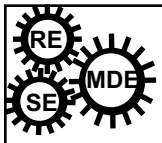

Information Security

An Introduction

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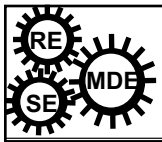

Acknowledgments

- Annie Anton
- Charles Pfleeger
- E. Spafford

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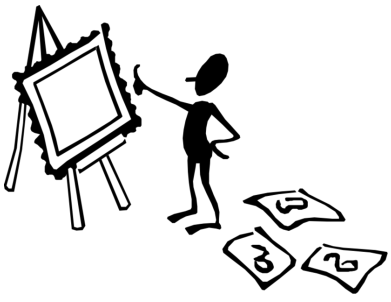
Outline

- Terminology
- Brief Introduction
- Security Planning
- Creating a Security Policy
- Threats, Attacks & Services
- Internet Privacy Policies



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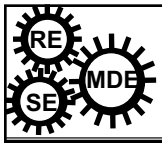

Terminology

- "A computer is ***secure*** if you can depend on it and its software to behave as you expect (intend)."
- '***Trust*** describes our level of confidence that a computer system will behave as expected.' (intended)

[Garfinkel & Spafford, Kasten]

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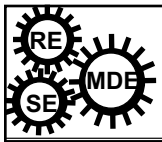

What is secure?

- Does not disclose information
- Does not allow unauthorized access
- Does not allow unauthorized change
- Maintains QoS despite input and load
- Preserves audit, authenticity, control
- No surprises!

[Spafford]

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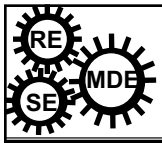

Why Worry?

- **Information has value**
  - when combined
  - when altered
  - when disclosed
- **Resource use has value**
  - unauthorized use
  - denial of service
- **Damage to reputation**
  - damage to your personal reputation
  - damage to your group
  - damage to your company
- **Your system is not alone**
  - other machines on the network
  - shared resources and files
  - indirect liability

[Spafford] CSE870: Advanced Software Engineering: Security Intro

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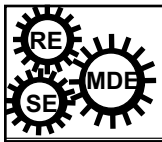

Three Common Failures

- Organization has no formal policy. Thus, personnel cannot *consistently* make necessary decisions.
- Organization has no reasonable response plans for violations, incidents, and disasters.
- Plans don't work when needed because they haven't been regularly tested, updated, and rehearsed. (E.g., failure of operational security)

[Spafford] CSE870: Advanced Software Engineering: Security Intro

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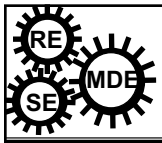

The Challenge

- "Without assurance that our systems will stay secure, we endanger our economies, our privacy, our personal safety and privacy, and our social institutions." [Spafford]

[Spafford]

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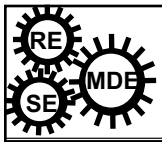

How do we get there?

- Understand the needs of the users
  - Narrow focus better than broad
- Understand basic tenets of security
  - Scarcity/rareness of programs and experts
- Capture requirements for design and validation
- Design with care using good tools and methods
- Validate & Verify

[Spafford]

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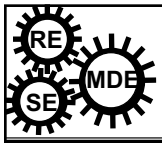

Understanding Security

- Good security means
  - Limiting what happens
  - Limiting who can make it happen
  - Limiting how it happens
  - Limiting who can change the system
- Users don't tolerate limits unless there is a paradigm shift
  - E.g.,
    - Mainframes to PCs/desktops
    - to laptops
    - to handhelds computers
    - to cellphones/blackberrys

[Spafford] CSE870: Advanced Software Engineering: Security Intro

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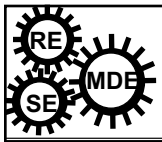
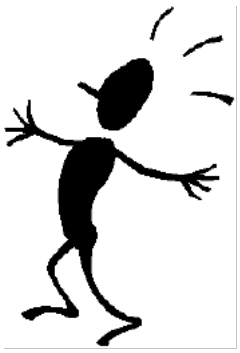


