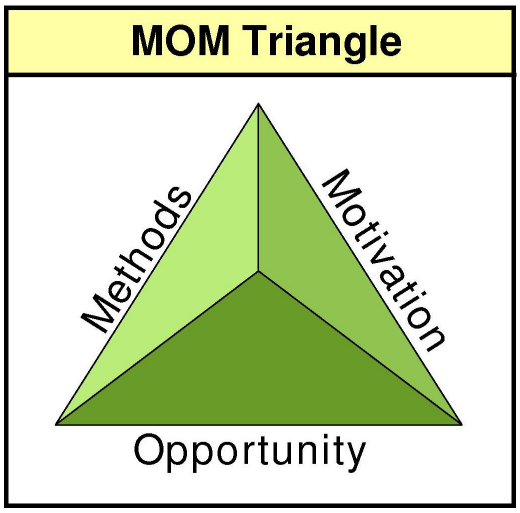
Opportunity Theft Model

Sometimes described as Desire, Skill, Opportunity.



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Terms *Definitions One*

- Vulnerability
  - A weakness in system security procedures, system design, implementation, internal controls, etc., that could be exploited to violate system security ...
- Threat
  - Any circumstance or event with the potential to cause harm to a system in the form of destruction, disclosure, modification of data, and/or denial of service.
- Risk
  - The probability that a particular threat will exploit a particular vulnerability ...
    - *From NCSC-TG-004 Aqua Book*

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Terms *Definitions Two*

- A threat is a potential violation of security.
  - An attack is defined as an action that might cause a security violation.
    - Those who execute such actions, or cause them to be executed, are called attackers.

Security:

- policy is a statement of what is, and what is not, allowed.
- mechanism is a method, tool, or procedure for enforcing a security policy.

--Bishop

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Risk Management's Objective

- The objective … is to enable the organization to accomplish its mission(s) by:
  - Better securing the IT systems
    - that store, process, or transmit organizational information
  - Enabling management to make well-informed risk management decisions
    - to justify the expenditures that are part of an IT budget;
  - Assisting management in authorizing (or accrediting) the IT systems
    - on the basis of the supporting documentation resulting from the performance of risk management.

NIST 800-30

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Vulnerabilities?

- People
- Processes
- Organizations
- Technology (systems, networks, etc…)
  - Workstations and Servers
  - Firewalls
  - IDS
  - Avs
  - VPNs
- Vulnerabilities are Dynamic

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Vulnerabilities *People*

- People
  - Things people know
  - Relations between people
  - How people they relate to machines
  - Passwords
    - Strong (Yellow Stickies)
    - Over the shoulder acquisition
  - Password Cracking and Password Guessing
    - Morris Worm
    - Rome Labs
  - Do Passwords work?

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Vulnerabilities *Organizations*

- Organizations
  - Dumpster Diving
    - Identity Theft
    - Sujeet Shenoi – Dumpster Diving
      - Founding member of Tulsa University's Center for Information Security
  - Social Engineering
    - Kevin Mitnick – The Art of Deception
  - Unsecured Web Servers, Unlisted URLs
    - Adrian Lamo
  - Insecure Back up tapes

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Vulnerabilities *Technology*

- Systems
  - Complexity is the enemy of security
    - In general, security is inversely proportional to the number of Lines of code in a program
      - 30 to 40 Million for Windows 2000
- Firewalls
- Detection Systems, Intrusion and Anti Virus
- Virtual Private Networks
- Local Area Networks
- Internet

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Vulnerabilities *System*

- "The Mythical Man-Month: Essays on Software Engineering,“
  - Frederick P. Brooks, 1975

Note

- Research indicates that there is a consistent number of bugs per thousand lines of code.
- Often, fixing one bug exposes another in a long cascade of problems that need to be fixed one after another

- More Patches become more problematic
  - Require more labor
  - Less well tested i.e. may break other applications
  - May reopen previously closed or create new vulnerabilities.
- Simplicity is security’s friend, complexity is its enemy!

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Technology Alone is Not Enough

Technology alone is not enough

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Technical Solutions

If you think technology can solve your security problems, then:

1. You don't understand the problems and
2. You don't understand the technology.

B. Schneier

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Vulnerability Trends

- Each day, on the average, 7 new vulnerabilities are discovered.
  - Blue Lance Houston InfraGard Conference
- Since 1972, vulnerabilities have been increasing at a rate of 90% per year.
  - Notes:
    - Not all vulnerabilities are ever exploited
    - It is impossible to predict which new vulnerabilities will ever be exploited.

