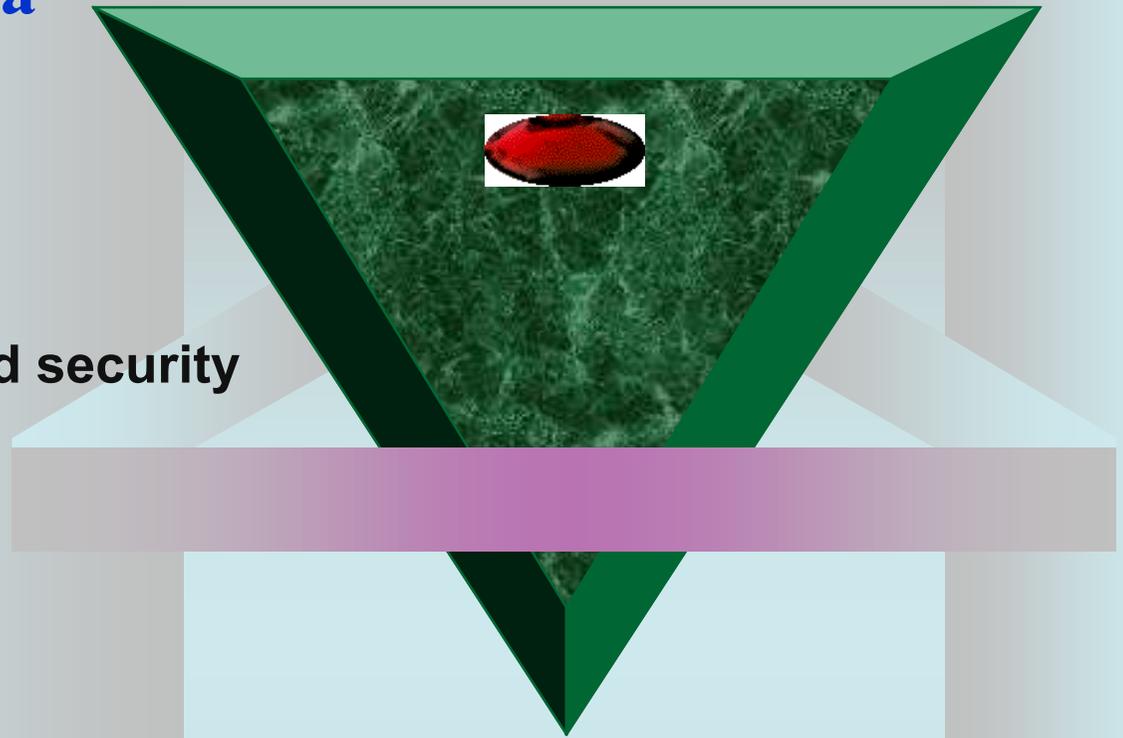


Chapter 3. Securing Data in Computer Networks and Internet

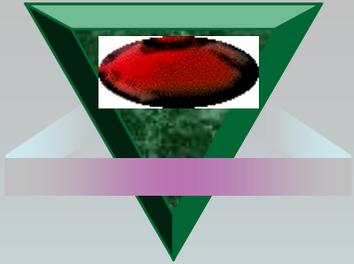
- 3.1 Internet vulnerabilities and security
- 3.2 Access Controls
- 3.3 Vulnerability and Attack
- 3.4 Basic security concepts
- 3.5 Security policy
- 3.6 The Top-Down Approach to Security

■ References



by Professor Vasile AVRAM, PhD

3.1 Internet vulnerabilities and security

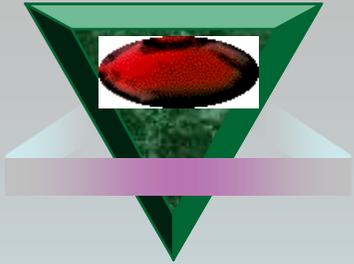


We consider here that the purpose of the computer security is to prevent unauthorized access to the operating system services and to protect the information from voluntary misuse or modification.

For Internet enabled/ based informatics systems or applications/ services where all functionality is based on message exchange, or better on communication, the purpose of the communication security is the protection of the data in a computer network or in a distributed system.



3.1 Internet vulnerabilities and security



It is now essential to design systems to withstand external attacks and to recover from such attacks.

Without security precautions, it is almost inevitable that attackers will compromise a networked system.

Security engineering is concerned with the development and evolution of systems that can resist malicious attacks, which are intended to damage the system or its data.

Software security engineering is part of the more general field of computer security. This has become a priority for businesses and individuals as more and more criminals try to exploit networked systems for illegal purposes.[IS-11]



3.1 Internet vulnerabilities and security

Client/Server Technology

Client/Server Technology. The Internet is based on client/server technology (figure 3.1). All data, including e-mail messages and Web pages, are stored on server. The individuals access that resources and the net control through client applications, such as Web browser. A client uses the Internet to request information or services from a distant computer and the server sends the request information back to the client via Internet.