Psychological Acceptability

- Easy to use
  - Should be as easy to use as to not use
- False alarms should be avoided
- Frequent changes and updates are bad
- Should not require great expertise to get correct

…Doesn't match user population



[Spafford] CSE870: Advanced Software Engineering: Security Intro

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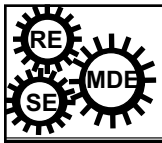
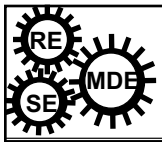


Patches

- Fixes for flaws that require an expert to install are not a good fix.
- Fixes that break something else are not a good fix.
- Frequent fixes may be ignored.
- Goal should be design, not patch

Other terms: "Service packs, upgrades, bug fixes, hot patching", etc.

[Spafford]

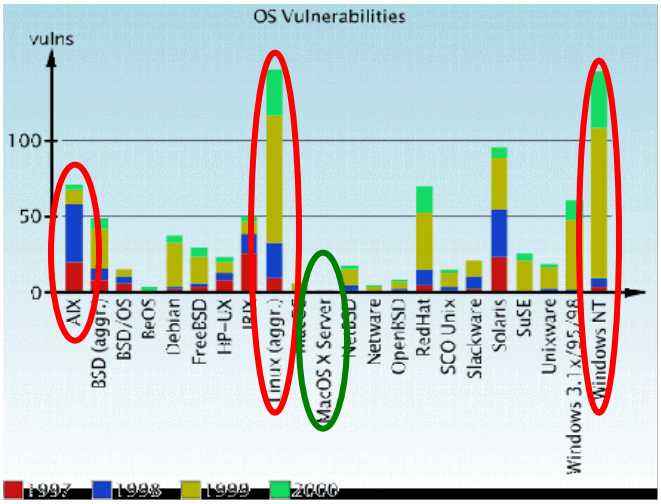


Source of Problems

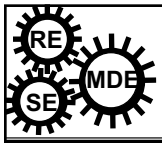
About 30% are buffer overflows or unchecked data

Over 90% are coding/design flaws.

Source: Securityfocus.com



[Spafford]



Quality as a Market Problem

- Good software engineers and security designers are scarce
- Productivity of coders varies:
  - Top 10% are at least 10x more productive than average coder.
  - Organizations should invest in raising skill level.
- That takes time and money, so there is a disincentive to improving quality

[Spafford]

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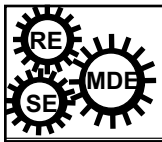

What can we do?

- Understand that there is no “average user”
- Understand balance between features and security
- Employ better testing
- Manage complexity and change
- Build in security from the start
- Understand policy differences.

[Spafford]

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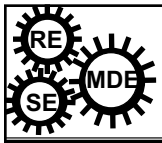

Security Planning

- Security needs planning
- Risk assessment
- Cost-benefit analysis
- Creating policies to reflect your needs
- Implementation
- Audit and incident response

[Garfinkel & Spafford]

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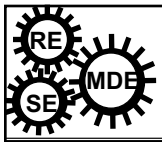
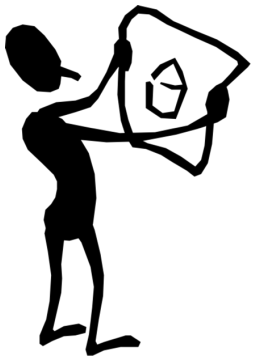


Planning Your Security Needs

- Confidentiality
- Data Integrity
- Availability
- Consistency
- Control
- Audit



[Garfinkel & Spafford]

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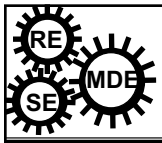

Critical Concerns for Various Industries?

- Banking environment?
- National defense-related system that processes classified information?
- University?
- E-Commerce?