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Trends

- With time there is an increasing number of :
  - Known vulnerabilities
  - Exploits.
    - Automated exploits can decrease skills required for an exploit.
    - Example ARP poisoning
  - People who employ exploits (threat agents).
  - Internet based ecommerce organizations.
  - People and organizations connecting to the Internet.

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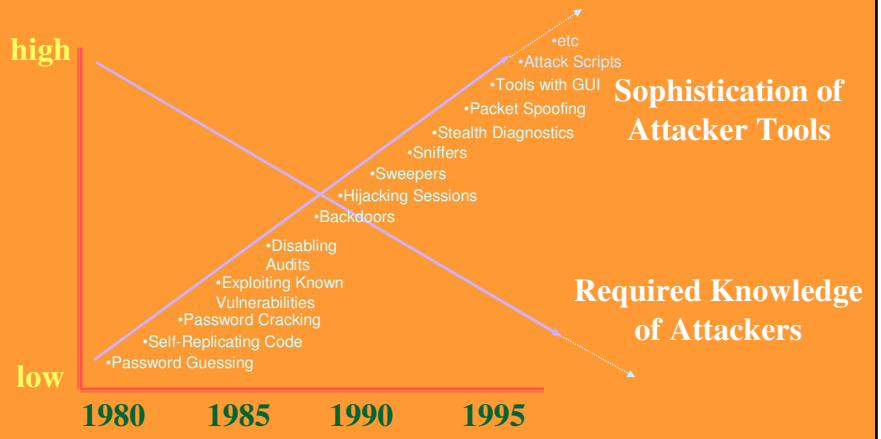
Required Knowledge Trend



Attackers Require Less Knowledge as Tool Sophistication Increases

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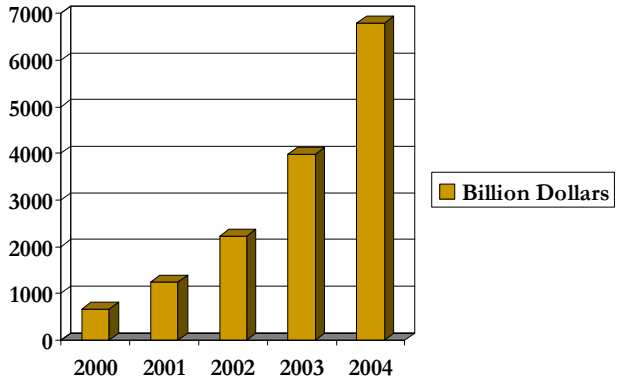
Trends Money

- Forrester Research predicts that by 2004, online commerce will reach $6.8 trillion.



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Why Hack?

- That's where the money is!
- Online, I can attack my opponent without exposing myself!
- Online, I can express my political views!
- Because I can!
  - For example, Kevin Mitnick claims to have never directly made money on any of his attacks.
  - He did however use other peoples services.

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Why Hack the Internet?

- The Cyber Economy is the Economy!
  - Condoleezza Rice
- On the Internet it is difficult to tell where my country's borders stop
  - No one country can police the Internet
  - International LE agencies will forge agreements but it will take time.
- Any system directly connected to the Internet is exposed to about a half billion other users and systems.

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Internet Threat Characteristics, *one*

- Automation
  - Automated infections (Worms and Trojan Horses)
    - Morris Worm, 1988
  - Honey Pot Project Record (17 seconds)
- Speed of Exploit Propagation
  - Negates traditional commerce reaction response
- Distance doesn't matter
  - No International Borders on the Internet
  - Legal jurisdiction scope

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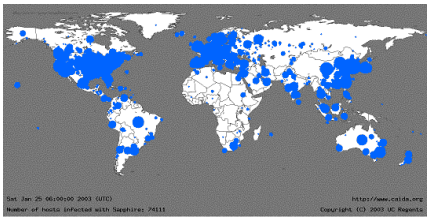
Threat Characteristics, *two*

- Blue color represents Slammer, 30 minutes after release



- In the first minute, the infected population doubled in size every 8.5 (±1) seconds.
- After approximately three minutes, the worm achieved max scanning rate (over 55 million scans per second)

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Worms and Viruses

- Robert Morris
  - Internet Worm, 1988
  - First conviction under the 1987 Computer Security Act
  - Father was the chief scientist at NSA's, National Computer Security Center (NCSC)
- Michael Buen & Onel de Guzman
  - I Love You Virus
  - Not in jail (Under Philippines law, hacking not a crime.)

