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Vulnerability Assessment
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July 6, 2001
Version 1.2e

I. Overview

The intention of this paper is to:
- Provide basic information to those who have recently entered the security field.
- Provide some insight as to why a vulnerability assessment is necessary.
- Provide an overview of the vulnerability assessment process from discovery to baseline standardization.
- Provide some assistance to those who want to perform a vulnerability assessment but do not know where to start.

II.   Definition

As documented by SANS, "Vulnerabilities are the gateways by which threats are manifested" [1]. In other words, a system compromise can occur through a weakness found in a system. A vulnerability assessment is a search for these weaknesses/exposures in order to apply a patch or fix to prevent a compromise.

How do these weaknesses occur? There are two points to consider:
- Many systems are shipped with: known and unknown security holes and bugs, and insecure default settings (passwords, etc.).
- Many vulnerabilities occur as a result of misconfigurations by system administrators.

Ways to counteract these conditions include:
1) creating and abiding by baseline security standards,
2) installing vendor patches (when appropriate),
3) vulnerability scanning,
4) subscribing to and abiding by security advisories,
5) implementing perimeter defenses, such as firewalls and router ACLs,
6) implementing intrusion detection systems and virus scanning software.

See also Section VI. Protective Measures.

III.   Statistics

Not to anyone's surprise, recent figures from numerous organizations, including CERT and CSI show a rise in intrusion attempts and attacks.

For instance, per the "2000 Computer Security Journal/FBI Computer Crime and Security Survey" [2], the trends that have emerged over the previous years are:

- Organizations are under cyber attack from both inside and outside of their electronic

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perimeters.
- A wide range of cyber attacks have been detected.
- Cyber attacks can result in serious financial losses.
- Defending successfully against such attacks requires more than just the use of information security technology.

Per CERT/CC statistics (3), the number of reported incidents went from 9,859 in 1999 to 21,756 in 2000. The number of vulnerabilities reported went from 417 in 1999 to 1090 in 2000. See http://www.cert.org/stats/cert_stats.html for more information.

What has been done in response to this increase in malicious activity?

- Vendor responses with more patches/updates.
- An attempt to increase public awareness of security issues by such organizations as CERT, SANS, FIRST, etc.
- The FBI has established the National Infrastructures Protection Center (NIPC) http://www.nipc.gov/ (possibly being replaced later this year with a new CyberSecurity Board commissioned by President Bush (4)) and the Regional Computer Intrusion Squads.
- The Department of Justice created the Computer Crime and Intellectual Property Section (CCIPS) http://www.cybercrime.gov
- New laws and regulations.
- Media attention.
- More tools in the security arsenal.
- Proposed stiffer penalties and jail time for those convicted.
- More responsibilities given to security professionals.
- See http://www.officer.com/special_ops/c_crimes.htm and http://www.computer-investigators.com/lawenforcement.html for more information on computer crime units.

IV.   Reporting

Depending on who discovers the vulnerability, it can either be exploited or reported. Vulnerabilities are reported in the hope that the vendor will provide a timely patch or someone will develop a fix.

The following represents two avenues for reporting vulnerabilities:

- BugTraq's (a moderated mailing list specific to discussion of security vulnerabilities) vulnerability reporting protocol (5) is as follows:

    1. Contact the product's vendor and give them one week to respond. If they don't respond, post to the BugTraq list. See http://www.securityfocus.com for posting information.

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2. If you do hear from the vendor, give them what you consider appropriate time to fix the vulnerability. This will depend on the vulnerability and the product.

- CERT Coordination Center. CERT/CC's reporting form (6) can be found at http://www.cert.org/reporting/vulnerability_form.txt

There is some disagreement on the proper vulnerability reporting protocol. First, BugTraq publishes the exploit scripts. But other organizations, such as CERT, FIRST, and NIPC publish vulnerabilities without the exploit scripts. Each has their reasons for doing so. The difference in opinion is due to the fact that many attackers exploit the newly published vulnerabilities. Second, a person should act responsibly after discovering a vulnerability. Before releasing the problem to the public, they should give the vendor ample time to provide a patch. Releasing the problem to the public too soon can cause an increase in malicious behavior.