- Confidentiality
- Data Integrity
- Availability
- Consistency
- Control
- Audit

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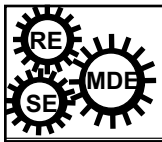

Risk Assessment

- Three questions to answer:
  - ***What*** am I trying to protect?
  - What do I need to ***protect against***?
  - ***How much*** time, effort and money am I willing to expend to obtain adequate protection?
- Three key steps:
  - Identify assets
  - Identify threats
  - Calculate risks

[Garfinkel & Spafford]

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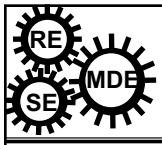

Risk Assessment
Step 1: Identify Assets

- Tangibles
  - Computers, disk drives, proprietary data, backups and archives, manuals, printouts, commercial software distribution media, communications equipment & wiring, personnel records, audit records
- Intangibles
  - Safety & health of personnel, privacy of users, personnel passwords, public image & reputation, customer/client goodwill, processing availability, configuration information

[Garfinkel & Spafford]

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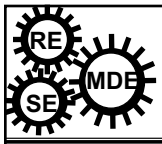

Risk Assessment
Step 2: Identify Threats

- Illness of key people
- Loss of key personnel
- Loss of phone/network services
- Loss of utilities (phone water, electricity) for a short or prolonged time
- Lightening or flood
- Theft of disks, tapes, key person's laptop or home computer
- Introduction of a virus
- Computer vendor bankruptcy
- Bugs in software
- Subverted employees or 3rd party personnel
- Labor unrest
- Political terrorism
- Random "hackers"

[Garfinkel & Spafford]

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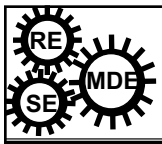

Broad Categories of Threats

- Interruption
- Interception
- Modification
- Fabrication

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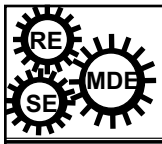

Interruption

- Asset becomes lost, unavailable, unusable
- Ex:
  - Malicious destruction of HW device
  - Erasure of program or data
  - Malfunction of OS (e.g., cannot find a file)

Ransomware:
NHS attack (May 2017); millions of patients in UK affected
150 countries affected by WannaCry → ransomware

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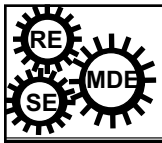
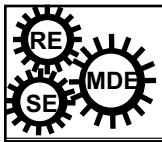


Interception

- Unauthorized party gained access to an asset
  - Outside party: person, program, system
- Ex:
  - Illicit copying of program/data files
  - Wiretapping to obtain data in network
- Loss may or may not be detected (i.e., leave no traces)



Interception

- Unauthorized party gained access to an

TECHNOLOGY

The New York Times

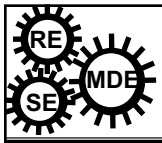
Facebook Security Breach Exposes Accounts of 50 Million Users

ify at-risk individuals after

Jan. 2018

June 2020

State University was the target of a ransomware attack on Memorial Day 2020. (WWMT/File)



Modification

- Unauthorized access tampers with asset
- Ex:
  - Change values in database
  - Add computation to a program
  - Modify data during transmission
  - Modify hardware
- Detection may be difficult

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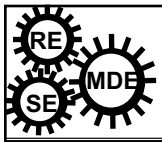

More Modification

- Trojan horse:
  - Overtly does one task, covertly does something else
- Virus:
  - example of trojan horse;
  - Spread infection from one computer to next
- Trapdoor: program has secret entry point
- Information leaks: (in program)
  - Make info accessible to unintended people/programs

"(in)Famous" Computer Viruses: https://uk.norton.com/norton-blog/2016/02/the_8_most_famousco.html

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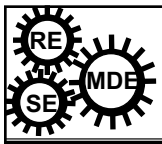