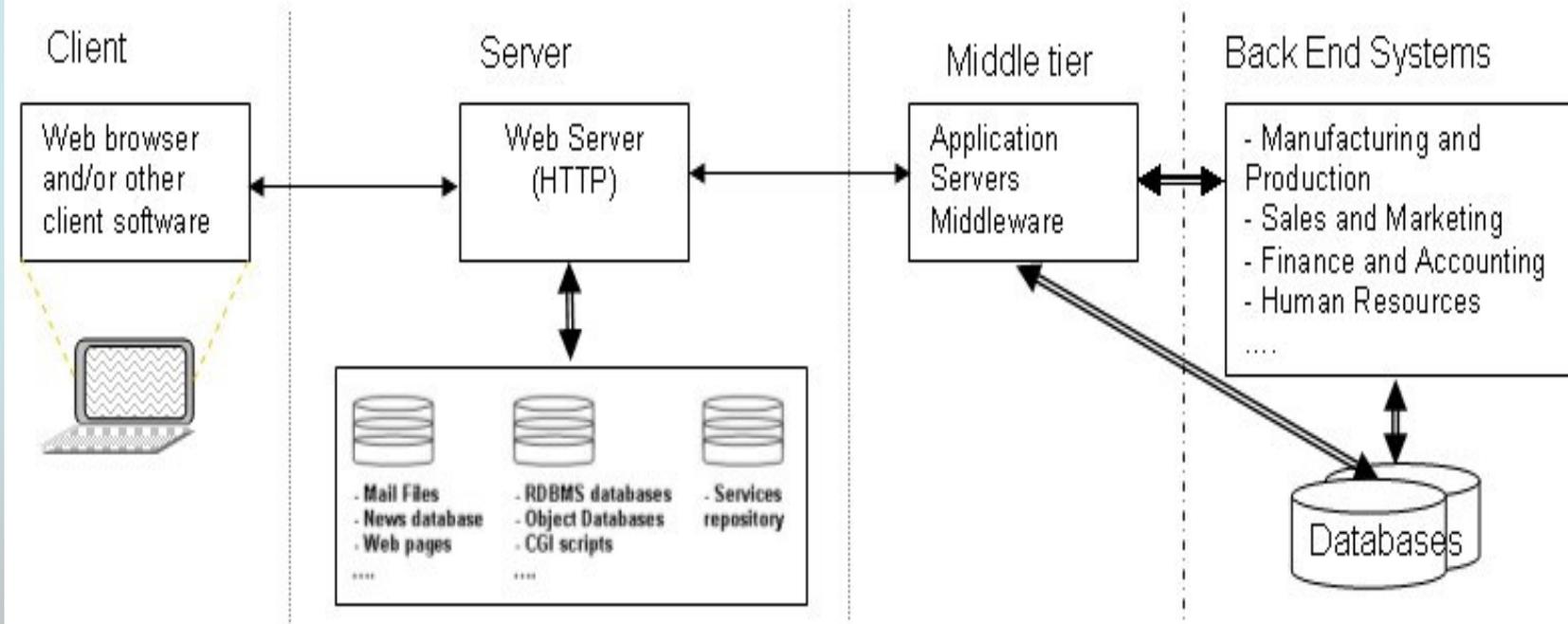


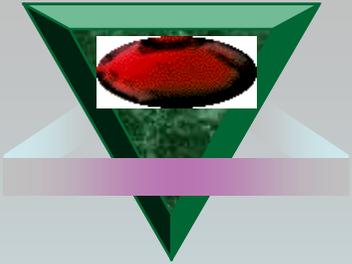
Figure 3.1 Client/server computing on the Internet

3.1 Internet vulnerabilities and security

Client/Server Technology

On a layered model the infrastructure for complex applications running in the back-end systems section in Figure 3.1 or in any server/ client computer may include:

- a platform as combination between specific hardware and an operating system;
- other generic applications/ services that run on that system;
- a database management system or at least its SQL-engine;
- middleware that supports distributed computing and database access or allows the communication with/ within legacy systems;
- libraries of reusable components that are used by the application software;
- Web-services repositories from where Web-services delivered at client request via service broker, to any computer access in “Web enabled” environments.



3.1 Internet vulnerabilities and security

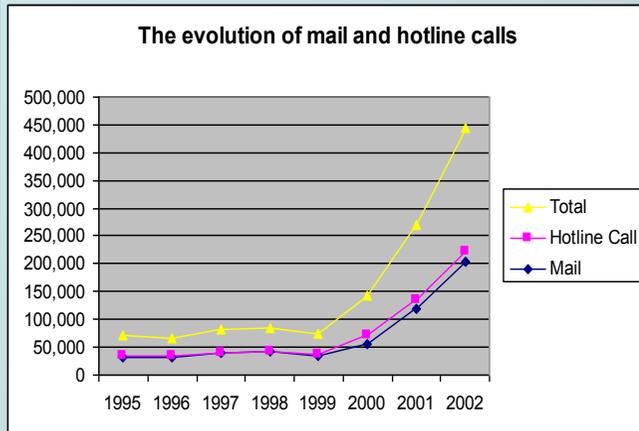


Figure 3.2 The evolution of number of mail messages (in thousands)

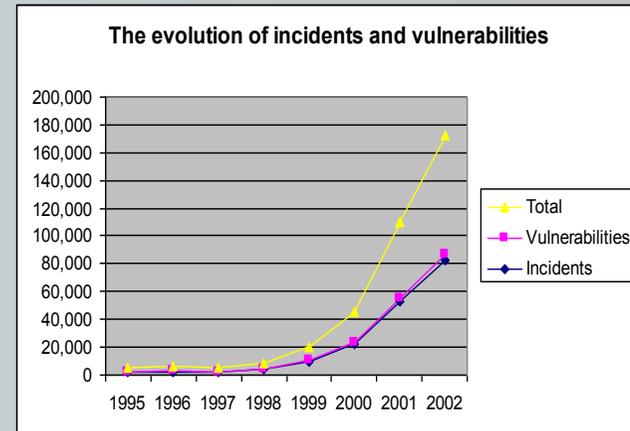


Figure 3.3 The evolution of number of signaled incidents and vulnerabilities (in thousands)

	2013	2014	2015	2016	2017
Worldwide Email Accounts (M)	3,899	4,116	4,353	4,626	4,920
Business Email Accounts (M)	929	974	1,022	1,078	1,138
<i>% Business Email Accounts</i>	<i>24%</i>	<i>24%</i>	<i>23%</i>	<i>23%</i>	<i>23%</i>
Consumer Email Accounts (M)	2,970	3,142	3,331	3,548	3,782
<i>% Consumer Email Accounts</i>	<i>76%</i>	<i>76%</i>	<i>77%</i>	<i>77%</i>	<i>77%</i>

Business vs. Consumer Email Accounts (M), 2013–2017

Figure 3.4 The Estimation 2013-2017 for Email Accounts (Source [IntStat-13-17])

<http://www.internetworldstats.com/stats.htm>

3.1 Internet vulnerabilities and security

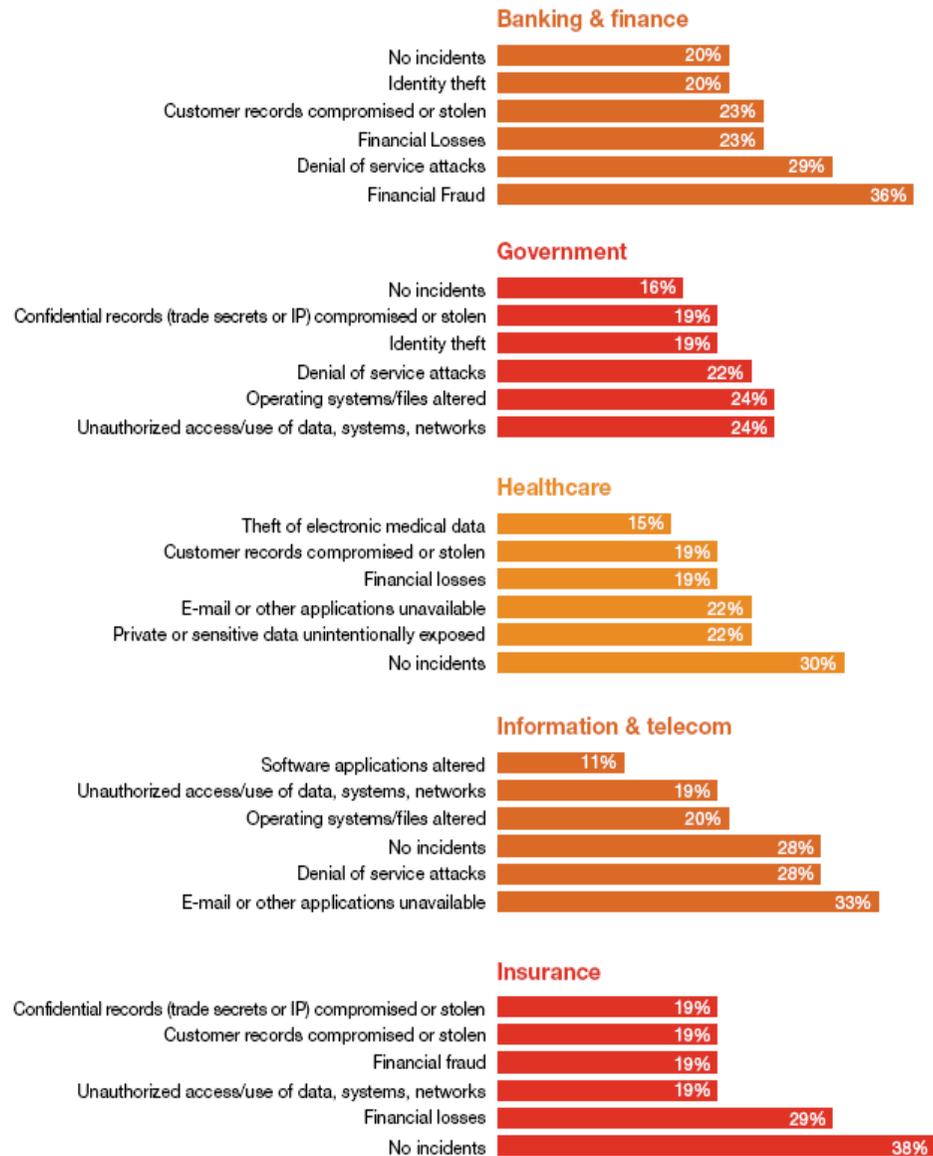
QB3 Which of the following activities do you do online? (MULTIPLE ANSWERS POSSIBLE)

