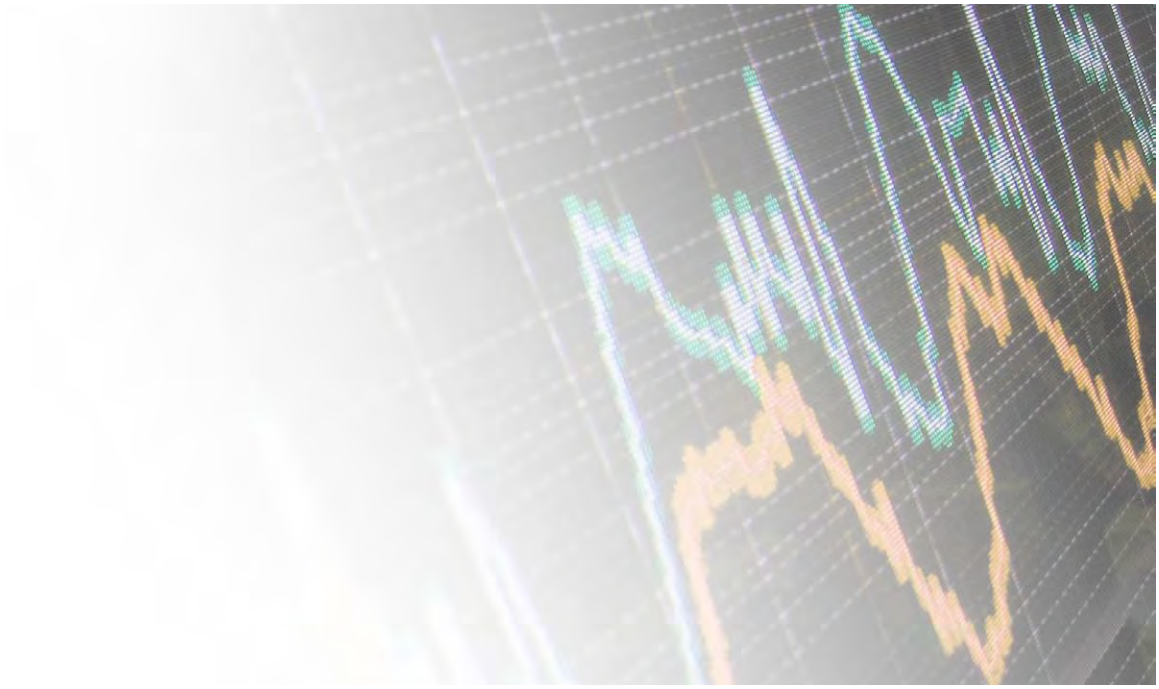
PROLEXIC
TECHNOLOGIES

White Paper

Distributed Denial of Service Attacks:
Protect Your Site from this Growing Threat



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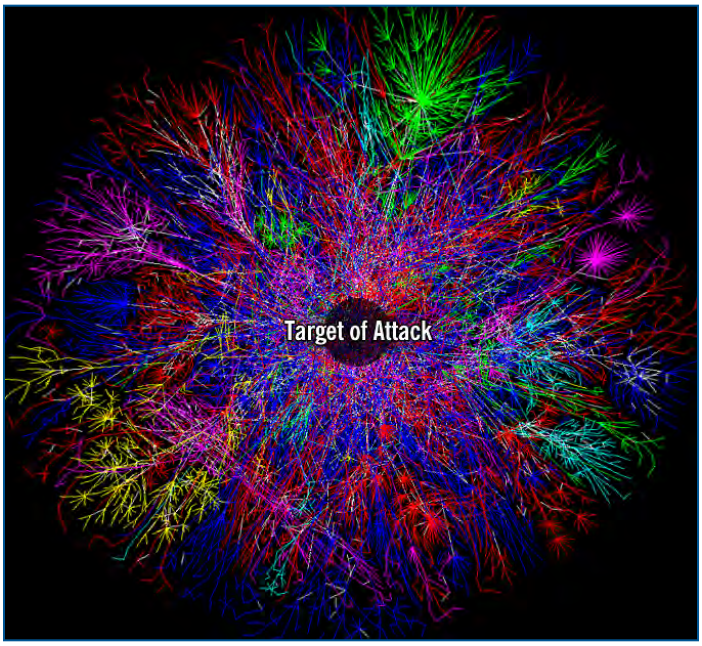
EXECUTIVE SUMMARY