Fabrication

- Unauthorized party produce/generate counterfeit objects on computing system
- Ex:
  - Insert spurious transactions to a network
  - Add records to an existing database
- Detection and authentication are problems

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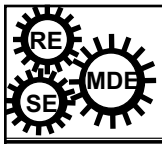

Costs of Cybersecurity Attacks

- CryptoLocker: Sept 2013
  - "spread through email attachments and encrypted the user's files so that they couldn't access them."
  - Cost of the malware: With 500,000 victims, CryptoLocker made upwards of **$30 million in 100 days.**
- ILOVEYOU Worm: 2000
  - "ILOVEYOU overwrote system files and personal files and spread itself over and over and over again."
  - Cost of the malware: **$15 billion.**
- MyDoom: 2004
  - "the fastest-spreading email-based worm ever."
  - Cost of the malware: **$38 billion.**

Source: Norton

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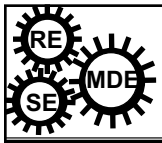

Risk Assessment
Step 3: Quantify Threats

- Estimate likelihood of each threat occurring
- If an event happens on a regular basis, you can estimate based on your records
- Other sources:
  - Power company: official estimate of likelihood for power outage during coming year
  - Insurance company: actuarial data on probabilities of death of key personnel based on age & health
  - Etc.
- Example: Earthquake once in 100 years (1% of your list) vs. discovery of 3 serious bugs in sendmail during next year (300%)

[Garfinkel & Spafford]

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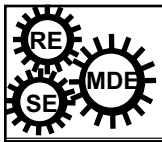

Security Goals

- Computer security objective: Maintain 3 characteristics ("CIA")
- Confidentiality:
  - Assets are accessible only by authorized parties
  - Read-type access: read, view, print, existence
  - AKA: secrecy and privacy
- Integrity:
  - Modified only by authorized parties in authorized ways
  - Modification: write, change, change status, delete, create
- Availability:
  - Assets accessible to authorized parties
  - AKA: denial of service

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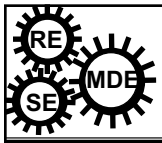

Vulnerabilities

- Reverse the 3 security objectives
- Major assets:
  - Hardware
  - Software
  - Data
- Their interconnection is also an asset

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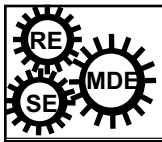

Threats to Hardware

- Physical device is visible – easy target
- "Involuntary computer-slaughter"
  - Accidental acts not intended to do harm
  - Ex: natural acts, human-oriented accidents (spilling of food/drink), dust, smoke, physical abuse
- "Voluntary computer slaughter" – machinicide:
  - Shoot or stab machines, bombs/fires/collisions, short out circuit boards (pens, knives, etc.), stolen
  - Theft and destruction major mechanisms for attack

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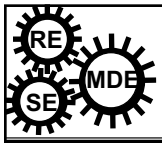

Threats to Software

- Computing Equipment worthless without software
- Deletion: easy to delete
  - Motivate need for configuration management
- Modification:
  - Trojan horse: overtly does one task, covertly does something else
  - Virus: type of Trojan horse; spread infection from one computer to another
  - Trapdoor: program has secret entry point
  - Information leaks: makes information accessible to unintended people/programs
- Theft: unauthorized copying of SW

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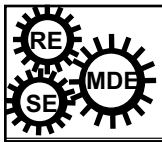

Detour to Automotive Cybersecurity

DETOUR

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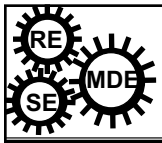

Threats to Data

- Printed data can be readily interpreted by general public
- Data attack more widespread than either HW or SW
- Data has cost:
  - Confidential data has value to competitors
  - Incorrectly modified data lead to loss of human life
  - Poor security can lead to financial liability
    - Personal data is leaked to public
- Data may have short life:
  - High value: (e.g., economic data and effect on stock market)