	Email	Reading news online	Using online social networks	Buying goods or services (holidays, books, music, etc.)	Online banking	Playing games online	Selling goods or services	Watching TV	Other (SPONTANEOUS)	Don't know
EU28	86%	63%	60%	57%	54%	29%	23%	22%	5%	1%
Gender										
Man	87%	66%	58%	59%	56%	32%	26%	25%	5%	1%
Woman	86%	60%	62%	54%	52%	27%	19%	19%	5%	1%
Age										
15-24	86%	63%	86%	52%	39%	50%	20%	34%	4%	1%
25-39	88%	65%	72%	61%	60%	34%	28%	25%	4%	1%
40-54	87%	64%	55%	59%	60%	23%	24%	20%	5%	1%
55 +	84%	60%	31%	50%	50%	16%	15%	13%	7%	1%
Education (End of)										
15-	72%	51%	46%	36%	34%	27%	12%	11%	12%	1%
16-19	84%	58%	55%	53%	50%	29%	21%	17%	5%	1%
20+	93%	73%	60%	68%	69%	24%	28%	27%	3%	0%
Still studying	88%	64%	87%	52%	36%	51%	20%	36%	5%	0%
Use of the Internet										
Every day	90%	66%	65%	62%	59%	32%	25%	26%	4%	0%
Often/ Sometimes	65%	46%	33%	28%	25%	15%	9%	6%	10%	3%
Level of information about cybercrime risks										
Total 'Well informed'	90%	68%	64%	64%	60%	33%	26%	27%	4%	0%
Total 'Not well informed'	81%	56%	54%	47%	46%	25%	19%	15%	6%	1%

Source: [EU-2015] Special Eurobarometer 423 "Cyber security", ISBN 978-92-79-46185-9, DOI 10.2837/411118, European Union, 2015 ,
http://ec.europa.eu/public_opinion/archives/ebs/ebs_423_en.pdf

3.1 Internet vulnerabilities and security

Figure 1: Significant detected incidents across industries



Source: US cybercrime: Rising risks, reduced readiness Key findings from the 2014 US State of Cybercrime Survey, <http://www.pwc.com/cybersecurity>

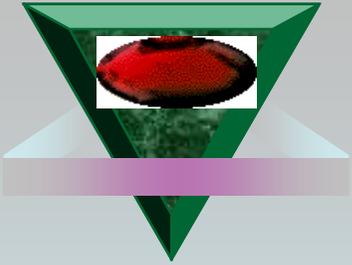
3.1 Internet vulnerabilities and security

A. Potential ecommerce threats

Natural disasters	Other disasters
Cold weather	Blackouts
Earthquakes	Fires
Floods	Gas leaks
Hot weather	Neighborhood hazards
Hurricanes	Nuclear attacks
Ice storms	Oil leaks
Ocean waves	Power failure
Severe dust	Power fluctuations
Snow	Radioactive fallout
Tornadoes	Structural failure

B. Intentional computer and e-commerce threats usually fall into one of the following categories:

- Computer viruses;
- Trojan horses;
- Logic bombs;
- Trap doors;
- Denial-of-access attacks



3.2 Access Controls

Topic	Meaning
Permission	the access granted for an object which determine what you can do with it, such as read permission for a file that allows only to open it, or create, read, edit, or delete that allow you to completely manipulate the file;
Rights	the ability to take an action on an object, for example to modify the hour and date in in the system settings;
Privileges	the combination rights and permissions.

The primary access control types can be categorized as:

- **Preventive** – stop unwanted or unauthorized activity from occurring.
- **Detective** – discover or detect unwanted or unauthorized activity;
- **Corrective** – modifies the environment to return systems to normal after an unwanted or unauthorized activity has occurred;
- **Deterrent** – discourage violation of security policies.;
- **Recovery** – repair or restore resources, functions, and capabilities after a violation of security policies;
- **Directive** – direct, confine, or control the actions of subjects to force or encourage compliance with security policies;
- **Compensation** – provide various options to other existing controls to aid in enforcement and support of security policies.

3.3 Vulnerability and Attack

A **vulnerability** is a weakness that a person can exploit to accomplish something that is not authorized or intended as legitimate use of a network or system.

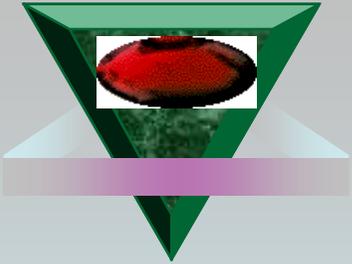
When a vulnerability is exploited to compromise the security of systems or information on those systems, the result is a **security incident**.

Vulnerabilities may be caused by engineering or design errors, or faulty implementation.

An **attack** is any attempt to exploit the vulnerability of a system. Here we must consider two categories **crackers** and **hackers**.

Typical hacking activities might include:

- defacement of a website;
- obtaining access to and stealing information;
- corrupting data;
- the illicit use of credit cards in corporate payment systems.



3.3 Vulnerability and Attack

The technical causes behind successful intrusion techniques are represented by the following (but not only) major technical vulnerabilities:

- flaws in software or protocol designs;
- weaknesses in how protocols and software are implemented;
- weaknesses in system and network configurations.