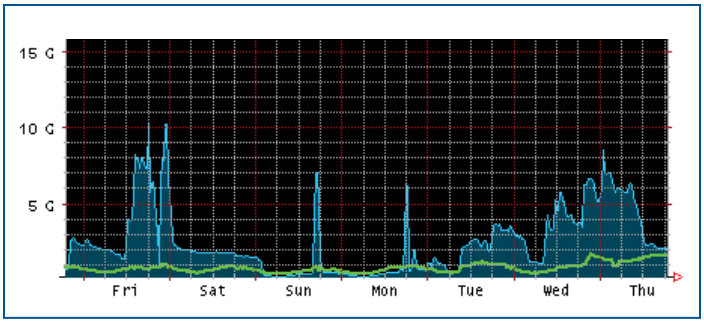
Distributed Denial of Services (DDoS) attacks present a serious threat to online organizations today — with constantly rising attack sizes and attack complexity, their ability to cripple websites grows on a daily basis. Not only do these attacks cost online organizations millions in lost revenues, they can cause severe damage to reputation, brand name and customer relationships.



Because ISPs are not equipped to deal with these attacks, online organizations have been forced to implement solutions on their own. Until recently, however, the tools used to mitigate DDoS attacks were inadequate. Traditional security solutions, such as routers, firewalls, and intrusion detection devices, were never designed to protect against DDoS attacks. While newer DDoS mitigation hardware devices do provide intrusion prevention capabilities that can proactively guard against DDoS attacks, these solutions are unable to withstand the rapidly increasing magnitudes of today's attacks, which have grown 3X over the past year and now reach over 10Gbps.

This white paper describes:

- The growing DDoS threat to e-commerce today
- Why existing solutions are unable to address DDoS threats
- The steps and technologies necessary to protect today's e-commerce sites
- How Prolexic solutions ensure that e-commerce sites remain operational in the face of even the largest DDoS attacks



DDoS: A Growing Threat

Distributed denial of service (DDoS) attacks — in which compromised PCs controlled by remote attackers inundate a victim's network resources with the intent of crashing the victim's web or application servers—are among the most serious threats on the Internet today. Twenty five percent of respondents to the 2006 CSI/FBI Computer Crime and Security Survey performed by the Computer Security Institute had experienced a DDoS Attack. Worldwide, as many as 10,000 such attacks occur each day.[1]

DDoS attacks, moreover, are growing larger and more destructive. While the largest attacks in 2005 were 3.5Gbps, attack sizes have grown by 3X during 2006 to more than 10Gpbs. With this size of attack at their disposal, attackers now have the capacity to take out entire hosting/co-location facilities by brute force.

The costs of these attacks can be monumental. Forrester, IDC, and the Yankee Group estimate that the cost of a 24-hour outage for a large e-commerce company would approach $30 million. In addition, by violating service level agreements, these attacks trigger costly service credits. Victims of these attacks also suffer from lost credibility and customer/partner confidence.

Anatomy of a Denial of Service Attack

DDoS attacks are among the nastiest and most difficult of all Internet attacks to address. These attacks are very easy to launch, hard to track, and it is difficult to deny the requests of attackers without also refusing legitimate requests for service.

Security experts segregate Denial of Service attacks into two types: standard and distributed. In a standard DoS attack, a single computer targets any network device, including routing devices and web, email, and DNS Servers with the intent of denying authorized access to systems by consuming all available resources, such as disk space or CPU time; disrupting configuration information, such as routing information; filling state-tables in firewalls; disrupting traffic monitoring and bandwidth billing capability; and disrupting physical network components.

Distributed denial of service (DDoS) attacks originate from a group of computers (often called a botnet), which are typically personal computers with broadband internet connections that viruses have compromised. The virus creator remotely controls these infected machines (often called zombies), using them to collectively "flood" a network with fake packets, thereby preventing legitimate network traffic from accessing a system. The distributed nature of these attacks makes them especially difficult to stop or prevent. With enough slave hosts, these attacks can bring down even the largest and most well-connected websites.

Regardless of whether they originate from one or many machines, denial of service attacks are highly disruptive. With increased bandwidth and the computing horsepower of today's PCs and servers, even a single zombie is able to generate attacks comprised of hundreds of Megabits per second, that can cause as much damage to unprepared targets as distributed attacks. Enterprises, therefore, must treat all types of DDoS attacks with respect.

Bots Created Through PHP Bug

The most widely used scripting language for the Web, the PHP Hypertext Preprocessor is a programming language that allows web developers to create dynamic content that interacts with databases. In recent months, attackers have taken over thousands of older, unpatched web servers running PHP-based applications and turned them into zombies that can be used to launch massive DDoS attacks.