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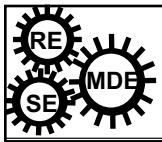

Threats to Data

- **Principle of Adequate Protection**:
  - Computer items must be protected only until they lose their value. They must be protected to a degree consistent with their value. [C. Plfeeger 2000]

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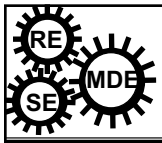

Threats to Data

- Confidentiality:
  - Preventing unauthorized disclosure
  - **Problems:** wiretapping, bugs in output devices, monitoring electromagnetic radiation, bribing key employees. (Data is often human readable.)
- Integrity:
  - Preventing unauthorized modification
  - **Problems:** malicious programs, erroneous file system utilities or flawed communication systems
    - Salami attack
    - Example?: Office Space
- Availability:
  - Preventing denial of authorized access
  - **Problems:** denial of service attacks. (flood server)

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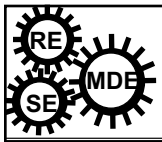

Other threatened entities

- Storage media
  - Need backups of data and physical protection of backups
- Networks:
  - Involve HW, SW, and data
- Access: access to computing equipment (unauthorized use of processing cycles, network, etc.)
- Key People
  - Crucial weak points

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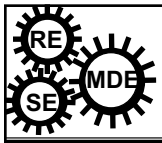

People Involved

- Amateurs:
  - Observed flaw in security
  - Normal/regular employees
  - Exploit system (innocently? E.g., Morris Worm)
- Crackers:
  - Students who attempt to access facilities
  - "victimless" crime?
  - Serious offense: caused millions of dollars in damage
- Career Criminals:
  - Start as computer professionals who engage in computer crime and have good payoffs
  - Electronic spies
  - Response: lack of criminal prosecution trend

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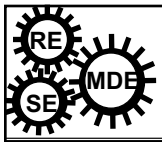

Methods of Defense

- Controls:
  - Encryption: transform data to unintelligible format to outside observers.
  - SW controls:
    - Internal program controls: parts of program enforce security restrictions (e.g., access limits)
    - Operating system controls: limitations enforced by OS to protect users from each other (e.g., number of processes)
    - Development controls: quality standards for design, code, test, and maintenance.

    May use HW components, encryption, or info collection.
    - Affect users directly, so is usually first solution considered
    - Care must be taken in design because it affects the way systems are used
    - Balance between ease of use and effectiveness.

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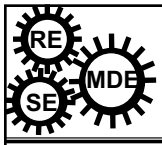

Methods of Defense (cont'd)

- Hardware Controls:
  - HW or smartcard implementations of encryption
  - Locks limiting access
  - Circuit boards that control access to disks in PCs
- Policies:
  - Added HW or SW features
  - Frequent changes of passwords
  - Must have training and administration
  - Legal and ethical controls (lack of understanding and standards for both)
- Physical Controls:
  - Locks on doors, guards at entry points,
  - backup copies of important artifacts,
  - physical site planning to avoid natural disasters

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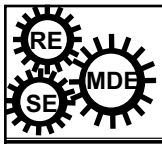

Effectiveness of Controls

- Awareness of problem
  - People using controls must understand the need
- Likelihood of Use:
  - *Principle of Effectiveness: Controls must be used to be effective. They must be efficient, easy to use, and appropriate.*
- Overlapping Controls:
  - Security for a PC may involve security for access to data, physical access to machine/storage media, and file locking mechanisms.
- Periodic Review:
  - Few controls are permanently useful.
  - Need to review and update.