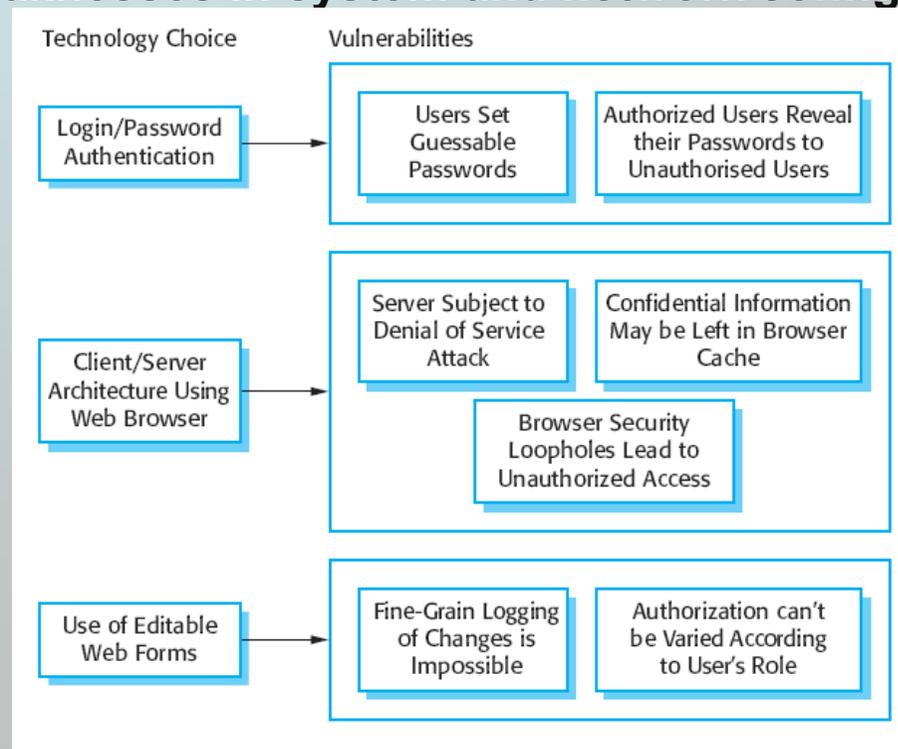


Figure 3.5 The Dependences Between Technology and Vulnerabilities (Source [IS-11])

3.3 Vulnerability and Attack

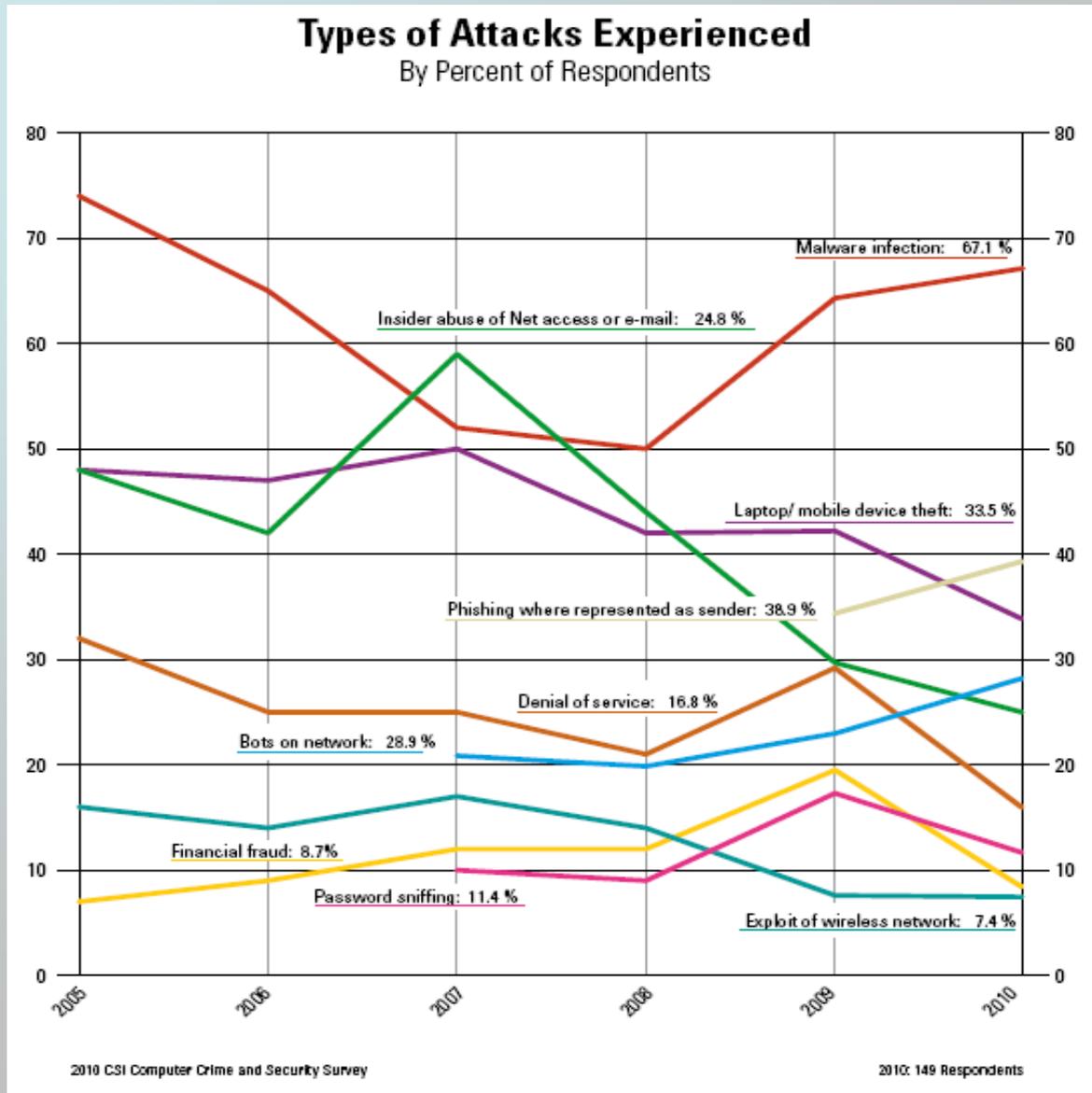


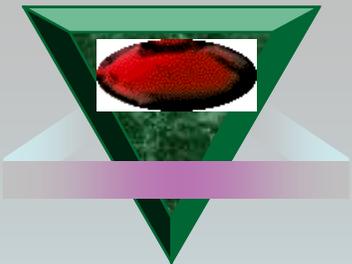
Figure 3.6 Types of Attacks Experienced (Source [CSI-10])

3.4 Basic security concepts

The concepts of confidentiality, integrity, and availability

Concept	Description
Confidentiality	<p>When information is read or copied by someone not authorized to do so, the result is known as <i>loss of confidentiality</i>. For some types of information, confidentiality is a very important attribute. Examples include research data, medical and insurance records, new product specifications, and corporate investment strategies.</p> <p>For example, when the buyer makes a payment on the Internet and inserts the credit card number, the system encrypts it so that on its way from the buyer to the merchant and from the merchant to a transaction processing network, the access to the places where it is stored will be limited. Confidentiality can be thus described as protection of the privacy of the clients' personal information.</p>
Integrity	<p>Information can be corrupted when it is available on an insecure network. When information is modified in unexpected ways, the result is known as <i>loss of integrity</i>. This means that unauthorized changes are made to information, whether by human error or intentional tampering. Integrity is particularly important for critical safety and financial data used for activities such as electronic funds transfers, air traffic control, and financial accounting.</p>
Availability	<p>Information can be erased or become inaccessible, resulting in <i>loss of availability</i>. This means that people who are authorized to get information cannot get what they need. Availability is often the most important attribute in service-oriented businesses that depend on information (e.g., airline schedules and online inventory systems). Availability of the network itself is important to anyone whose business or education relies on a network connection. When a user cannot get access to the network or specific services provided on the network, they experience a <i>denial of service</i> (DoS).</p>