1 "Cyber Extortion, A Very Real Threat," By Jose Nazario, IT Observer, June 7, 2006

Three Types of Attacks

Standard and distributed DDoS attacks can disrupt networks in three ways, through:

Targeted Attacks

Targeted attacks usually work in layers 4-7 of the Open System Interconnection (OSI) model and take advantage of known vulnerabilities in specific applications, such as a programming flaw in a system, service, or protocol. The main objective of a targeted attack is to emulate the real world operation of a given resource, overrunning it with traffic.

Increasingly, DDoS attackers are using sophisticated spoofing techniques and essential protocols that cannot be blocked to make DDoS attacks more clandestine and effective. Because they piggyback on legitimate application protocols and services, these attacks are difficult to identify and stop. To make matters worse, common solutions, such as rate-limiting and packet filtering, also block legitimate traffic (creating false positives), thus, partially achieving the attacker's objective.

Consumption Attacks

Consumption attacks (also known as flooding attacks) typically employ botnets to direct large amounts of traffic at a system or network in an attempt to consume all available network resources and shut down a system. Such attacks can cripple not only corporate networks but entire backbones.

Exploitative Attacks

Exploitative attacks are a type of consumptive attack that targets bugs in operating systems and works with other consumption attacks to cause network congestion.

The most sophisticated attacks today encompass elements from all three types of attacks. As Figure 1 illustrates, attackers will go after all visible resources, attacking DNS servers as well as the full path of the network to find the weakest route or hop until all network resources are consumed. In most cases, the attack will sever the web farm and internal networks from the Internet.

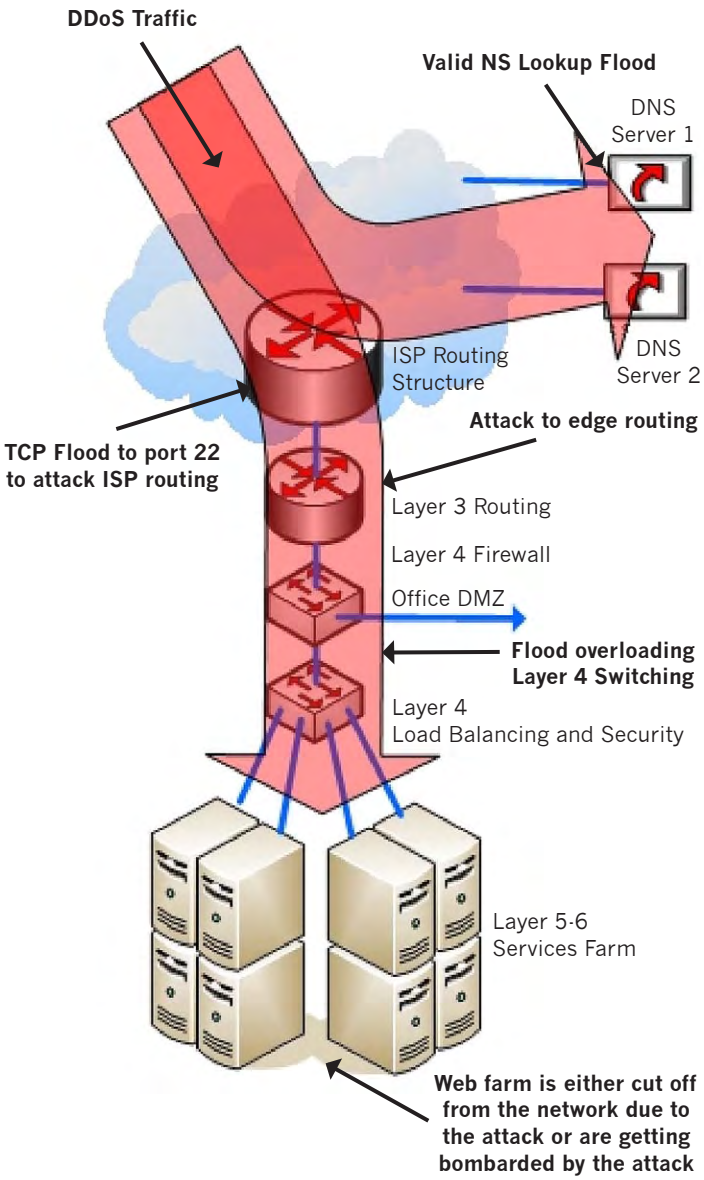


Figure 1: A Total Attack Scenario

Botnet networks can be extremely sophisticated. As Figure 2 illustrates, the attacker (location 1) uses several different compromised machines (zombies) to bounce the connection through to hide his identity. The attacker uses locations 1, 2, 3, and 4 to reach and communicate with location 5, an Internet Relay Chat (IRC) server used to unify and control the botnet. The zombies at location 6, connect to the IRC server and are instructed to attack points 7 and 8.