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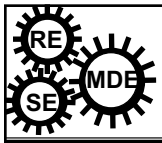
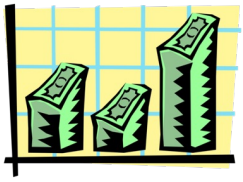


Cost Benefit Analysis

- Cost of Loss
  - Assigning cost range is sufficient
- Cost of Prevention
  - Cost of preventing each loss
- Adding up the Numbers
  - Matrix w/ assets, risks, possible losses
  - Includes: probability, the predicted loss, $ required to defend against the loss
- Convincing Management
  - Risk assessment helps you make proper justifications for management



[Garfinkel & Spafford]

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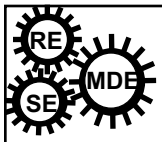

Security Policy

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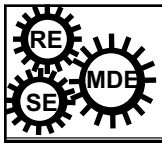

Creating Policy

- Defines what you consider to be valuable and what steps should be taken to safeguard those assets.
- General Policy
- Policy for Different Sets of Assets
  - Email, personnel data, etc.

[Garfinkel & Spafford]

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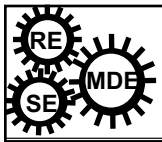

The Role of Policy

- Makes clear what is being protected and why
- States the responsibility for that protection
- Provides grounds upon which to interpret and resolve any later conflicts that might arise
- Should be general and change little over time
- Should *not* list specific threats, machines or individuals by name

[Garfinkel & Spafford]

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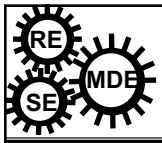
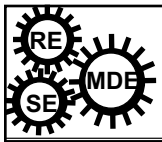


Policy Example

- "Information to be protected is any information discovered, learned, derived, or handled during the course of business that is not generally known outside of company X. This includes trade secret information (ours, and that of other organizations), patent disclosure information, personnel data, financial information, information about business opportunities, and anything else that conveys an advantage to company X so long as it is not disclosed. Personnel information about employees, customers and vendors is also to be considered confidential and protectable.

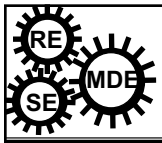
[Garfinkel & Spafford]



Standards

- Standards codify successful practice of security in an organization.
- Generally phrased in terms of "shall"
- Platform independent
- Imply a metric to determine if they have been met
- Developed to support policy
- Change slowly over time

[Garfinkel & Spafford]



Example: Standard for Backups

- Backups shall be made of all online data and software on a regular basis. In no case will backups be done any less often that once every 72 hours of normal business operation. All backups should be kept for a period of at least six months; the first backup in January and July of each year will be kept indefinitely at an off-site, secured storage location. At least one full backup of the entire system shall be taken every other week. All backup media will meet accepted industry standards for its type, to be readable after a minimum of five years in unattended storage.

[Garfinkel & Spafford]

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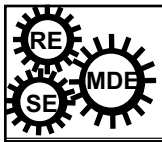

Guidelines

- "Should" statements in policies
- Interpret standards for a particular environment
- Guidelines may be violated
- Guide behavior
- Example:
  - Once per week, the administrator will pick a file at random from some backup made that week. The operator will be required to recover that file as a test of the backup procedures.

[Garfinkel & Spafford]

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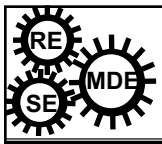
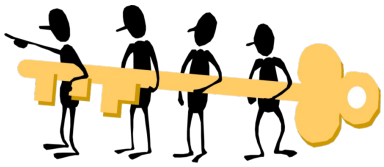


Keys to Developing Policy

- Assign an owner
- Be positive
  - People respond better to positive statements than to negative ones



- Remember that employees are people too
- Concentrate on education
- Have authority commensurate with responsibility
- Pick a basic philosophy
  - Be consistent
- Defend in depth

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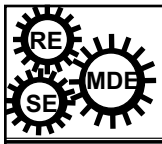

Goals for Security Policies

- Ensure only authorized users have access
- Prevent unauthorized users from gaining access
- Protect sensitive data from unauthorized access
- Prevent accidental damage to HW or SW
- Prevent intentional damage to HW or SW
- Create an environment that can recover quickly
- Communicate employee responsibilities

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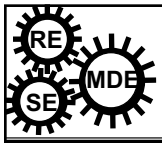
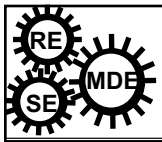


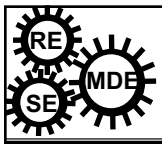
How to Attain the Goals?