3.4 Basic security concepts

The concepts of identification, authentication, authorization, nonrepudiation, and accountability

Concept	Description
Identification	<i>A subject</i> claims an identity. Is the process by which a subject professes an identity and accountability is initiated.
Authentication	<i>Authentication</i> is proving that a user is whom he or she claims to be, it proves a claimed identity. That proof may involve something the user knows (such as a password), something the user has (such as a "smartcard"), or something about the user that proves the person's identity (such as a fingerprint). Thus we consider that authentication is the process of verifying or testing that a claimed identity is valid. Identification and authentication always occur together as a single two-step process. The most common authentication technique is the use of password that is generally transmitted encrypted using hashing algorithms such as Message Digest 5 (MD5) or Secure Hash Algorithm 1 (SHA-1).
Authorization	<i>Authorization</i> is the act of determining whether a particular user (or computer system) has the right to carry out a certain activity, such as reading a file or running a program. Subjects are granted access to objects based on proven identities.
Nonrepudiation	Users must be authenticated before carrying out the activity they are authorized to perform. Security is strong when the means of authentication cannot later be refuted - the user cannot later deny that he or she performed the activity. This is known as <i>nonrepudiation</i> .
Accountability	When auditing is implemented subjects can be held accountable for their actions



3.4 Basic security concepts

A **network security incident** is any network-related activity with negative security implications. This usually means that the activity violates an explicit or implicit security policy (see the section on security policy).

Category	Description
Probe	A probe is characterized by unusual attempts to gain access to a system or to discover information about the system.
Scan	A scan is simply a large number of probes done using an automated tool.
Account Compromise	An account compromise is the unauthorized use of a computer account by someone other than the account owner, without involving system-level or root-level privileges (privileges a system administrator or network manager has).
Root Compromise	A root compromise is similar to an account compromise, except that the account that has been compromised has special privileges on the system.
Packet Sniffer	A packet sniffer is a program that captures data from information packets as they travel over the network.
Denial of Service	The goal of denial-of-service attacks is not to gain unauthorized access to machines or data, but to prevent legitimate users of a service from using it.
Exploitation of Trust	Computers on networks often have trust relationships with one another and attackers can forge their identity, appearing to be using the trusted computer, they may be able to gain unauthorized access to other computers.
Malicious Code	Malicious code is a general term for programs that, when executed, would cause undesired results on a system. Users of the system usually are not aware of the program until they discover the damage. Malicious code includes: Trojan horses, viruses, and worms. Trojan horses and viruses are usually hidden in legitimate programs or files that attackers have altered to do more than what is expected. Worms are self-replicating programs that spread with no human intervention after they are started. Generally they used as transport vector for viruses. Viruses are also self-replicating programs, but usually require some action on the part of the user to spread inadvertently to other programs or systems. These sorts of programs can lead to serious data loss, downtime, denial of service, and other types of security incidents.
Internet Infrastructure Attacks	These rare but serious attacks involve key components of the Internet infrastructure rather than specific systems on the Internet.

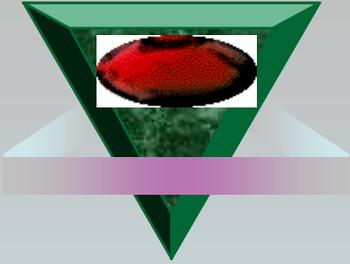
Categories of incidents



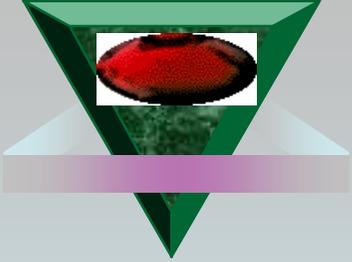
3.4 Basic security concepts

Social Engineering Attacks

Phishing	Attempts to trick users into giving up sensitive information, opening an attachment, or clicking a link. It often tries to obtain personally identifiable information such as usernames, passwords, or credit card details by masquerading as a legitimate company.
Spear Phishing	A form of phishing targeted to a specific group of users. It may appear to originate from a colleague or co-worker within the organization or from an external source.
Whaling	A variant of phishing that targets senior or high-level executives such as CEOs and presidents.
Vishing	A variant of phishing that uses the phone system or VoIP commonly to spoof the caller ID number to impersonate a valid bank or financial institution.
Smart Card Attacks	The attack is a side-channel attack it means is a passive, noninvasive attack intended to observe the operation of a device. When the attack is successful, the attacker is able to learn valuable information contained within the card, such as an encryption key and personal identification number (PIN).
Denial of Service Attacks (DoS)	DoS prevents a system from processing or responding to legitimate traffic or requests for resources.



3.4 Basic security concepts

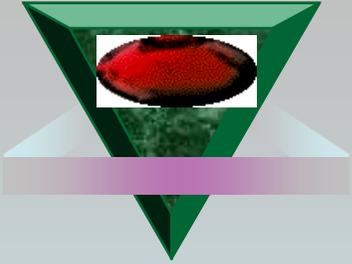


Some computer virus symptoms are represented by:

- **Certain programs are bigger than normal;**
- **Data disintegrates;**
- **Data or programs are damaged;**
- **Hard disk space diminishes significantly;**
- **Keyboard locks;**
- **Memory becomes constrained;**
- **Screen freezes (no cursor movement);**
- **Sluggish disk access;**
- **Unexpected disk activity;**
- **Unusual messages appear on the screen;**
- **The computer takes too much time to boot.**



3.5 Security policy



A **security policy** is a documented high-level plan for organization-wide computer and **information security**.

It defines the security requirements for an organization, identifies assets that need protection and the extent to which security solutions should go to protect them, and provides a framework for making specific decisions, such as which defense mechanisms to use and how to configure services, and is the basis for developing secure programming guidelines and procedures for users and system administrators to follow.



3.5 Security policy

A security policy covers the following (among other topics appropriate to the organization):

- high-level description of the technical environment of the site, the legal environment (governing laws), the authority of the policy, and the basic philosophy to be used when interpreting the policy;
- risk analysis that identifies the site's assets, the threats that exist against those assets, and the costs of asset loss;
- guidelines for system administrators on how to manage systems;
- definition of acceptable use for users;
- guidelines for reacting to a site compromise.



3.5 Security policy

Technical options that support policy include (but are not limited to);

- challenge/response systems for authentication;
- auditing systems for accountability and event reconstruction;
- encryption systems for the confidential storage and transmission of data;
- network tools such as firewalls (Figure 3.7) and proxy servers.

