Intrusion Prevention Systems (IPS)

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Introduction

In a recent survey commissioned by VanDyke Software, some 66 per cent of the companies who responded said that they perceive system penetration to be the largest threat to their enterprises.

The survey revealed that the top eight threats experienced by those surveyed were *viruses* (78 per cent of respondents), *system penetration* (50 per cent), *DoS* (40 per cent), *insider abuse* (29 per cent), *spoofing* (28 per cent), *data/network sabotage* (20 per cent), and *unauthorised insider access* (16 per cent).

Although 86 per cent of respondents use firewalls (a disturbingly **low** figure in this day and age, to be honest!), it is apparent that firewalls are not always effective against many intrusion attempts. The average firewall is designed to deny clearly suspicious traffic - such as an attempt to telnet to a device when corporate security policy forbids telnet access completely - but is also designed to allow some traffic through - Web traffic to an internal Web server, for example.

The problem is, that many exploits attempt to take advantage of weaknesses in the very protocols that **are** allowed through our perimeter firewalls, and once the Web server has been compromised, this can often be used as a springboard to launch additional attacks on other internal servers. Once a "rootkit" or "back door" has been installed on a server, the hacker has ensured that he will have unfettered access to that machine at any point in the future.

Firewalls are also typically employed only at the network perimeter. However, many attacks, intentional or otherwise, are launched from within an organisation. Virtual private networks, laptops, and wireless networks all provide access to the internal network that often bypasses the firewall. Intrusion detection systems may be effective at detecting suspicious activity, but do not provide *protection* against attacks. Recent worms such as Slammer and Blaster have such fast propagation speeds that by the time an alert is generated, the damage is done and spreading fast.

Intrusion Prevention Systems (IPS)

The inadequacies inherent in current defences has driven the development of a new breed of security products known as *Intrusion Prevention Systems* (IPS). This is a term which has provoked some controversy in the industry since some firewall and IDS vendors think it has been "hijacked" and used as a marketing term rather than as a description for any kind of new technology.

Whilst it is true that firewalls, routers, IDS devices and even AV gateways all have intrusion prevention technology included in some form, we believe that there are sufficient grounds to create a new market sector for true *Intrusion Prevention Systems*.

These systems are proactive defence mechanisms designed to detect malicious packets within normal network traffic (something that the current breed of firewalls do not actually do, for example) and stop intrusions dead, blocking the offending traffic automatically before it does any damage rather than simply raising an alert as, or after, the malicious payload has been delivered.

Within the IPS market place, there are two main categories of product: *Host IPS* and *Network IPS*.

Host IPS (HIPS)

As with Host IDS systems, the Host IPS relies on agents installed directly on the system being protected. It binds closely with the operating system kernel and services, monitoring and intercepting system calls to the kernel or APIs in order to prevent attacks as well as log them.

It may also monitor data streams and the environment specific to a particular application (file locations and Registry settings for a Web server, for example) in order to protect that application from generic attacks for which no "signature" yet exists.

One potential disadvantage with this approach is that, given the necessarily tight integration with the host operating system, future OS upgrades could cause problems.

Since a Host IPS agent intercepts all requests to the system it protects, it has certain prerequisites - it must be very reliable, must not negatively impact performance, and must not block legitimate traffic. Any HIPS that does not meet these minimum requirements should never be installed in a host, no matter how effectively it blocks attacks.

Network IPS (NIPS)

The Network IPS combines features of a standard IDS, an IPS and a firewall, and is sometimes known as an *In-line IDS* or *Gateway IDS (GIDS)*. The next-generation firewall - the *deep inspection firewall* - also exhibits a similar feature set, though we do not believe that the deep inspection firewall is ready for mainstream deployment just yet.

As with a typical firewall, the NIPS has at least two network interfaces, one designated as *internal* and one as *external*. As packets appear at the either interface they are passed to the detection engine, at which point the IPS device functions much as any IDS would in determining whether or not the packet being examined poses a threat.

However, if it should detect a malicious packet, in addition to raising an alert, it will discard the packet and mark that flow as bad. As the remaining packets that make up that particular TCP session arrive at the IPS device, they are discarded immediately.

Legitimate packets are passed through to the second interface and on to their intended destination. A useful side effect of some NIPS products is that as a matter of course - in fact as part of the initial detection process - they will provide "*packet scrubbing*" functionality to remove protocol inconsistencies resulting from varying interpretations of the TCP/IP specification (or intentional packet manipulation).

Thus any fragmented packets, out-of-order packets, or packets with overlapping IP fragments will be re-ordered and "cleaned up" before being passed to the destination host, and illegal packets can be dropped completely.

