Lesson Proper for Week 9

Distributed Denial of Service Attack

Introduction of DoS

A **denial-of-service attack** (**DoS attack**) is an attempt to make a computer resource unavailable to its intended users. Although the means to carry out, motives for, and targets of a DoS attack may vary, it generally consists of the concerted efforts of a person, or multiple people to prevent an Internet site or service from functioning efficiently or at all, temporarily or indefinitely. Perpetrators of DoS attacks typically target sites or services hosted on high-profile web servers such as banks, credit card payment gateways, and even root name servers. The term is generally used relating to computer networks, but is not limited to this field; for example, it is also used in reference to CPU resource

management.

One common method of attack involves saturating the target machine with external communications requests, such that it cannot respond to legitimate traffic, or responds so slowly as to be rendered effectively unavailable. Such attacks usually lead to a server overload. In general terms, DoS attacks are implemented by either forcing the targeted computer(s) to reset, or consuming its resources so that it can no longer provide its intended service or obstructing the communication media between the intended users and

the victim so that they can no longer communicate adequately.

Denial-of-service attacks are considered violations of the IAB's Internet proper use policy, and also violate the acceptable use policies of virtually all Internet

Introduction of DDoS

A distributed denial-of-service (DDoS) attack is one in which a multitude of compromised systems attack a single target, thereby causing denial of service for users of the targeted system. The flood of incoming messages to the target system essentially

forces it to shut down, thereby denying service to the system to legitimate users.

In a typical DDoS attack, a hacker (or, if you prefer, cracker) begins by exploiting a vulnerability in one computer system and making it the DDoS master. It is from the master system that the intruder identifies and communicates with other systems that can be compromised. The intruder loads cracking tools available on the Internet on multiple -

- sometimes thousands of -- compromised systems. With a single command, the intruder instructs the controlled machines to launch one of many flood attacks against a specified

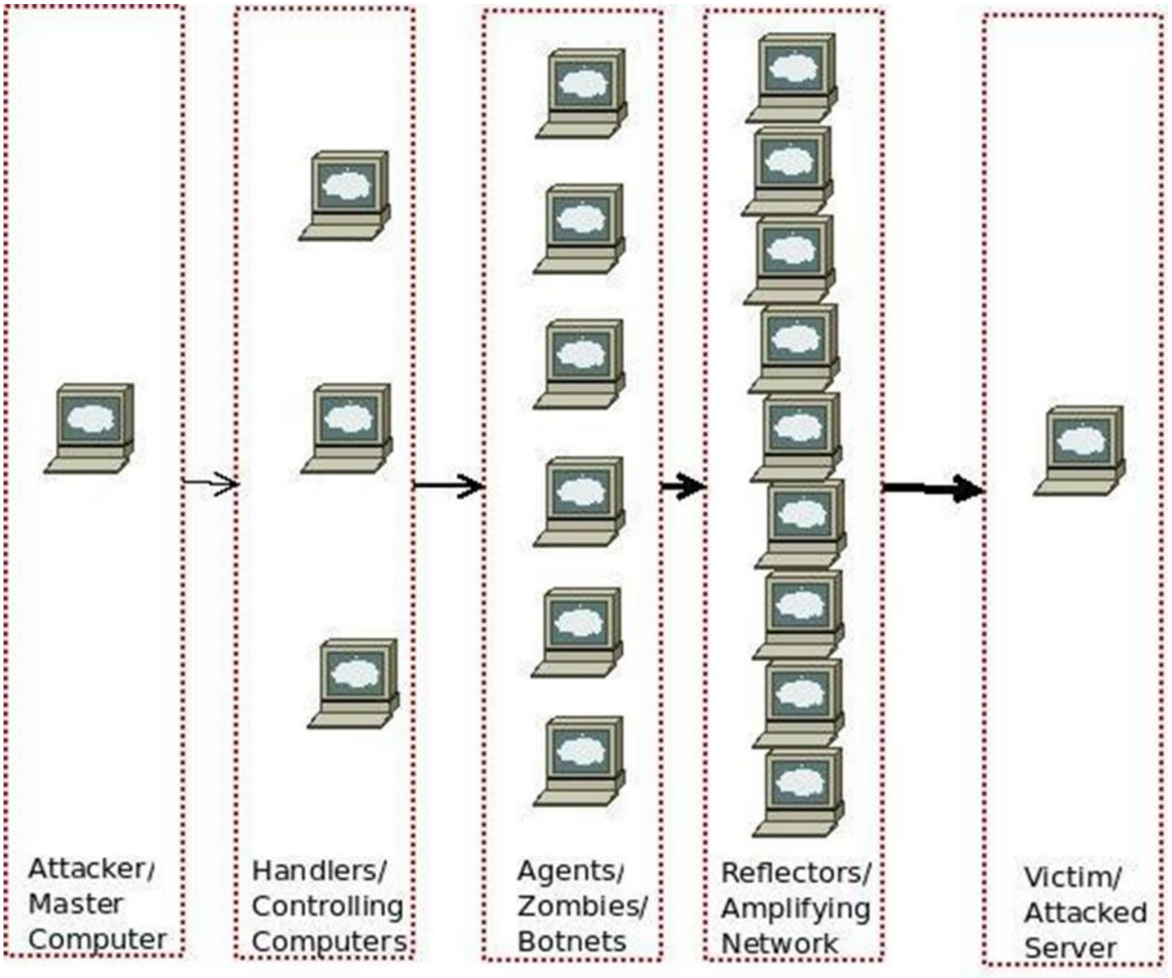
target. The inundation of packets to the target causes a denial of service.

