Chapter 1.31
Current Challenges in Intrusion Detection Systems

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INTRODUCTION

Along with its numerous benefits, the Internet also created numerous ways to compromise the security and stability of the systems connected to it. In 1995, 171 vulnerabilities were reported to CERT/CC © while in 2003, there were 3,784 reported vulnerabilities, increasing to 8,064 in 2006 (CERT/CC©, 2006). Operations, which are primarily designed to protect the availability, confidentiality, and integrity of critical network information systems are considered to be within the scope of security management. Security management operations protect computer networks against denial-of-service attacks, unauthorized disclosure of information, and the modification or destruction of data. Moreover, the automated detection and immediate reporting of these events are required in order to provide the basis for a timely response to attacks (Bass, 2000). Security management plays an important, albeit often neglected, role in network management tasks.

Defensive operations can be categorized in two groups: static and dynamic. Static defense mechanisms are analogous to the fences around the premises of a building. In other words, static defensive operations are intended to provide barriers to attacks. Keeping operating systems and other software up-to-date and deploying firewalls at entry points are examples of static defense solutions. Frequent software updates can remove the software vulnerabilities, which are susceptible to exploits. Firewalls provide access control at the entry point; they therefore function in much the same way as a physical gate on a house. In other words, the objective of a firewall is to keep intruders out rather than catching them. Static defense mechanisms are the first line of defense, they are relatively easy to deploy and provide significant defense improvement compared to the

initial unguarded state of the computer network. Moreover, they act as the foundation for more sophisticated defense mechanisms.

No system is totally foolproof. It is safe to assume that intruders are always one step ahead in finding security holes in current systems. This calls attention to the need for dynamic defenses. Dynamic defense mechanisms are analogous to burglar alarms, which monitor the premises to find evidence of break-ins. Built upon static defense mechanisms, dynamic defense operations aim to catch the attacks and log information about the incidents such as source and nature of the attack. Therefore, dynamic defense operations accompany the static defense operations to provide comprehensive information about the state of the computer networks and connected systems.

Intrusion detection systems are examples of dynamic defense mechanisms. An intrusion detection system (IDS) is a combination of software and hardware, which collects and analyzes data collected from networks and the connected systems to determine if there is an attack (Allen, Christie, Fithen, McHugh, Pickel, & Stoner, 1999). Intrusion detection systems complement static defense mechanisms by double-checking firewalls for configuration errors, and then catching the attacks that firewalls let in or never perceive (such as insider attacks). IDSs are generally analyzed from two aspects:

- **IDS deployment:** Whether to monitor incoming traffic or host information.
- **Detection methodologies:** Whether to employ the signatures of known attacks or to employ the models of normal behavior.

Regardless of the aspects above, intrusion detection systems correspond to today's dynamic defense mechanisms. Although they are not flawless, current intrusion detection systems are an essential part of the formulation of an entire defense policy.

DETECTION METHODOLOGIES

Different detection methodologies can be employed to search for the evidence of attacks. Two major categories exist as detection methodologies: misuse and anomaly detection. Misuse detection systems rely on the definitions of misuse patterns, which are the descriptions of attacks or unauthorized actions (Kemmerer & Vigna, 2002). A misuse pattern should summarize the distinctive features of an attack and is often called the signature of the attack in question. In the case of signature based IDS, when a signature appears on the resource monitored, the IDS records the relevant information about the incident in a log file. Signature-based systems are the most common examples of misuse detection systems. In terms of advantages, signature-based systems, by definition, are very accurate at detecting known attacks, which are included in their signature database. Moreover, since signatures are associated with specific misuse behavior, it is easy to determine the attack type. On the other hand, their detection capabilities are limited to those within signature database. As the new attacks are discovered, a signature database requires continuous updating to include the new attack signatures, resulting in potential scalability problems. Furthermore, attackers are known to alter their exploits to evade signatures. Work by Vigna, Robertson, Balzarotti (2004) described a methodology to generate variations of an exploit to test the quality of detection signatures. Stochastic modification of code was employed to generate variants of exploits to render the attack undetectable. Techniques such as packet splitting, evasion, and polymorphic shellcode were discussed.

As opposed to misuse IDSs, anomaly detection systems utilize models of the acceptable behavior of the users. These models are also referred to as normal behavior models. Anomaly-based IDSs search for the deviations from the normal behavior. Deviations from the normal behavior are consid-