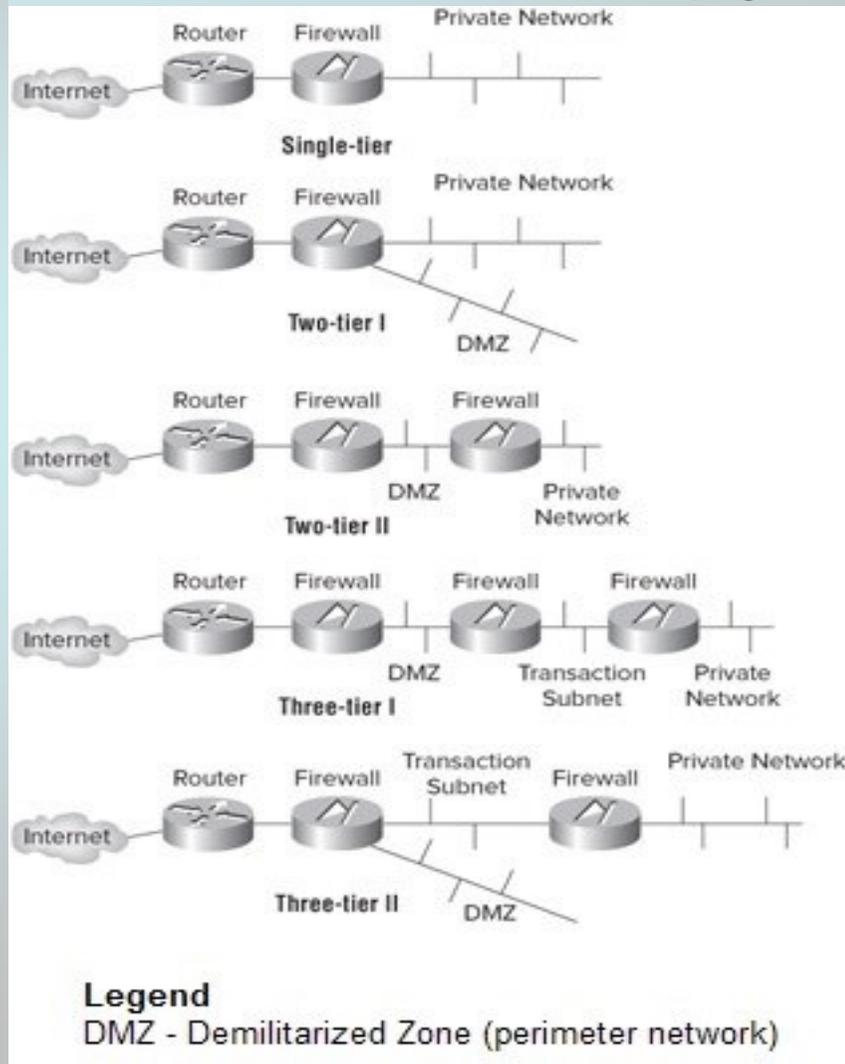
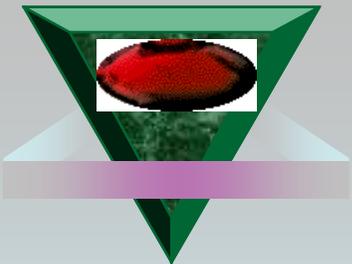


Figure 3.7 Some firewall deployment architectures (Source:[HTMK-07],[CISSP-12])



3.5 Security policy

The commonly recommended practices for improving security are represented by the following:

- all accounts must have a password and the passwords are difficult to guess (maybe, a one-time password system is preferable to other);
- the cryptographic techniques must be used to ensure the integrity of system software on a regular basis;
- apply secure programming techniques when writing software;
- must be vigilant in network use and configuration and all necessary changes must be realized as vulnerabilities become known;
- apply the latest available fixes and keep systems current with upgrades and patches as vendors deliver them;
- regularly check on-line security archives for security alerts and technical advice;
- audit systems and networks, and regularly check logs.

... combined with:

Biometric Security Measures:

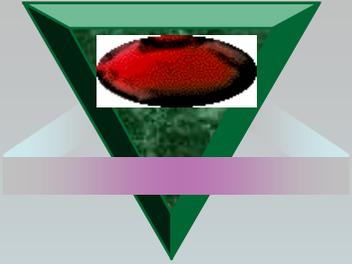
- Fingerprint
 - Hand geometry
 - Palmprint
 - Retinal scanning
 - Signature analysis
 - Voice recognition
- 

3.5 Security policy

A 10 points security guideline that is helpful in designing system security (based on [IS-11]) is:

Nr.	Security Guideline	Explanation
1	Base security decisions on an explicit security policy	After the definition of security policy all security decisions must consider them
2	Avoid a single point of failure	The security must not be enshured by a single mechanism
3	Fail securely	Since system failures are inevitable in all systems security critical systems should always 'failsecure' (protect the system even when failling).
4	Balance security and usability	The demands of security and usability are often contradictory
5	Log user actions	Maintain a log of user actions
6	Use redundancy and diversity to reduce risk	Maintain more than one version of software or data in a system
7	Validate all inputs	
8	Compartmentalize your assets	Should not provide all-or-nothing access to information in a system
9	Design for deployment	System must be configured correctly when it is deployed in its operational environment
10	Design for recoverability	Design the system with the assumption that a security failure could occur

3.5 Security policy



The security of a system must be checked on a scheduled basis and any time a suspicion appear in systems behavior.

The check of the security of a system can be realized by using a combination of testing, tool-based analysis, and formal verification:

- Experience-based testing - system is analyzed against types of attack that are known to the validation team;**
- Tool-based testing – usage of various security tools to analyze the system;**
- Formal verification – verify system against a formal security specification.**



3.5 Security policy

The Figure 3.8 shows the protection applied on a Patient system at infrastructure levels.

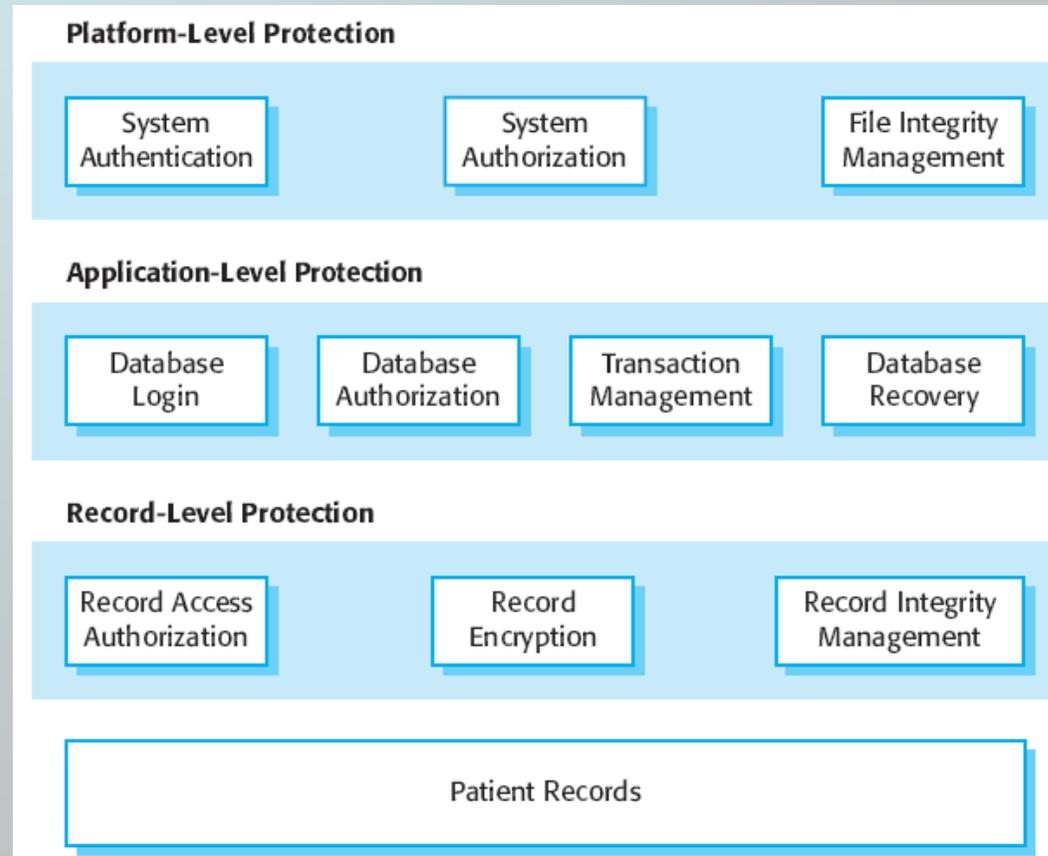
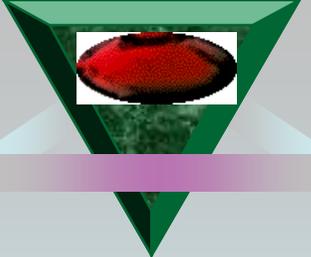