While the press tends to focus on the target of DDoS attacks as the victim, in reality there are many victims in a DDoS attack -- the final target and as well the systems controlled by the intruder. Although the owners of co-opted computers are typically unaware that
their computers have been compromised, they are nevertheless likely to suffer degradation of service and malfunction. Both owners and users of targeted sites are affected by a denial of service. Yahoo, Buy.com, RIAA and the United States Copyright Office are among the victims of DDoS attacks. DDoS attacks can also create more widespread disruption. In October 2010, for example, a massive DDoS attack took the

entire country of Myanmar offline.

A computer under the control of an intruder is known as a zombie or bot. A group of co- opted computers is known as a botnet or a zombie army. Both Kaspersky Labs and Symantec have identified botnets -- not spam, viruses, or worms -- as the biggest threat to Internet security.

Components & Architecture diagram



Distributed Denial Of Service Attacks (DDoS) - Architecture Diagram

As you can see in the above architecture diagram representing Distributed Denial of Service (DDoS) attacks, there maybe up to five components. Two of them are aways there – The attacker/ master computer from where the attacks are initiated and the
Victim/ Attacked server which comes under the attack. Presence of just these two components makes it a Denial of Service attack (DOS).

The three components in the middle, make it a Distributed Denial of Service attack! Zombies / botnets are the computers from which the DDoS attacks are carried out.

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Classification of DDoS

Classification by exploited vulnerability DDoS attacks according to the exploited vulnerability can be divided in the following categories flood attacks, amplification attacks, protocol exploit attacks and malformed packet attacks.

1. **Flood Attacks:** In a flood attack, the zombies send large volumes of IP traffic to a victim system in order to congest the victim system_s bandwidth. Theimpact of packet streams sent by the zombies to thevictim system varies from slowing it down or crashing the system to saturation of the network bandwidth. Some of the well-known flood attacks are UDP flood attacks and ICMP flood attacks.

a. **UDP Attacks**: A UDP Flood attack is possible when a large number of UDP packets is sent to a victim system. This has as a result the saturation of the network and the depletion of available bandwidth for legitimate service requests to the victim system. In a DDoS UDP Flood attack, the UDP packets are sent to either random or specified ports on the victim system. Typically, UDP flood attacks are designed to attack random victim ports. A UDP Flood attack is possible when an attacker sends a UDP packet to a random port on the victim system. When the victim system receives a UDP packet, it will determine what application is waiting on the destination port. When it realizes that there is no application that is waiting on the port, it will generate an ICMP packet of ‘‘destination unreachable’’ [14] to the forged source address. If enough UDP packets are delivered to ports of the victim, the system will go down. By the use of a DDoS tool the source IP address of the attacking packets can be spoofed and this way the true identity of the secondary victims is prevented from exposure and the return packets from the victim system are not sent back to the zombies.

b. **ICMP Flood Attacks:** ICMP Flood attacks exploit the Internet Control Message Protocol (ICMP), which enables users to send an echo packet to a remote host to check whether it_s alive. More specifically during a DDoS ICMP flood attack the agents send large volumes of ICMP_ECHO_ REPLY packets (‘‘ping’’) to the victim. These packets request reply from the victim and this has as a result the saturation of the bandwidth of the victim_s network connection .During an ICMP flood attack the source IP address may be spoofed.