In light of this difference of opinion, committees have been formed by security-industry leaders to standardize security practices. One event, held in November 2000, was the Security Vulnerability Summit (7), a gathering of thirty industry leaders "to identify and discuss the principal issues surrounding security vulnerability disclosures". The goal of the Summit was to "create a clear, timely, and predictable process by which customers, vendors, government organizations and other key parties can be alerted to potential security threats and take the appropriate measures to protect their digital assets". See Appendix A for a follow-up to the Security Vulnerability Summit meeting. Also, you can read more at http://www.zdnet.com/enterprise/stories/main/0,10228,2652346-4,00.html.

However, creating an industry-wide standard is an overwhelming task and this is clearly a topic that needs further discussion.

V. Classification

Another problem facing the security industry is the way vulnerabilities are named or grouped. With various security professionals and product manufacturers giving different names to the same vulnerabilities, it can be confusing to the security practitioners who work in the field.

However, organizations have stepped in to help in developing a common language for the vulnerabilities. The result is CVE - Common Vulnerabilities and Exposures List (8). Sponsored by the Mitre Corporation, CVE has set a standard in the naming convention of security vulnerabilities making them easier to discuss & document. The entire CVE List of vulnerability naming standards can be downloaded at http://cve.mitre.org/cve/index.html.

Per Laura Taylor, founder of Relevant Technologies, the CVE "makes it easier for security vendors to develop intrusion detection and scanning tools. As more IT decision makers understand the meaning of CVE, products with CVE-compatible names will likely receive a better reception on the market".

Many products already use the CVE standard. They include:
- STAT (Security Threat Avoidance

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Technology) Scanner by Harris Corp. http://www.statonline.com/index.asp
- Internet Scanner by ISS Internet Security Systems http://www.iss.net
- Nessus Security Scanner http://www.nessus.org/

See http://www.cve.mitre.org/compatible/ for more CVE-compatible products.

VI.   Protective Measures

Common exploits occur because of weaknesses found in a computing environment. These exploits are an attack against:

1. **Confidentiality** - being secure from unauthorized access.   Example: Vulnerabilities in telnet (user names and passwords sent unencrypted from a remote connection) can allow an attack against Confidentiality.

2. **Integrity** - accuracy and completeness of data. Example: Vulnerabilities in sendmail (mail can be forged from any address) can allow an attack against integrity.

3. **Availability -** data and systems ready for use at all times by authorized users. Example: Variations in ping (request for information, can cause a denial of service attack - i.e., floods, ping of death) can be an attack against Availability.

Examples of Protective Security Measures

- access controls - user IDs and passwords, appropriate password and security policies,
- separation of duties,
- user authentication, with appropriate use of controls, where possible, e.g. smart cards, biometrics, etc.
- workstation lock screens,
- encryption,
- proper registry permissions,
- proper directory and file permissions,
- properly defined user rights,
- social engineering prevention,
- applying patches/updates,
- firewalls,
- VPN tunneling,
- screening routers,
- anti-virus software,
- prompt removal of terminated/transferred employee accounts, default passwords and unnecessary services running on the system,
- implementing and enforcing change control policy to limit activity to authorized users only,
- review and management signoffs of user authorizations,
- use of checksums with attendant software to report file modifications,

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- enable audit logging and perform log reviews,
- review of open ports and services,
- properly configured routers,
- searching for and disconnecting unauthorized or poorly configured modem services.

Vulnerability Listings

Various organizations maintain a vulnerability listing. They include vendor sites, such as, ISS
http://xforce.iss.net/security_library/ and Microsoft
http://www.microsoft.com/technet/treeview/default.asp?url=/technet/itsolutions/security/current.
asp , and security organizations, such as SANS http://www.sans.org/topten.htm and CERT
http://www.cert.org/current/current_activity.html

Tripwire has created a poster of exploits you can obtain at:
http://www.tripwire.com/literature/poster/index.cfml?cfid=643809&cftoken=708

Subscribing to these site's newsletters will keep you abreast of current activity.

VII.   Tools

There are different types of vulnerability scanners available: layer of analysis: host scanners,
network scanners, database scanners; engine types and platforms; wardialers; open-source and
commercial scanners.