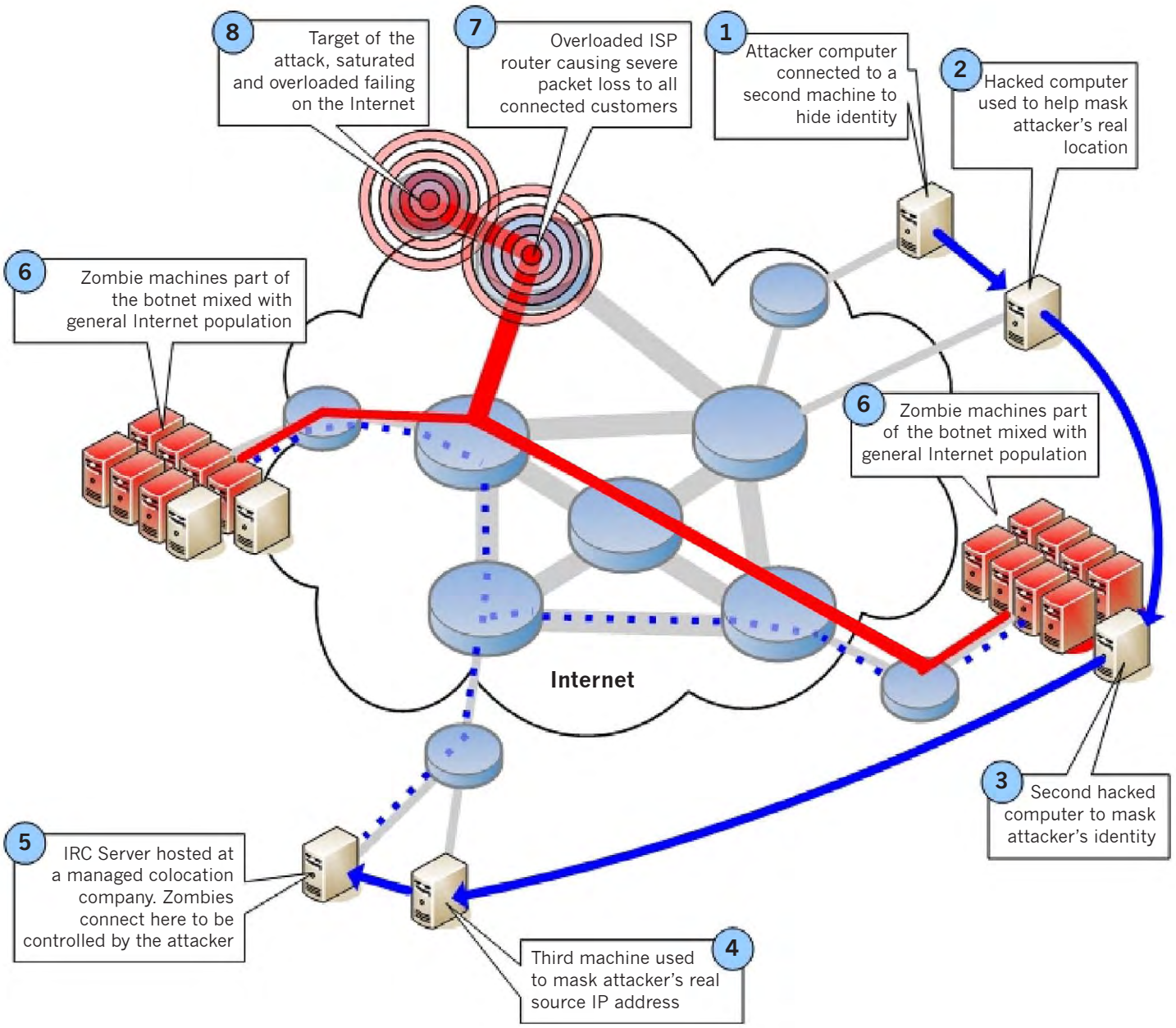


Figure 2: Botnet Illustration

CURRENT SOLUTIONS — AND WHY THEY FAIL

Until recently, online organizations installed devices such as routers, firewalls and Intrusion Detection Systems (IDS) to secure their websites. Yet, while these solutions protect enterprises from many forms of cyber-crime, none was designed to defend against DDoS attacks and therefore, they exhibit serious limitations when faced with a state-of-the-art DDoS attack.

Routers

Networks require many types of routers, including Layer 3 routers that service specific internet connections and Layer 4 switches that serve the outer edge of the network. All of these routers analyze incoming and outgoing traffic and route it to its intended destination. In the process, routers provide filtering that protects against simple attacks, such as ping attacks.