Figure 8 Protection Levels for a Patient Application (Source [IS-11])



3.5 Security policy

Preventing Access Control Attacks

The protection against access control attacks requires a rigid adherence to a strong security policy and to take numerous security precautions such as:

- Control physical access to systems;
- Control electronic access to password files;
- Encrypt password files;
- Create a strong password policy;
- Offer tips to users on how to create strong passwords;
- Use password masking;
- Deploy multifactor authentication;
- Use account lockout controls;
- Use last logon notification;
- Educate users about security;
- Audit access controls;
- Actively manage accounts;
- Use vulnerability scanners.



3.5 Security policy

Types of Security Technology Used By Percent of Respondents

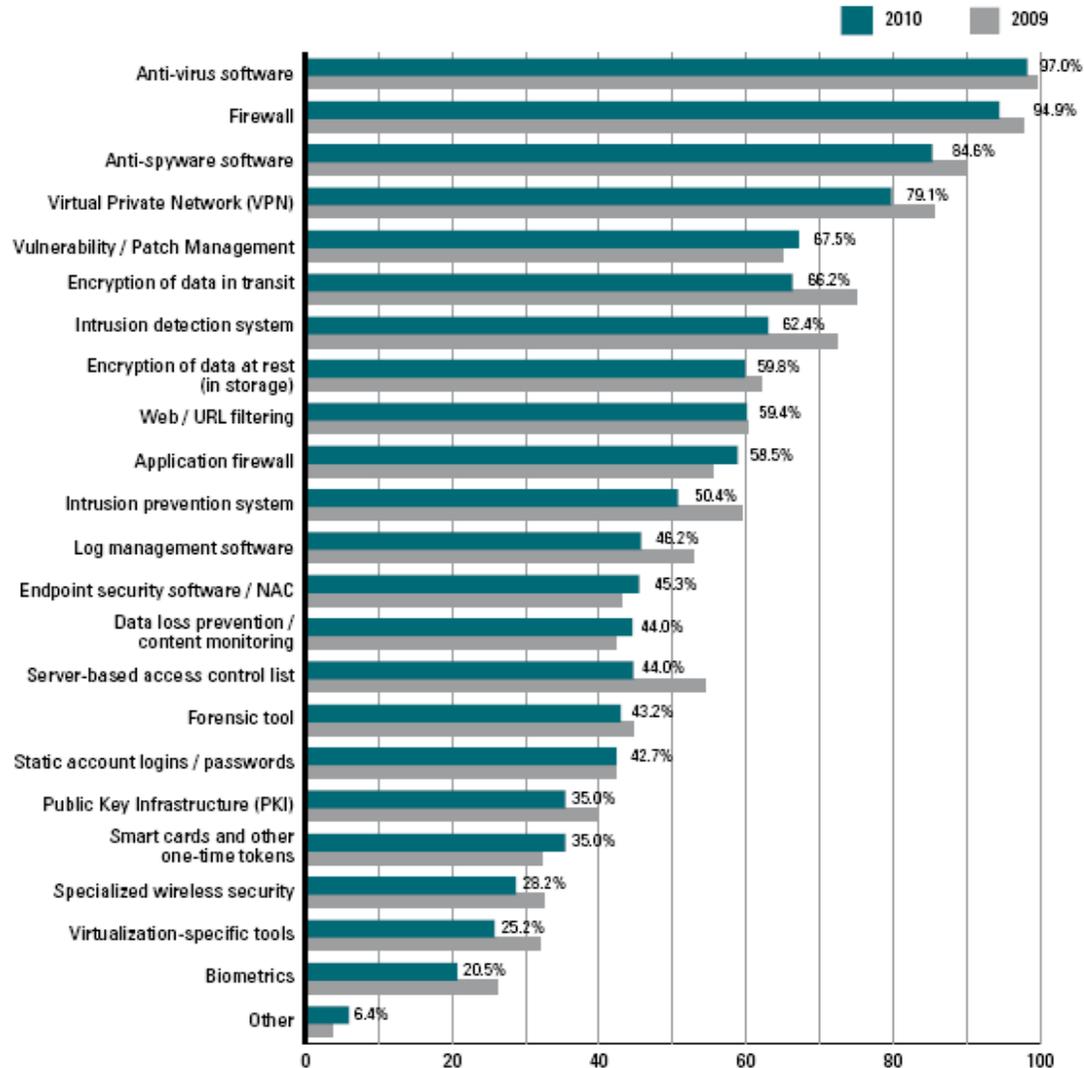


Figure 9 Type of Security Technology Used (Source [CSI-10])