- Form a committee
- Who should be involved?
- Decision-making people
- Security coordinator



Security Policy Content

- Password policy
- S/W installation policy
- Confidential and sensitive data policy
- Network access policy
- Email use policy
- Internet use policy
- Modem use policy
- Remote access policy
- Policies for connecting to remote locations
  - Internet
  - Customer's networks
  - Vendor's networks
- Policies for use of laptops and loaner machines
- Computer room access policy



Response Policy

- Response team identified in policy
  - Dispatcher
  - Manager
  - Technical support specialist
  - Public relations specialist

[J.B. Earp]

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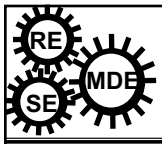

Four Easy Steps to a More Secure Computer

1. Decide how important security is to your site
2. Involve and educate your user community
3. Devise a plan for making and storing backups of your system data
4. Stay inquisitive and suspicious

[Garfinkel & Spafford]

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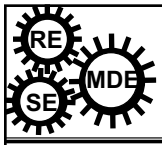

Threat Categories

- Data disclosure
  - Unauthorized access to an IS containing sensitive data (e.g., attacks resulting in data disclosure - eavesdropping)
- Fraud
  - Misrepresentation of identities (need to authenticate credit cards, etc.)
- Data insertion, removal, and modification
  - If it is possible to modify the data during transit, then it is possible to alter the financial transactions.

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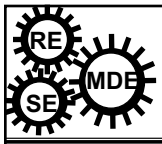
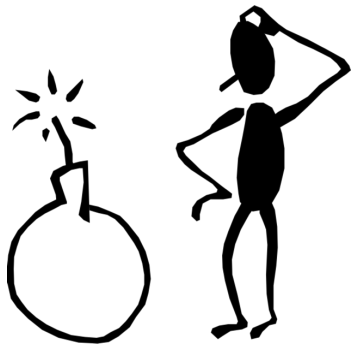


Attack Methods

- DoS (Denial of Service)
  - attacks involve restricting a shared resource from privileged users
  - maliciously causing a Net server to go down
  - unlawful under state and federal laws
- E-mail bombs (e.g., Spam)
  - series of mail messages sent as an annoyance.
- Viruses
- Spoofing
  - impersonation to gain unauthorized access



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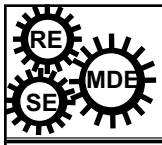

Security Services - 1

- Privacy
  - protect against unauthorized access to data.
- Authentication
  - positively identify an object or identity.
- Access Control
  - restrict access to an object or resource to only privileged identities.

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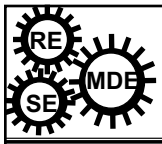

Security Services - 2

- Integrity
  - ensure that the data has not been altered since its creation.
- Non-repudiation:
  - Origin: message sender cannot deny being source msg
  - Submission: a provider can't deny submitting an order (time)
  - Delivery: can't deny receiving an item (for a customer)
  - Receipt: can't deny receiving a message/order
- Replay Prevention
  - ensure that data previously deemed valid cannot be resent by an attacker and mistakenly validated by a system a second time.