However, routers are not effective at mitigating most DDoS attacks. To begin with, they are unable to process the millions of packets-per-second that characterize a standard DDoS attack. When attacked, the line cards in a vulnerable router can fail and take the entire router offline. Most routers must be manually configured to stop even simple attacks — something usually performed only after an attack has taken down the site. Nor can many routers support access control lists (used to filter invalid IP addresses) larger than 100 lines, which is far shy of the tens-of-thousands of IP addresses used in many DDoS attacks. Moreover, most DDoS attacks today use valid protocols and spoof valid IP address spaces that are essential for internet operations, rendering protocol and IP address filtering useless.

Routers can also mitigate DDoS attacks by limiting the rate of traffic flow. However, the enormous packet flows seen in DDoS attacks can overload the router's CPU and cause it to fail. Even if the router remains operational, legitimate traffic will be limited as well.

Firewalls

Firewalls, the next line of defense, generally reside in Layer 5. A firewall separates a trusted environment, such as a corporate intranet, from an untrusted environment, such as the Internet, and regulates traffic to limit access to the trusted environment to users with proper authorization. Firewalls mitigate many types of attacks, including certain known worms, malicious URLs, directory traversal attacks, WebDAV attacks, and man-in-the-middle attacks. However, firewalls are not designed to protect services that are available to the public over the internet and are thus unable to guard against DDoS attacks.

Intrusion Detection System (IDS) and Monitored Security Services (MSS)

Intrusion detection systems (IDS) and monitored security services (MSS) are passive solutions designed specifically to analyze traffic and detect and identify attacks. While such information helps companies respond more quickly to an attack, these solutions are unable to mitigate attacks. Further, because IDS examines nearly every packet, the sheer volume of DDoS attacks can cause IDS systems to fail.

New DDoS Mitigation Hardware Isn't Enough

Today, online organizations can turn to hardware designed specifically to mitigate DDoS attacks. While organizations can purchase these solutions themselves, many internet service providers (ISPs) have also begun offering these DDoS mitigation devices on their networks.

Typically billed as plug-and-play, one-size-fits-all solutions, these DDoS mitigation devices employ newer intrusion prevention technology that not only inspects traffic, but also takes proactive action to mitigate attacks based on rules established by the network administrator. For example, an IPS might drop a packet that it determines to be malicious and block all further traffic from that IP address or port while allowing unaffected traffic to flow unimpeded. These mitigation systems can perform complex monitoring and analysis, such as watching and responding to both individual packets and overall traffic patterns.

Unfortunately, these solutions suffer from performance limitations. Regardless of the horsepower of the hardware included with the solution, the rapidly increasing size of today's attacks means that any static hardware device will ultimately be unable to keep up with attacks. After hardware devices reach their limits, they allow "attack leakage" back onto the system, hurting the network. Modifying these solutions to add capacity is a slow process that can take days to years — far slower than the rate at which attack sizes are increasing.

Networks themselves can also be a bottleneck. Should a high packet per second DDoS attack cause a network or upstream router to fail, the network can crash before the mitigation hardware has a chance to do its job.

To make matters worse, very intelligent people launch DDoS attacks and can alter an attack in real time based on its outcome. As these attackers become familiar with the various types of DDoS mitigation hardware, they are able to come up with ways to circumvent these devices.

When ISPs provide DDoS mitigation hardware on their networks, their NOC staff are unable to fight back against constantly changing types of DDoS attacks because they are not trained experts in DDoS attacks. Moreover, most ISP service level agreements (SLAs) are typically limited to a GigE connection, which is 1Gbps, while today's attacks can reach 10 Gbps.

Fighting Back: Requirements for a Solution

As this white paper has shown, modern DDoS attacks are characterized by increasingly large sizes that often attack multiple locations at once, simultaneously using multiple attack types to overwhelm all layers of the OSI model. To make matters worse, attackers are very adept at modifying their attacks to circumvent solutions as they are unveiled. These DDoS attacks are an ever changing problem, akin to an arms race. As a result, mitigating DDoS attacks requires a highly scalable and holistic approach that can identify sources of attacks wherever possible (in order to directly block these attacks), use multiple pieces and types of equipment to protect every OSI layer, as well as take advantage of DDoS experts who can react immediately as new types of attacks arise.

Over the past several years, a new breed of outsourced, managed service providers has begun to address the challenges posed by today's massive DDoS attacks by providing:

- High capacity and scalability
- Complete monitoring and filtering at all OSI layers
- Multiple routing options
- Adaptability to new attacks
- Service Level Agreements

High-capacity and Scalability

In order to handle today's massive attacks, online organizations need tremendous amounts of bandwidth for routing network traffic away from their website, huge processing capacity to filter this traffic, and the ability to deliver purified traffic back to the site. Organizations of all sizes find that acquiring the requisite bandwidth and processing capacity is an expensive proposition, particularly when these resources will be used infrequently.