3.5 Security policy

Satisfaction With Security Technology

On a scale of 1 to 5

Deployed
July 2009 - June 2010

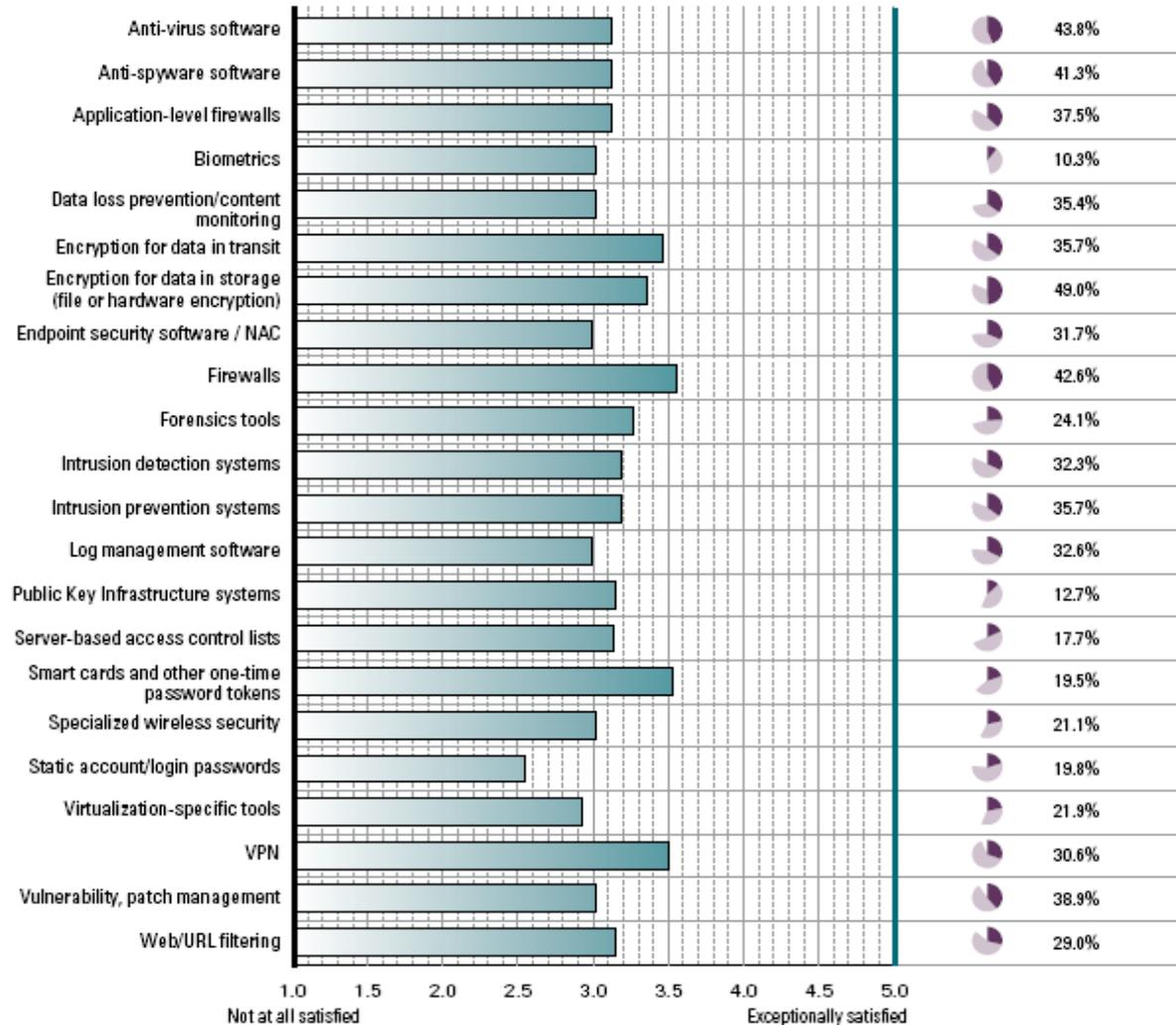


Figure 10 Satisfaction With Security Technology (Source [CSI-10])



3.6 The Top-Down Approach to Security

The initiation, support, and direction come from top management, work their way through middle management, and then reach staff members so that a security program must be designed and implemented based on a top-down approach.

A top-down approach makes sure the people actually responsible for protecting the company's assets (senior management) are driving the program [HS-10].

The approach includes two phases:

1. Design and implement a security program.
2. Develop and implement procedures, standards, and guidelines that support the security policy and to identify the security countermeasures and methods to be put into place.



The Ransomware (excerpts from reference [Sy-15])

There are two main forms of ransomware in circulation today:

- Locker ransomware (computer locker): Denies access to the computer or device;
- Crypto ransomware (data locker): Prevents access to files or data. Crypto ransomware doesn't necessarily have to use encryption to stop users from accessing their data, but the vast majority of it does.

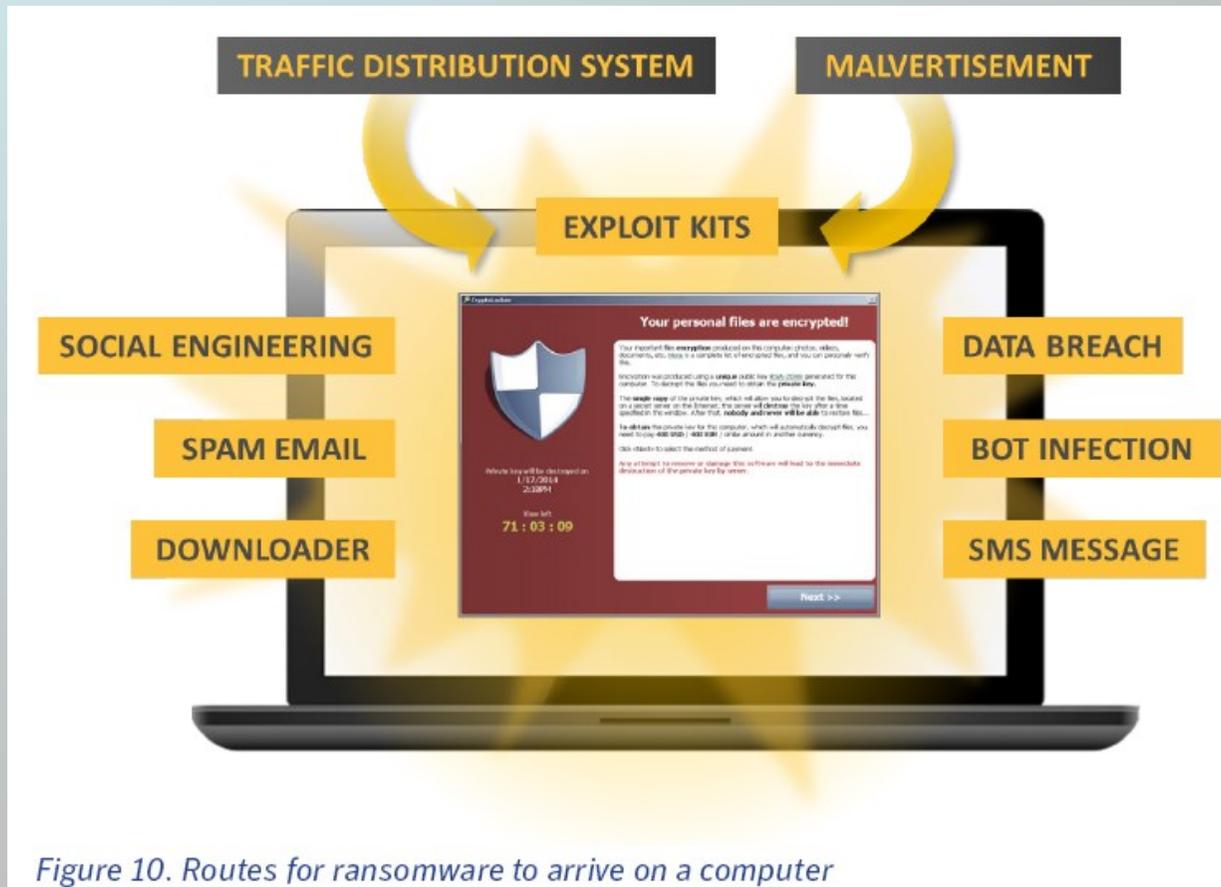


Figure 10. Routes for ransomware to arrive on a computer

http://www.symantec.com/content/en/us/enterprise/media/security_response/whitepapers/the-evolution-of-ransomware.pdf - find the article here

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