One thing to watch out for - don't let the "reactive" IDS vendors kid you into believing that they have *intrusion prevention* capabilities just because they can send TCP reset commands or re-configure a firewall when they detect an attack (a worrying piece of FUD that we have noticed in some IDS marketing literature recently).

The problem here is that unless the attacker is operating on a 2400 baud modem, the likelihood is that by the time the IDS has detected the offending packet, raised an alert, and transmitted the TCP Resets - and especially by the time the two ends of the connection have received the Reset packets and acted on them (or the firewall or router has had time to activate new rules to block the remainder of the flow) - the payload of the exploit has long since been delivered….. *game over*! Our guess is that there are not many crackers using 2400 baud modems these days….

A true IPS device, however, is sitting in-line - **all** the packets have to pass through it. Therefore, as soon as a suspicious packet has been detected - and **before** it is passed to the internal interface and on to the protected network, it can be dropped. Not only that, but now that flow has been flagged as suspicious, **all** subsequent packets that are part of that session can also be dropped with very little additional processing. Oh, and for good measure, some products are also capable of sending *TCP Resets* or *ICMP Unreachable* messages to the attacking host.

Implementation Challenges

There are a number of challenges to the implementation of an IPS device that do not have to be faced when deploying passive-mode IDS products. These challenges all stem from the fact that the IPS device is designed to work in-line, presenting a potential choke point and single point of failure.

If a passive IDS fails, the worst that can happen is that some attempted attacks may go undetected. If an in-line device fails, however, it can seriously impact the performance of the network. Perhaps latency rises to unacceptable values, or perhaps the device fails closed, in which case you have a self-inflicted Denial of Service condition on your hands. On the bright side, there will be no attacks getting through! But that is of little consolation if none of your customers can reach your e-commerce site.

Even if the IPS device does not fail altogether, it still has the potential to act as a bottleneck, increasing latency and reducing throughput as it struggles to keep up with up to a Gigabit or more of network traffic. Devices using off-the-shelf hardware will certainly struggle to keep up with a heavily loaded Gigabit network, especially if there is a substantial signature set loaded, and this could be a major concern for both the network administrator - who could see his carefully crafted network response times go through the roof when a poorly designed IPS device is placed in-line - as well as the security administrator, who will have to fight tooth and nail to have the network administrator allow him to place this unknown quantity amongst his high performance routers and switches.

As an integral element of the network fabric, the Network IPS device must perform much like a network switch. It must meet stringent network performance and reliability requirements as a prerequisite to deployment, since very few customers are willing to sacrifice network performance and reliability for security. A NPS that slows down traffic, stops good traffic, or crashes the network is of little use.

Dropped packets are also an issue, since if even one of those dropped packets is one of those used in the exploit data stream it is possible that the entire exploit could be missed. Most high-end IPS vendors will get around this problem by using custom hardware, populated with advanced FPGAs and ASICs - indeed, it is necessary to design the product to operate as much as a switch as an intrusion detection and prevention device.

It is very difficult for any security administrator to be able to characterise the traffic on his network with a high degree of accuracy. What is the average bandwidth? What are the peaks? Is the traffic mainly one protocol or a mix? What is the average packet size and level of new connections established every second - both critical parameters that can have detrimental effects on some IDS/IPS engines? If your IPS hardware is operating "on the edge", all of these are questions that need to be answered as accurately as possible in order to prevent performance degradation.

Another potential problem is the good old *false positive*. The bane of the security administrator's life (apart from the script kiddie, of course!), the false positive rears its ugly head when an exploit signature is not crafted carefully enough, such that legitimate traffic can cause it to fire accidentally. Whilst merely annoying in a passive IDS device, consuming time and effort on the part of the security administrator, the results can be far more serious and far reaching in an in-line IPS appliance.

Once again, the result is a self-inflicted Denial of Service condition, as the IPS device first drops the "offending" packet, and then potentially blocks the entire data flow from the suspected hacker. If the traffic that triggered the false positive alert was part of a customer order, you can bet that the customer will not wait around for long as his entire session is torn down and all subsequent attempts to reconnect to your e-commerce site (if he decides to bother retrying at all, that is) are blocked by the well-meaning IPS.

Another potential problem with any Gigabit IPS/IDS product is, by its very nature and capabilities, the amount of alert data it is likely to generate. On such a busy network, how many alerts will be generated in one working day? Or even one hour? Even with relatively low alert rates of ten per second, you are talking about 36,000 alerts every hour. That is 864,000 alerts each and every day. The ability to tune the signature set accurately is essential in order to keep the number of alerts to an absolute minimum. Once the alerts have been raised, however, it then becomes essential to be able to process them effectively. Advanced alert handling and forensic analysis capabilities - including detailed exploit information and the ability to examine packet contents and data streams - can make or break a Gigabit IDS/IPS product.