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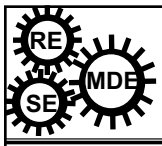
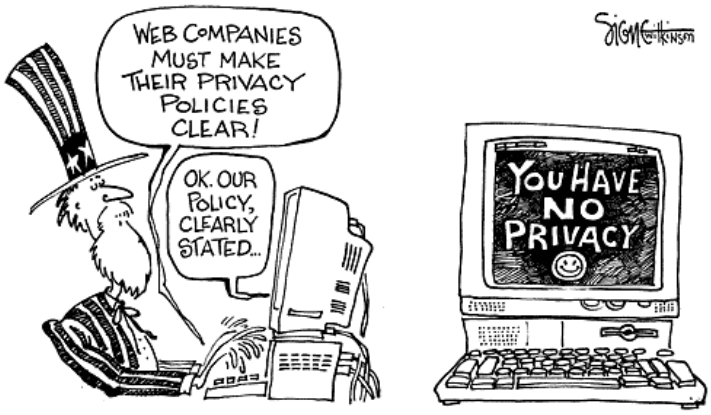
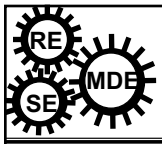


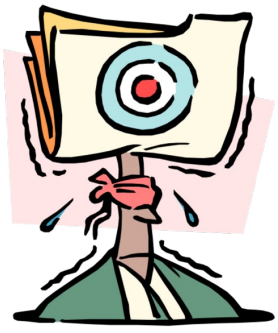
What is the Policy?

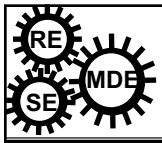




User Anxiety & Perceptions

- **Oblivious**
  - "Privacy Policy? What's a privacy policy?"
- **Paranoid**
  - Doesn't accept *any* cookies
  - Feels like a target
- **Misinformed**
  - "If there's a seal, my personally identifiable information is safe"
  - "If there's a privacy policy posted, I need not worry"
- **Informed**
  - Guards PII & ensures transactions w/ trusted source
  - PII: Personally Identifiable Information





Internet Privacy Policies

- Beware of the short & sweet policies
  - Toysmart
- Beware of the long & legalese laden policies
- Trust seals are misleading to many customers
  - TRUSTe, BBBOnline PrivacyRatings.com
- Policies often do not reflect actual site practices

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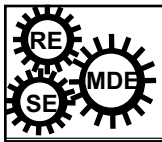

TRUSTe

- Monitors licensees for compliance with posted privacy practices through a variety of measures
- A TRUSTe licensee's privacy policy must disclose:
  - what personal information is being gathered;
  - how the information will be used;
  - who the information will be shared with;
  - the choices available regarding how collected information is used;
  - safeguards in place to protect personal information from loss, misuse, or alteration;
  - and how individuals can update or correct inaccuracies in information collected about them

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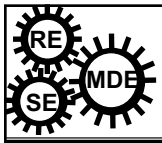

Rules that were supposed to apply…

- "The rules would have banned internet providers from collecting, storing, sharing and selling certain types of personal information - such as browsing histories, app usage data, location information and more - without your consent."

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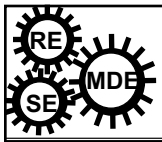

More recently…

- Congress voted on March 28, 2017 to allow ISPs to sell users' browsing history.
- Some ISPs have privacy policy and if they violate, they could be brought to court by state attorney general.
  - Companies can now also relax their privacy policies
- If businesses' data practices are considered "unfair'' to other businesses
  - State attorney general could investigate
  - Federal Communications Commission could sue

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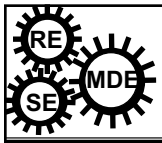
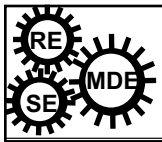


What can you do…

- Use virtual private networks (VPNs)
  - Can hide your location;
  - Surf "undercover"
- Make use of "https"-websites.
  - ISPs can still see that you're visiting certain sites
  - Decrease the amount of details known about you.
- Realistically:
  - Individual users typically not targeted
  - Looking for "categories" of users for marketing purposes
  - Let's not consider the politically-motivated uses for now



Relevant video links

- Jeep hacking:
  - https://www.youtube.com/watch?v=MK0SrxBC1xs
- Office Space virus:
  - https://www.youtube.com/watch?v=GlRG9x0JRMc