Today, managed service provider companies are able to spread the cost of these resources over many customers, providing a type of insurance policy that customers can use on an as needed basis. As a result, managed service providers are able to purchase massive amounts of resources that can scale to handle the largest attacks in a manner that is cost effective for each customer. For example, one such service provider employs the services of 12 Tier-1 providers that can manage more than 30 gigs of traffic as well as more than 10 Terahertz of computing power with the ability to process 40,000,000 packets per second.

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In addition to purchasing resources for their own network, managed service providers are also setting up peering partnerships to exchange network traffic with large numbers of corporations and networks. Peering allows managed service providers to increase the size of their networks (and therefore the size of attacks they can defend against) without significant additional costs that would be otherwise passed to customers. Peering also increases the quality of service to customers because it greatly shortens the path to get traffic back and forth to the managed service providers' network. Shortening the path also reduces the likelihood of third-party carriers' issues interrupting traffic flowing to and from the customer.

Providing multiple bandwidth arrangements protects customers from the largest of DDoS attacks. This gives managed service providers a substantial advantage over any one ISP that must rely on its own backbone.

Complete Monitoring and Filtering at all OSI Layers

Because they handle only DDoS attacks, state-of-the-art managed service providers are able to devote the services of DDoS experts to develop filtering solutions that handle all layers of the OSI model, including:

Filtering at the Border

Filtering at the border blocks traffic to restricted ports from an extensive list of infected hosts and limits traffic to allowed protocols. It also includes filtering for bogon packets--packets from an area of IP address space reserved but not yet allocated by the Internet Assigned Numbers Authority (IANA) or a delegated Regional Internet Registry (RIS) that are useless or forged for illegitimate purposes.

Protocol Verification

Next, these solutions filter packets by verifying that Layer 3 network switching and routing protocols and Layer 4 transport protocols are being used correctly. This helps the solution mitigate against packet floods.

Stateful Packet Inspection

Stateful packet inspection filtering verifies state by ensuring that the three-way TCP/IP handshake is completed. This verification is used to block SYN Floods and other similar attempts to consume system resources.

Application Layer Filtering

Many attackers attempt to overwhelm system resources by establishing valid connections. Filtering at the application layer prevents this type of Get and Resource Flood attack. This layer collects and filters source IP based rate limiting information. It can also enact customized security policies, such as blocking traffic from specified ports.

String matching/Algorithmic Filtering

String matching and algorithmic filtering monitors traffic for unusual behavior and flags anomalies. Engineers can then examine these anomalies to determine whether the activity should be blocked on the network. Once an activity is determined to be malicious, it is labeled in the system and blocked at the border.

Multiple Routing Choices

Organizations using managed filtering service require various options for connecting their networks to the filtering service that vary according to their corporate requirements. Managed service providers are able to provide multiple routing choices.

Adaptability to New Attacks

A managed service has the advantage of employing teams of DDoS mitigation experts that have seen every type of attack, every size of attack, and every variation of attack and are always available to react in real-time to new attacks. Vast experience with the newest and largest attacks enables a managed service provider to remain one step ahead of attackers.

Service Level Agreements

Managed service organizations can guarantee the effectiveness of their service by offering strong service level agreements.

THE PROLEXIC SOLUTION

Prolexic Technologies is a managed service provider that meets all the requirements for customers requiring protection against the most advanced DDoS attacks with its patent-pending Clean Pipe Virtual Transport® service.

Prolexic utilizes a robust intrusion prevention network (IPN) infrastructure to absorb all attacks targeting its customers, filter out bad data from the customer's inbound traffic, and then deliver purified traffic back to the customer's network, completely transparent to the people using the services, and without any hardware investment or major network changes. The Prolexic Clean Pipe service leverages a multi-million dollar, multi-facility, global network, unique filtering techniques, high-speed bandwidth and peering, advanced routing, and other patent-pending devices to protect enterprises of varying sizes, regardless of network resources, existing security hardware, and/or physical location. Prolexic has demonstrated success in monitoring, filtering, and routing massive traffic flows, often shouldering multi-gigabit-per-second distributed attacks for its customers.

CleanPipe Virtual Transport® can be deployed in one of the three following delivery methods:

DNS Redirection / Proxy

The CleanPipe Virtual Transport Proxy is the quickest method to deploy Prolexic's solution. Through a DNS change, all customer traffic is routed to the Prolexic infrastructure, where it is cleansed. Once traffic is filtered of malicious content, it is proxied back to the customer's infrastructure. Proxy is a simple configuration and provides the additional benefit of content caching.