2. **Amplification Attacks:** In amplification attacks the attacker or the agents exploit the broadcast IP address feature found on most routers to amplify and reflect the attack and send messages to a broadcast IP address. This instructs the routers servicing the packets within the network to send them to all the IP addresses within the broadcast address range. This way the malicious traffic that is produced reduces the victim systems bandwidth. In this type of DDoS attack, the attacker can send the broadcast message directly, or by the use of agents to send the broadcast message in order to increase the volume of attacking traffic. If the broadcast message is sent directly, the attacker can use the systems within the broadcast network as agents without needing to infiltrate them or install any agent software.Some well known amplification attacks, are Smurf and Fraggle attacks.

a. **Smurf Attacks**: Smurf attacks send ICMP echo request traffic with a spoofed source address of the target victim to a number of IP broadcast addresses. Most hosts on an IP network will accept ICMP echo requests and reply to the source address, in this case, the target victim. On a broadcast network, there could potentially be hundreds of machines to reply to each ICMP packet. The use of a network in order to elicit many responses to a single packet has been labeled as ‘‘amplifier’’ . In this type of attack the party that is hurt is not only the spoofed source address target (the victim) but also he intermediate broadcast devices (amplifiers)

b. **Fraggle Attacks:** The Fraggle attacks are a similar attack to the Smurf except that they use UDP echo packets instead of ICMP echoes. Fraggle attacks generate even more bad traffic and can create even more damaging effects than just a Smurf attack.

3. **Prototype exploit Attacks:** Protocol exploit attacks exploit a specific feature or implementation bug of some protocol installed at the victim in order to consume excess amounts of its resources. A representative example of protocol exploit attacks is TCP SYN attacks.

a. **TCP SYN Attacks:** TCP SYN attacks exploit the inherent weakness of the three-way handshake involved in the TCP connection setup. A server, upon receiving an initial SYN (synchronize/start) request from a client, sends back a SYN/ACK (synchronize/acknowledge) packet and waits for the client to send the final ACK (acknowledge). An attacker initiates an SYN flooding attack by sending a large number of SYN packets and never acknowledges any of the replies, essentially leaving the server waiting for the nonexistent ACKs . Considering that the server only has a limited buffer queue for new connections, SYN Flood results in the server being unable to process other incoming connections as the queue gets overloaded.

4. **Malformed packet Attacks:** Malformed packet attacks rely on incorrectly formed IP packets that are sent from agents to the victim in order to crash the victim system. The malformed packet attacks can be divided in two types of attacks: IP address attack and IP packet options attack. In an IP address `attack, the packet contains the same source and destination IP addresses. This has as a result the confusion of the operating system of the victim system and the crash of the victim system. In an IP packet options attack, a malformed packet may randomize the optional fields within an IP packet and set all quality of service bits to one. This would have as a result the use of additional processing time by the victim in order to analyze the traffic. If this attack is combined with the use of multiple agents, it could lead to the crash of the victim system.

DDoS defense problems and classification

DDoS attacks are a hard problem to solve. First, there are no common characteristics of DDoS streams that can be used for their detection. Furthermore, the distributed nature of DDoS attacks makes them extremely difficult to combat or trace back. Moreover, the automated tools that make the deployment of a DDoS attack possible can be easily downloaded. Attackers may also use IP spoofing in order to hide their true identity, and this makes the traceback of DDoS attacks even more difficult. Finally, there is no sufficient security level on all machines in the Internet, while there are persistent security holes in Internet hosts. We may classify DDoS defense mechanisms using two different criteria. The first classification categorizes the DDoS defense mechanisms according to the activity deployed. Thus we have the following four categories:

→ Intrusion Prevention,

→ Intrusion Detection,

→ Intrusion Tolerance and Mitigation

→ Intrusion response.