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Malicious Software

- Trojans
  - Email
    - A virus posing as a photo of Russian tennis player Anna Kournikova. Spread twice as fast as I Love You.
      - Polymorphic
      - Encrypted
  - DDOS
    - Distributed Denial of Service Attack
    - Mafia Boy and Tribal Flood knocked down Yahoo and Ebay.
- Spyware

The computer hacker known as "Mafiaboy," who crippled several major Internet sites, arrives in court Thursday in Montreal, Canada

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Internet Threat Characteristics *Costs*

- Automated infections (Worms, Viruses, and Trojan Horses)
  - Figures from Computer Economics indicate that the original Code Red cost companies around $1.2 billion.
    - Reflects both expenditures for monitoring and clean-up and losses in productivity.
  - The I LOVEYOU worm and its family of mutations have caused an estimated $6.7 billion in productivity losses and the price tag will go up even more...
    - (Analyst Samir Bhavnanim)

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Internet Threat Characteristics *Trends*

- Speed of Propagation is increasing.
- For example, NIMDA (ADMIN backwards) went from nonexistent to nationwide in an hour, lasted for days, and attacked 86,000 computers.
  - NIMDA caused significant problems in well-protected industries, forcing firms offline, shutting down customer access, and requiring some firms to rebuild systems entirely.
- Because there is no consistent method to track such damage, the actual financial cost of the NIMDA attack is unknown.
- However, industry sources estimate that the overall financial impact of cyber attacks resulting from malicious code could have been $13 billion in the year 2001.

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Digital Attack Types

- Criminal
  - Traditional crime facilitated by computers
  - Crimes against computers
- Privacy Violations
  - Increasingly regulated
  - SB 1386
- Publicity Attacks
- Legal Attacks

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Digital Attacks *Criminal*

- Extortion
  - Alexey Ivanov and Vasiliy Gorshkov (50,000 CC#)
- Fraud & Scams
  - Email from Nigeria
- Intellectual Property Theft
- Identity Theft

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Digital Attacks *Privacy Violations*

- (HIPAA) Health Insurance Portability and Accountability Act (1996)
  - aka Kennedy Kassenbaum Health Insurance Portability and Accountability Act
  - Compliance required by April 2003.
  - Standards aim to maintain the right of individuals to keep private information about themselves.
- "A covered entity must have in place appropriate administrative, technical, and physical safeguards to protect the privacy of protected health information."
- SB 1386

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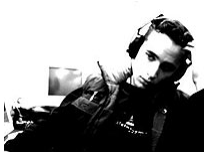
Digital Attacks *Publicity Attacks*



Publicity Attacks

- Publicity seekers don't fall into the same threat model that criminals do …
- Adrian Lamo
  - Used a back door in The New York Times' intranet to obtain home phone numbers of over 3,000 Op-Ed contributors, including Vint Cerf, Warren Beatty, and Rush Limbaugh.
  - Added himself to their roster of experts
- Bumped from NBC telecast after hacking them
  - On camera, demonstrated his techniques for NBC Nightly News. When he cracked the network's own systems, their lawyers killed the story.

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Digital Attacks *Legal Attacks*

- Don't exploit technical system flaws.
- Aim to persuade a judge or jury that there could be a system flaw.
- When successful, puts doubt in the minds of the judge or jury that the security isn't perfect and a client is innocent.
  - George Mason University lost a 4.3 million dollar court case after a judge refused to allow evidence from their intrusion detection systems into court

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Potential Attackers

- Common criminals
  - Financial gain
- Industrial spies
  - Competitive advantage
- Hackers
  - People skilled beyond their maturity
- National Intelligence organizations
- Malicious Insiders
- Internet Businesses (Spyware)

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Threat Attributes

- Attackers may have different :
  - Objectives
  - Skill levels
  - Risk tolerance

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Hacker

- Person who experiments with the limits of a system out of intellectual curiosity i.e. a person with a particular set of skills not a particular set of morals
  - Some distinguish between a cracker and a hacker with the former being bad and the later being good
- Black, white, or gray hat

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Hacker Hierarchy

- Government funded
- Sophisticated with programming background
- Sophisticated with Network Admin background
- Semi Sophisticate
- Ankle Biter aka Script Kiddie

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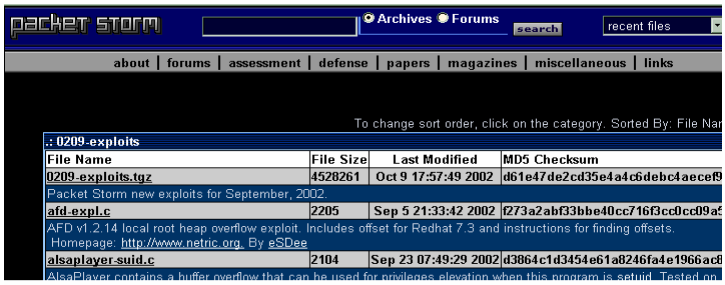
Exploits

- Tools that automate the process of breaking into systems
- Readily available on the Internet



Malicious Insiders

- Not necessarily employees
  - Consultants
  - Contractors
- Not necessarily in the same country as you
- Many security measures firewalls, intrusion detection systems, etc. deal with external threats.
  - Insiders aren't impacted by perimeter security.
  - Certain technologies (VPNs for example) may screen an insider's activities from your ID systems.