BGP Routing/ GRE Tunneling

Clean Pipe Virtual Transport® can be easily implemented over a dedicated GRE tunnel. Prolexic announces the customer's subnet and tunnels traffic to the customer's location via a GRE tunnel. GRE tunneling provides customers with total control over when traffic is filtered. Traffic re-routes can be performed quickly using BGP, the standard routing protocol in use today to support complex routing policies.

Dedicated Circuits

Dedicated circuits enable businesses to withstand 10+ Gbps SYN flood or TCP connection flood without notice. Clean Pipe Virtual Transport® circuits can be implemented like a standard BGP4-enabled Internet circuit. Connections can be made directly within Prolexic's points-of-presence, or via a Prolexic partnered low-cost dedicated circuit directly to Prolexic's IPN.

Additional Security

In addition to protecting against DDoS attacks, Prolexic's Clean Pipe technology provides virus protection and e-mail SPAM filtering.

Enhanced Performance

The Prolexic Clean Pipe Proxy Service also helps boost customers' web site performance by caching static web content. The cache size can be increased during peak demand periods to further improve performance.

Service Level Agreement

Prolexic offers the best service level agreements in the industry to guarantee the effectiveness of its service.

Benefits

The effectiveness and superiority of Prolexic's solution is demonstrated by its track record of stopping any size/type of DDoS attack.

• Prolexic's flexible service allows it to immediately adapt to and mitigate the most innovative attacks. Each of its IPN centers have several racks of equipment to stop attacks at any OSI layer, and a 24/7 team of DDoS mitigation experts can react in real-time to new attacks.

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• Prolexic's managed service business model eliminates the need for customers to make costly investments in mitigation hardware.

• Prolexic's large, distributed network scales to handle the largest attacks.

• Prolexic's vast experience with the newest and largest attacks enables it to remain one step ahead of the attackers. Prolexic observes and mitigates more DDoS attacks than any competitive hardware or service.

• Prolexic is the only solution that consistently works as demonstrated by its willingness to back up its service with the strongest SLA in the market.

Conclusion

With the increasing seriousness of today's DDoS attacks, customers need assurance that they have a solution that can prevent even the largest attacks from taking down their servers and networks. By engaging Prolexic services, customers gain the peace of mind of having a solution that works, the ability to immediately mitigate today's largest attacks, and responsiveness to new, ever evolving types of attacks — all without modifying their existing network and without having to make costly investments in mitigation hardware.

For More Information

For more information on Prolexic's DDoS mitigation solutions, visit us at www.prolexic.com or at:

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Prolexic Technologies Ends Massive DNS Amplification DDoS Attacks Against StormPay

StormPay.com is a leader in online payment processing, serving thousands of e-commerce Web sites. The StormPay.com service allows anyone with an email address to send or receive payments, offering customers and vendors alike a safe and secure method for performing financial transactions across the Internet while reducing the risk of exposing their financial information.

On Saturday, February 3, 2006 a series of massive DNS Amplification DDoS attacks brought down the StormPay.com site despite pre-existing security measures that included hardware and application-based firewalls, as well as a DDoS solution from MCI. "The attack was so large that it took down both of our data centers 75 percent of the time that weekend," said Jim Grago, Chief Technology Officer of StormPay, Inc.

On Sunday, February 4th, Superbowl Sunday, StormPay turned to Prolexic. By halftime, Prolexic technical experts had set StormPay up on Prolexic's IPN. With the Clean Pipe service, Prolexic directed the StormPay.com traffic to its network, filtered out the malicious traffic, then directed the legitimate traffic back to StormPay.com's DNS servers. StormPay.com was back in business.

But as soon as the attackers realized that StormPay.com was operational, they began attacking StormPay's hosting facilities. This time Prolexic partnered with StormPay.com's hosting facility. Using BGP announcements and VPN tunneling, Prolexic was able to ensure connectivity to the hosting facility — despite repeated attempts to take all the incoming links down.

Only after the attacks provided ineffective over a two week period did the attackers assume that StormPay.com had moved its Website and ended the attacks. Since then, StormPay.com has continued to use the Prolexic Clean Pipe service and has remained attack free. Said Grago, "We have been very satisfied with the Prolexic service and we would recommend it to other companies as well."

APPENDIX A: EXAMPLES OF KEY TYPES OF DDOS ATTACKS

DDoS attack types include Targeted, Consumptive, and Exploitative. Within each type, are a wide range of variations. The following are some examples of each type of attack.