1. Intrusion Prevention

The best mitigation strategy against any attack is to completely prevent the attack. In this stage we try to stop DDoS attacks from being launched in the first place. There are many DDoS defense mechanisms that try to prevent systems from attacks Using globally coordinated filters, attacking packets can be stopped, before they aggregate to lethal proportions. Filtering mechanisms can be divided into the following categories: Ingress filtering is an approach to set up a router such that to disallow incoming packets with illegitimate source addresses into the network. Ingress filtering, proposed by Ferguson and Senie , is a restrictive mechanism to drop traffic with IP address that does not match a domain prefix connected to the ingress router. This mechanism can drastically reduce the DoS attack by IP spoofing if all domains use it.

Sometimes legitimate traffic can be discarded by an ingress filtering when Mobile IP is used to attach a mobile node to a foreign network Egress filtering is an outbound filter, which ensures that only assigned or allocated IP address space leaves the network. Egress filters do not help to save resource wastage of the domain where the packet is originated but it protects other domains from possible attacks. Besides the placement issue, both ingress and egress filters have similar behavior. Route-based distributed packet filtering has been proposed by Park and Lee . This approach is capable of filtering out a large portion of spoofed IP packets and preventing attack packets from reaching their targets as well as to help in IP traceback. Route-based filters use the route information to filter out spoofed IP packets, making this their main difference from ingress filtering. If route-based filters are partially deployed, a synergistic filtering effect is possible, so that spoofed IP flows are prevented from reaching other Autonomous Systems.

The main disadvantage of this approach is that it requires global knowledge of the network topology leading to scalability issues. History-based IP filtering (HIP) is another filtering mechanism that has been proposed by Peng et al. in order to prevent DDoS attacks. According to this approach the edge router admit the incoming packets according to a pre-built IP address database. The IP address database is based on the edge router_s previous connection history. This scheme is robust, does not need the cooperation of the whole Internet community, is applicable to a wide variety of traffic types and requires little configuration. On the other hand, if the attackers know that the IP packet filter is based on previous connections, they could mislead the server to be included in the IP address database. This can be prevented by increasing the period over which IP addresses must appear in order to be considered frequent. Secure Overlay Services (SOS) is an architecture in which only packets coming from a small number of nodes, called servlets, are assumed to be legitimate client traffic that can reach the servlets through hash-based routing inside an overlay network. All other requests are filtered by the overlay. In order to gain access to the overlay etwork, a client has to authenticate itself with one of the replicated access points (SOAPs). SOS is a distributed system that offers excellent protection to the specified target at the cost of modifying client systems, thus it is not suitable for protection of public servers.

2. Intrusion Detection

Intrusion detection has been a very active researcharea. By performing intrusion detection, a host computer and a network can guard themselves against being a source of network attack as well as being a victim of a DDoS attack. Intrusion detection systems detect DDoS attacks either by using the database of known signatures or by recognizing anomalies in system behaviors. Anomaly detection relies on detecting behaviors that are abnormal with respect to some normal standard. Many anomaly detection systems and approaches have been developed to detect the faint signs of DDoS attacks.

A scalable network monitoring system called NOMAD has been designed by Talpade et al. This system is able to detect network anomalies by making statistical analysis of IP packet header information. It can be used for detecting the anomalies of the local network traffic and does not support a method for creating the classifier for the high-bandwidth traffic aggregate from distributed sources.

Another detection method of DDoS attacks uses the Management Information Base (MIB) data from routers. The MIB data from a router includes parameters that indicate different packet and routing statistics. Cabrera et al. has focused on identifying statistical patterns in different parameters, in order to achieve the early detection of DDoS attacks. It looks promising for possibly mapping ICMP, UDP and TCP packet statistical abnormalities to specific DDoS attacks. Although, this approach can be effective for controlled traffic loads, it needs to be further evaluated in a real network environment. This research area could provide important information and methods that can be used in the identification and filtering of DDoS attacks. A mechanism called congestion triggered packet sampling and filtering has been proposed by Huang and Pullen . According to this approach, a subset of dropped packets due to congestion is selected for statistical analysis. If an anomaly is indicated by the statistical results, a signal is sent to the router to filter the malicious packets.