Of course, one point in favour of IPS when compared with IDS is that because it is designed to prevent the attacks rather than just detect and log them, the burden of examining and investigating the alerts - and especially the problem of rectifying damage done by successful exploits - is reduced considerably.

Requirements for effective prevention

Having pointed out the potential pitfalls facing anyone deploying these devices, what features are we looking for that will help us to avoid such problems?

- **In-line operation -** only by operating in-line can an IPS device perform true protection, discarding all suspect packets immediately and blocking the remainder of that flow
- **Reliability and availability -** should an in-line device fail, it has the potential to close a vital network path and thus, once again, cause a DoS condition. An extremely low failure rate is thus very important in order to maximise up-time, and if the worst should happen, the device should provide the option to

fail open or support fail-over to another sensor operating in a fail-over group (see below). In addition, to reduce downtime for signature and protocol coverage updates, an IPS must support the ability to receive these updates without requiring a device re-boot. When operating inline, sensors rebooting across the enterprise effectively translate into network downtime for the duration of the reboot

- **Resilience -** as mentioned above, the very minimum that an IPS device should offer in the way of High Availability is to fail open in the case of system failure or power loss (some environments may prefer this default condition to be “fail closed” as with a typical firewall, however - the most flexible products will allow this to be user-configurable). Active-Active stateful fail-over with cooperating in-line sensors in a fail-over group will ensure that the IPS device does not become a single point of failure in a critical network deployment

- **Low latency -** when a device is placed in-line, it is essential that its impact on overall network performance is minimal. Packets should be processed quickly enough such that the overall latency of the device is as close as possible to that offered by a layer 2/3 device such as a switch, and no more than a typical layer 4 device such as a firewall or load-balancer.

- **High performance -** packet processing rates must be at the rated speed of the device under real-life traffic conditions, and the device must meet the stated performance with all signatures enabled. Headroom should be built into the performance capabilities to enable the device to handle any increases in size of signature packs that may occur over the next three years. Ideally, the detection engine should be designed in such a way that the number “signatures” (or “checks”) loaded does not affect the overall performance of the device.

- **Unquestionable detection accuracy -** it is imperative that the quality of the signatures is beyond question, since false positives can lead to a Denial of Service condition. The user MUST be able to trust that the IDS is blocking only the user selected malicious traffic. New signatures should be made available on a regular basis, and applying them should be quick (applied to all sensors in one operation via a central console) and seamless (no sensor reboot required)

- **Fine-grained granularity and control -** fine grained granularity is required in terms of deciding exactly which malicious traffic is blocked. The ability to specify traffic to be blocked by attack, by policy, or right down to individual host level is vital. In addition, it may be necessary to only alert on suspicious traffic for further analysis and investigation

- **Advanced alert handling and forensic analysis capabilities -** once the alerts have been raised at the sensor and passed to a central console, someone has to examine them, correlate them where necessary, investigate them, and eventually decide on an action. The capabilities offered by the console in terms of alert viewing (real time and historic) and reporting are key in determining the effectiveness of the IPS product.

The NSS Intrusion Prevention Group Test

The NSS Group has conducted the first comprehensive IPS test of its kind. This exhaustive review will give readers a complete perspective of the capabilities, maturity and suitability of the products tested for their particular needs.

As part of its extensive IPS test methodology The NSS Group subjects each product to a brutal battery of tests that verify the stability and performance of each IPS tested, determine the accuracy of its security coverage, and ensure that the device will not block legitimate traffic.

If a particular IPS has been designated as *NSS Approved*, customers can be confident that the device will not significantly impact network/host performance, cause network/host crashes, or otherwise block legitimate traffic.

To assess the complex matrix of IPS performance and security requirements, the NSS Group has developed a specialised lab environment that is able to exercise every facet of an IPS product. The test suite contains over 750 individual tests that evaluate IPS products in three main areas: *performance and reliability, security accuracy,* and *usability*. This thorough review should give readers a complete perspective of the capabilities, maturity and suitability of the products tested for their particular needs.

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The NSS Group is Europe's foremost independent security testing facility. Based in the UK with separate security and network infrastructure testing facilities in the South of France, The NSS Group offers a range of specialist IT, networking and security-related services to vendors and end-user organisations world-wide. The Group consists of two wholly-owned subsidiaries: NSS Network Testing Laboratories and Network Security Services.

Output from the labs, including detailed research reports, articles and white papers on the latest network and security technologies, are made available on the NSS web site at http://www.nss.co.uk

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