Examples of targeted attacks include:

HTTP GET - A terrorist uses a zombie network to create numerous HTTP/1.0 or 1.1 compliant GET requests to consume all network and server resources available on the victim network.

SIP Chopping - Used to implement voice over internet protocol (VoIP) service, the session initiation protocol (SIP) is a lightweight service that uses a stateless protocol such as the user datagram protocol (UDP). SIP can be easily emulated in text over UDP. A single computer using a UDP flooding engine to inject SIP requests can bring a SIP server to its knees, rendering VoIP calls impossible.

DNS - A standard Berkeley Internet Name Domain (BIND) server, the most common type of DNS server on the Internet, can service about 10,000 valid queries per second. A DDoS attack that pulls millions of Pointer (PTR) records per-second for a target domain can thus easily overrun a DNS server.

Simple mail transfer protocol (SMTP) - Mail servers are frequent targets for all types of TCP attacks. Because checking emails is highly resource intensive, an attack that emulates email and generates a 1 Gbps mail flood can render a company's communications network and all associated services useless. Even outsourced email systems may be unable to process such attacks.

Secure sockets layer (SSL) - SSL manages the key security handshakes between servers. These exchanges are complex. If a terrorist generates millions of valid certificate lookups per-second along with the requisite port connections, a secure site will be overrun and stop functioning.

Virtual private network (VPN) - VPN services are often located on the exposed network because the concentrator or connection devices are considered trusted devices. However, they can also be attacked to sever a company's B2B communications and telecommunications.

Common consumption attacks include:

SYN Flooding - In SYN Flooding, an attacker initiates a TCP connection with the victim machine, sending only the SYN, which is the first part of the three-way TCP handshake. The victim machine returns the SYN-ACK, waits for the ACK packet to return and reserves one of the limited number of data structures required to complete the connection. Legitimate connections are denied while the victim machine waits to complete the bogus connection.

RESET Flooding (also called SYN-ACK Flooding) - Hosts can mask an attacker by sending spoofed packets to relay points. By forging a packet with the victim's IP address as the source of a SYN packet, a site can be used to relay SYN-ACK packets to the victim's site, consuming both victim and relay site resources.

ACK Flooding - Most networks use filters to guard against SYN floods. To get around these filters, a variation of SYN Flooding called ACK Flooding floods the host with SYN-ACK segments. Since the host did not send the initial SYN segment, it expends processing resources sending out error messages.

Fragmentation Flooding - Disassembling and reassembling packets takes considerable computing power, both for security devices and servers. Fragmentation flooding attacks send partial packets to a server, which expends resources attempting to reassemble these packets.

ICMP Flooding - ICMP flooding is one of the most common types of DDoS attacks. One form of ICMP flooding uses the 'ping' capability, taking advantage of the – f command

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to flood a network with ICMP echo (type 8) and ICMP echo reply (type 4) messages. In a variation on this type of attack, basic ICMP packets use forged or randomly spoofed source addresses to reduce the chances of tracking attackers to their true host address. Some attacks randomize the ICMP type to evade Access Control Lists (ACLs). ICMP flooding can also be combined with broadcast attacks. For example, in the Smurf attack, terrorists directed ICMP echo request packets to IP broadcast addresses from remote locations to generate denial-of-service attacks.

UDP Flooding - The User Datagram Protocol (UDP) is a stateless protocol that does not require the establishment of a handshake or connection with a remote site. The protocol is commonly used for audio/video traffic and other high bandwidth services that can tolerate lost packets in the stream. DDoS attacks commonly use UDP packets to flood a target network. These attacks are relatively difficult to detect and prevent since an attacker can use a random source or destination port. Additionally, UDP is inconspicuous because it does not show up in standard "netstat" commands or other network troubleshooting tools. Since the DNS service uses UDP, it is not possible to completely disable it on a network.

DNS Amplification - DNS amplification attacks have become an increasingly disruptive threat. With DNS amplification attacks, a terrorist requests large DNS records from large numbers of recursive name services that exist globally. The attacker spoofs the source IP address when he sends the request with the IP address of the target. By answering the requests, the recursive name servers effectively launch a DDoS attack on the target.

Common exploitative attacks include:

Teardrop - In some TCP/IP implementations, large packets of data are split into smaller segments, each of which is identified to the next by an offset marker; the receiving system later uses the offset marker to help reassemble the packets. In a teardrop attack, the attacker enters a confusing offset value in the second or subsequent fragments, which can crash the recipient's system.

Land - In a Land attack, the attacker sends a packet with the source/host port the same as the destination host/port. This condition is capable of crashing many systems.