Mirkovic et al. proposed a system called DWARD that does DDoS attack detection at the source based on the idea that DDoS attacks should be stopped as close to the sources as possible. D-WARD is installed at the edge routers of a network and monitors the traffic being sent to and from the hosts in its interior. If an asymmetry in the packet rates generated by an internal host is noticed, D-WARD rate limits the packet rate. The drawback of this approach is that there is a possibility of numerous false positives while detecting DDoS conditions near the source, because of the symmetry that there might be in the packet rates for a short duration. Furthermore, some legitimate flows like real time UDP flows do exhibit asymmetry.

3. **Intrusion Tolerance and Mitigation**

§ Research on intrusion tolerance accepts that it s impossible to prevent or stop DDoS completely and focuses on minimizing the attack impact and on maximizing the quality of its services. Intrusion tolerance can be divided in two categories: fault tolerance and quality of service (QoS).

§ Fault tolerance is a well-developed research area whose designs are built-in in most critical infrastructures and applied in three levels: hardware, software and system . The idea of fault tolerance is that by duplicating the network_s services and diversifying its
access points, the network can continue offering its services when flooding traffic congests one network link.

§ Quality of service (QoS) describes the assurance of the ability of a network to deliver the predictable results for certain types of applications or traffic. Many Intrusion Tolerant QoS Techniques and Intrusion Tolerant QoS systems have been developed in order to mitigate DDoS attacks.

A similar approach to VIPnets was adopted by Khattab et al. and they propose an approach called proactive server roaming in order to mitigate DoS attacks. According to this approach the active server proactively changes its location within a pool of servers to defend against unpredictable and undetectable attacks. Only legitimate clients can track the moving server. This roaming scheme has insignificant overhead in attack-free situations and can provide good response time in case of attacks.

4. **Intrusion Response**

Once an attack is identified, the immediate response is to identify the attack source and block its traffic accordingly. The blocking part is usually performed under manual control (e.g. by contacting the administrators of upstream routers and enabling access control lists) since an automated response system might cause further service degradation in response to a false alarm. Automated intrusion response systems do exist, but they are deployed only after a period of self-learning (for the ones that employ neural computation in order to discover the DDoS traffic) or testing (for the ones that operate on static rules). Improving attack source identification, techniques can expedite the capture of attackers and deter other attack attempts. There are many approaches that target the tracing and identifying of the real attack source . IP traceback traces the attacks back towards their origin, so one can find out the true identity of the attacker and achieve detection of asymmetric routes, as well as path characterization. Some factors that render IP traceback difficult is the stateless nature of Internet routing and the lack of source accountability in the TCP/IP protocol. For efficient IP traceback it is necessary to compute and construct the attack path. It is also necessary to have a low router overhead and low false positive rate. Furthermore, a large number of packets is required to reconstruct the attack path. It is also important the robustness against multiple attacks, the reduction of the privacy of IP communication, the incremental deployment and the backward compatibility. At a very basic level, you can think of this as a manual process in which the administrator of the network under attack places a call to his Internet Service Provider (ISP) asking for the direction from which the packets are coming. Since the manual traceback is very tedious there have been various proposals in the recent past to automate this process.

ICMP traceback has been proposed by Bellovin . According to this mechanism every router samples the forwarding packets with a low probability (1 out of 20,000) and sends
an ICMP traceback message to the destination. If enough traceback messages are gathered at the victim, the source of traffic can be found by constructing a chain of traceback messages. A major issue of this approach is the validation of the traceback packets. Although the PKI requirement prevents attackers from generating false ICMP traceback messages, it is unlikely that every router will implement a certificate-based scheme. Furthermore, ICMP traffic generates additional traffic and an upstream router map is required to construct an attack path since the IP addresses of the routers are encoded in the ICMP traceback message.

An alternative, which introduces an intention-bit in the routing and forwarding table, is called Intention- Driven ICMP Traceback . In order to face DDoS attacks by reflectors, Barros proposed a modification of ICMP traceback messages. In this approach, routers send ICMP messages to the source of the currently being processed packet rather than its destination. This reverse trace enables the victim to identify the attacking agent(s) from these packets.