Press

- A subspecies of industrial spy with different motivations
- Kevin Lee Poulsen aka Dark Dante
- Can be well funded
- Can tolerate risk

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Kevin Lee Poulsen

- aka Dark Dante
  - Currently, a well know journalist.
  - Disabled the phone system of KIIS_FM so he could be the102nd caller and win the $50,000 Porsche giveaway.
  - While on under indictment, won four more radio contest grand prizes from L.A.-area Top 40 stations.
  - Usually featured on Security Focus website.

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Organized Crime

- Hacking supports core competencies
  - Identity Theft
  - Extortion
- What do you get when you combine lone criminals with a money and organization?
  - Russian/East European Mafia

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Terrorists

- Generally more concerned with causing harm than gathering intelligence
- Infowar
  - Asymmetrical warfare
- Tend to lack funding and skills
  - May change in the future
    - Rome Labs
    - *Datastrean and Kuji*
  - Politically motivated hacking increasing

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National Intelligence Orgs

- CIA, NSA, DIA, NRO, MI6, MI5, …
  - Federal documents indicate over 100 countries are developing Information Warfare capabilities
- Well funded
- Formidable
- Usually highly risk averse.
- Already engaged in industrial espionage?

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INFOWar

- A military adversary who tries to undermine his target's ability to wage war by attacking the information or network infrastructure.
- Short term focus of affecting his target's ability to wage war.
- Objects:
  - Military advantage
  - Chaos
- Assymetrical Warfare

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Security Services

- Confidentiality (Privacy)
  - Privacy and the Government
- Integrity
- Availability
- Authentication
- NonRepudiation

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Confidentiality and Privacy

- Controls who can read, or access, information
- Different countries have different laws
  - In the US, individuals don't own the data about themselves.
  - The European Union (EU) laws protecting individual privacy.
  - There are legal constraints on companies moving information across national borders.
- Moving privacy information from the EU into the United States where similar protections do not exist is considered illegal

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Integrity

- Integrity has to do with the data validity.
- The electronic world has no context
- Concerned with trust i.e. how much can you trust a system or data
- Can be divided into system and data domains
  - If you loose system integrity, you will soon loose data integrity

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Audit and Other Assurance Mechanisms

- Trust but verify
  - Vital whenever security is taken seriously
- Detective security service
  - Enables (facilitates or makes possible) forensics
- Assurance requires more than thinking or believing that you, or your organization, are secure. It requires a mechanism to demonstrate that you have a reason for your belief.
  - i.e. belief based upon external data

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Authentication

- Authentication is about the continuity of relationships
  - Knowing who to trust and who not to trust…
- Military aircraft have IFF systems to authenticate themselves to allied aircraft and antiaircraft batteries.
  - When this malfunctions, people die. (Iraq war friendly fire.)
  - When it doesn't malfunction, sometimes people die. (Argentine war exocet identification.)
- Session authentication -- IRC
- Transaction authentication – credit card
- Internet is connectionless

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E-Commerce

Security requirements for e-commerce

- Authentication
- Privacy
- Integrity
- Nonrepudiation
- Audit

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Security Principles and Models

- Security is a process.
- Needs to be based upon a model.

Some helpful data points:

- Generally Accepted Security Principles (GASSP) (NIST 800-14)
- Layered Security Model (aka DID)
- NSA Security Model
- Risk Management (NIST 800-30)

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Achieving Security Goals

- Generally Accepted Security Principles (GASSP)
  - Began in mid-1992 in response to the report "Computers at Risk" (CAR), published by the United States National Research Council in 1990.
  - The GASSP Pervasive Principles, based on the Organization of Economic Cooperation and Development (OECD) principles.
  - Developing Linkages with ISC^2

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GASSP

- Generally Accepted Security Principles
- Security supports an organization's goals
- Information security controls should be proportionate to the risks.
- Risks should be assessed periodically.

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GASSP

- All parties, with a need to know should have access to applied or available principles, standards, conventions, or mechanisms for the security of information and information systems.
- They should also be informed of applicable threats.