What are the differences?
As stated in "FDIC: Risk Assessment Tools and Practices for Information System Security" [9],

Host based tools search for vulnerabilities on an individual computer.."are effective at identifying
security risks that result from internal misuse or hackers using a computer system….detect holes
that would allow unauthorized access…and confirm that various security policies are being
followed".

Network based scanners "reside on the network to detect if it is vulnerable to known
attacks….effective at detecting network attacks…can detect unauthorized systems on a network
or insecure connections to business partners".

Database Scanners identify potential security exposures in database systems.

Wardialers search for modems, which are capable of providing unauthorized remote access to an
organization.

Below is a sample of tools [10 - websites updated 7/16/01] categorized by their scanning platform -
whether host, network, database-based or a wardialer.

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NETWORK BASED SCANNING TOOLS

NAME	ENGINE TYPE	OPENSOURCE	COMMERCIAL	WEBSITE
Cisco Secure Scanner	NT		X	Http://www.cisco.com/warp/public/cc/pd/sqsw/nesn/
Whisker	Linux	X		http://www.wiretrip.net/rfp/p/doc.asp?id=21&iface=2
Retina	NT/2000		X	http://www.eeye.com/html/Products/Retina/
Nessus	Unix/Linux	X		http://www.nessus.com
Nmap Footprinting tool	Unix/NT	X		http://www.insecure.org/nmap/

HOST BASED SCANNING TOOLS

NAME	ENGINE TYPE	FREEWARE	COMMERCIAL	WEBSITE
STAT	NT		X	http://www.statonline.com/index.asp
CyberCop	Win32/Linux		X	http://www.pgp.com/products/cybercop-scanner/default.asp

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TARA	Linux/Unix	X		http://www.www-arc.com/tara/index.shtml
ISS System Scanner	NT/2000		X	http://www.iss.net/securing_e-business/security_products/security_assessment/system_scanner/
VigilEnt	Various		X	http://www.pentasafe.com/products/

DATABASE SCANNING TOOLS

NAME	ENGINE TYPE	FREEWARE	COMMERCIAL	WEBSITE
ISS Database Scanner	Oracle, SQL, Sybase		X	http://www.iss.net/securing_e-business/security_products/security_assessment/database_scanner/index.php
SQLdict	MS SQL	X		http://www.ntsecurity.nu/toolbox/sqldict/
Various Products for security of Databases	Oracle, SQL		X	http://www.pentasafe.com/products/vamsqlserver.htm

WARDIALERS

NAME	FREEWARE	COMMERCIAL	WEBSITE
PhoneSweep		X	http://www.sandstorm.net/phonesweep/
Telesweep Secure Scanner		X	http://telesweepsecure.securelogix.com
ppp Scanner		X	Http://xforce.iss.net/static/804.php
THC Scan	X		http://www.thehackerschoice.com/
Modem Scan		X	http://verttex.com

Method

A general approach to vulnerability assessment would be roughly as follows: (Written authorization to perform these steps should be obtained from upper management.)

External:
- Use tools e.g. Nmap, Samspade, etc. to glean as much information about the target system as possible.
- Wardial all phone numbers and attempt penetration if targets are found.
- Try gleaning some useful information via "social engineering".
- If you can get the operating system ID from Nmap, use it to set up the scanner for custom probings.
- Update scanners with the latest attack signatures prior to use.
- Perform scans against all targets found.
- Analyze results and take corrective action.

Internal:
- Update scanner with latest attack signatures prior to use.

- You may wish to do custom scans on selected machines that require simpler probe configurations, e.g., scan all system administrator and technical personnel machines for backdoors or other illicit software. You may be scanning all new servers prior to rollout for certification.
- Check for weak passwords using a password cracking tool.
- Analyze results and take corrective action.

Vulnerability Mapping

Another method that can be used to locate weaknesses within a system is called vulnerability mapping (11). This entails analyzing the software and services running on the computer, then matching each to a known vulnerability. Services can easily be found using a tool such as Nmap, DumpSec (http://www.systemtools.com/free_frame.htm) or Hyena http://www.systemtools.com/index.html . As mentioned previously, vulnerability listings can be found at CERT and BugTraq. If a vulnerability associated with a service running on the computer is found, the appropriate patch or fix should be applied. See CERT Report on "Identifying data that characterize systems and aid in detecting signs of suspicious behavior" at http://www.cert.org/security-improvement/practices/p091.html .