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Systems and Security

- Effective security has to be thought of as a system within larger systems
- Real world issues include design tradeoffs, unseen variables, and imperfect implementations.
- Not a product but a process.
  - Dynamic
- Layered Security Model

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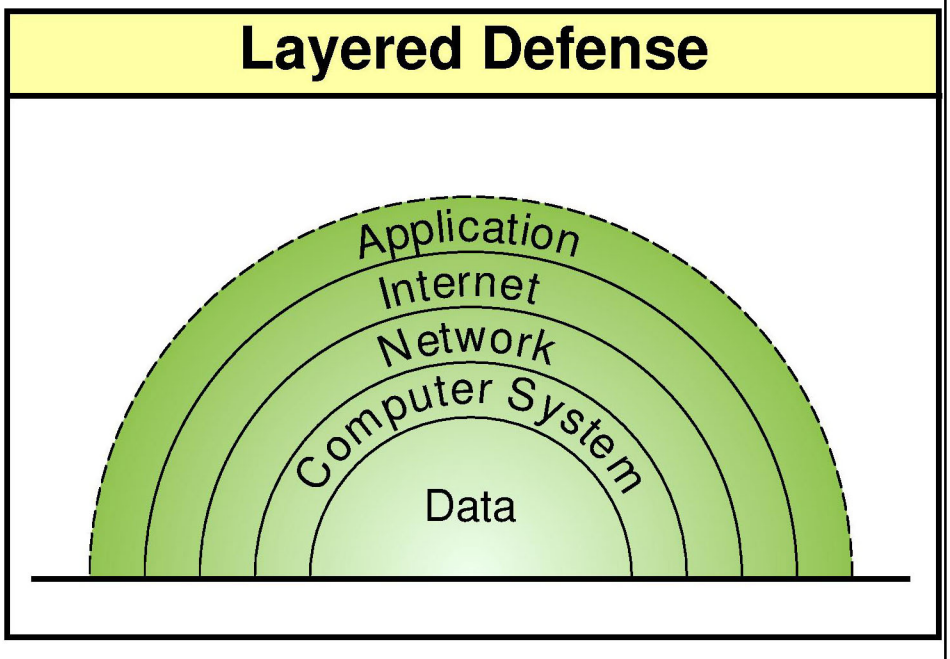

Security is a Process

- Each layer adds security over existing layers
  - Theoretically, not possible to penetrate multiple layers simultaneously
- Like a chain, security is only as secure as the weakest link
- Security is not a product
  - It can't be bought.
- Like the context that it exists within, information system security is dynamic

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Systems Theory

- In order to understand system security of, you need to look at the entire system and its context.
- Viewing any component in isolation is flawed.
- Security should not depend on any particular technology.

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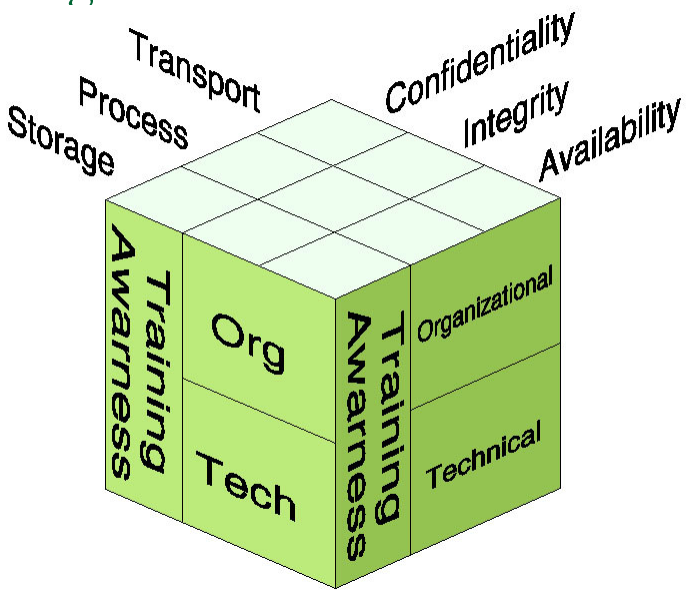
The Big Picture NSA Model



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NSA Model

- Developed and modified over time.
- One of its primary authors is Vic Maconachy

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Proactive Solutions

- The notion of fixing a security flaw after it becomes a problem won't work on the Internet.
- Education and Training are critical components of any security plan.

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Education

Graduate Program

- MS, Technology Project Management
- Information Systems Security Specialization
  - NSA, CNSS, accredited

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Questions?