The guidelines suggested by CERT (http://www.cert.org/security-improvement/) will also help harden your system configuration and operational environment and protect it against known attacks. It covers planning, configuration, maintenance, improving user awareness, and testing.

Also, see http://www.anti-online.com/focus/ih/articles/vulnassess.html for a Vulnerability Assessment Survey developed by Richard Wiens.

VIII. Configuration Management

Configuration Management is the process of controlling changes made to a system's configuration after installation.   Periodic reviews should be performed to ensure parameter settings are set as originally intended and not changed over the course of new installations and network updates.

Per Dr. Bruce Hartley in "The Process of Security" (12), "the best type of configuration management system involves defining a system for documentation, establishing a defined procedure for making changes to that system, and evaluating all changes against the overall security of the system and documenting them. You should also make sure you receive, evaluate and disseminate security warnings and advisories".

See specific CERT guidelines at http://www.cert.org/security-improvement/ and http://www.cert.org/nav/index_green.html

IX.   Conclusion

Statistics show that system compromises are on the rise so we must guard against them using the methods available to us. Vulnerability scanners

are one tool available for ensuring secure systems. However, scanners should not be the only weapon in the security arsenal. They should be used in addition to firewalls, intrusion detection tools, good security policies, and all the other defenses noted in this paper. Ideally, scanners should be used as a last defense to complement the security practices already in place. Just keep in mind that a good follow-up plan to correct any vulnerabilities found is just as important as detecting them.

X.   APPENDIX A: Security Vulnerability Summit Outcomes (7)

Summit working groups

Unlike political "summit meetings" that plan their conclusions in advance, the Vulnerability Summit didn't end with a planned communiqué. Rather, it marked the beginning of a process in which working groups (most with three or more participants) will develop the issues and draft proposed statements of best practices. Following are the working groups formed at the summit and their missions.

Charter Definition Propose follow-on communication plan and threat- ranking system to make summit conclusions useful for continuing guidance to Web administrators and the general Web community.

Stakeholder Recognition Propose a means of resolving the gap between those who want maximum information at the earliest opportunity and those who prefer that threats not be widely disclosed before remedies are identified and available. Develop usable guidelines for distinguishing among intruders, authorized investigators and independent researchers.

Information Release Consider criteria and methods for publication of threat effects, preventive measures and technical details; evaluate role of press and opportunities for affirmative outreach/education of mainstream media outlets; coordinate with working groups on vendor notification and public relations.

Vulnerability Life Cycle Consider relative importance of immediate response to new threats vs. long-term knowledge-base maintenance as resource for system administrators; examine actual damage caused vs. age of threat.

Vendor Notification Propose guidelines for interaction between independent researchers, paid

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consultants, and vendors of vulnerable products or services; consider merits of vendor premium-support plans vs. full-scale disclosure policies as means of disclosing information and providing follow-up support to affected customers; coordinate with working groups on information release and public relations.

Vulnerability Verification Examine role and magnitude of hoaxes as burden on threat analysis; propose guidelines for vendors to invite/investigate vulnerability reports; weigh benefits of anonymous reporting (to encourage early discovery) vs. attribution requirements (to discourage irresponsible or malicious input).

Patch and Solution Development Propose criteria for disseminating workarounds, patches or remedies incorporated into general product upgrades, considering costs and secondary threats involved in testing/releasing/deploying/supporting updates in the field.

Public Relations Examine issues of credit for independent researchers, whose reputations are enhanced by role in threat discovery, vs. need to give vendors time to analyze threats before system attackers exploit them en masse; coordinate with working groups on information release and vendor notification.

Legal Issues Examine gaps between best-practice consensus vs. laws, licenses and international agreements. Consider issues of intent in determining criminality; consider role of proposed cyber-crime laws in providing false sense of security to users; consider spillover effects of cyber-crime laws in preventing legitimate investigation of vulnerabilities.

Ethics Propose statements of good-faith conduct for identified stakeholders.

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