Design and Implementation of Modular Honeynet System Based on SDN

Yan Li[1], Bin Wu[1]
[1] *School of Cyberspace security, Beijing University of Posts and Telecommunications, No.10 Xitucheng Road, Beijing, China*

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Abstract: Traditional honeynets cannot dynamically migrate traffic. The flexibility of SDN can solve this problem. At the same time, the traditional honeynets have the disadvantages of complicated alarm logs and inability to carry out targeted analysis, and lacks protection for the honeypot. It is easy to completely destroy the honeypot and make it a jumper for the attacker to launch the next attack on the intranet. This paper proposes a modular honeynet system based on SDN, which can respond to the scanning probe-exploit-worm injected attack chain, reducing the complexity of the alarm log and improving the efficiency of the researchers in analyzing attacks. Also, a honeypot switching strategy based on the detection of the attack tree phase is proposed in the module of vulnerability response, which can delay the attacker's attack progress and reduces the risk of the honeypot. The experiment also verified the feasibility of the modular system.

1 INTRODUCTION

The Internet has become an indispensable part of people's daily lives and network security has become an issue of increasing concern. The defenders proposed the honeynet technology (Jianwei Zhuge, 2013) as a mean of active defense in a passive situation. In terms of passive defense, active defense emphasizes that it can promptly warn before the intrusion causes damage to the system, avoiding and diverting the attack risk faced by the system. In this paper, the Software Defined Network (SDN) technology and honeypot technology are deeply studied.

The honeynet is a hacker trap network system consisting of several honeypots that can seduce attackers and collect attack data. The honeynet stores false sensitive data and does not provide normal services. It is pre-arranged in the honeypot. The vulnerability and monitoring system can seduce the attacker and monitor and record the attack behavior, so that the defensive party can restore and trace the attack behavior, so as to better defend the service network where the real host is located. However, traditional honeynets are mostly based on traditional network devices as honeynet gateways (More Asit, 2013), which achieve the purpose of traffic migration through program burning. This method is not flexible enough and has security risks. On the other hand, the traditional honeynet responds to the attacker's overall attack behavior, which often causes the recorded attack data to be too cumbersome and confusing. It is difficult for defenders to judge the impact of each attacker's attack, which is not easy to analyze the attack behavior.

To solve the problem that the traditional honeynet alarm log has high complexity and lacks protection for honeypots, this paper combines honeynet and SDN technology, and uses SDN flexible and convenient features to innovatively propose a modular honeynet system based on SDN. The attack behavior of the attacker is divided into three stages: topology scanning-exploiting-worm injecting. The three modules respond to the three-stage attack respectively. It reduced the level of alarm confounding, which is convenient for researchers to analyze the attack in stages. Also, this paper proposed a honeypot switching strategy based on the attack tree to cut the exploit behavior and reduce the success rate of the attacker, so as to prevent the honeypot from being completely attacked by the attacker and become a jumper for attacking the net. It solved the problem of traditional honeynet lack of protection for honeypots.

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2 RELATED RESEARCH

2.1 Related Research on SDN

SDN technology is an innovative network architecture proposed by the Clean State group of Stanford University (Nunes, B., 2014). Different from OSI seven-layer model, the SDN architecture consists of the infrastructure layer, the control layer and the application layer, as shown in Figure 1. In the SDN architecture, the infrastructure layer is responsible for data processing, forwarding, and state collection. The control layer is responsible for sending flow tables to the infrastructure layer devices to achieve fast processing of matching flow table traffic. The application layer includes various services and applications. The application written by the SDN controller is running on this layer to implement network business functions (McKeown, N., 2008).

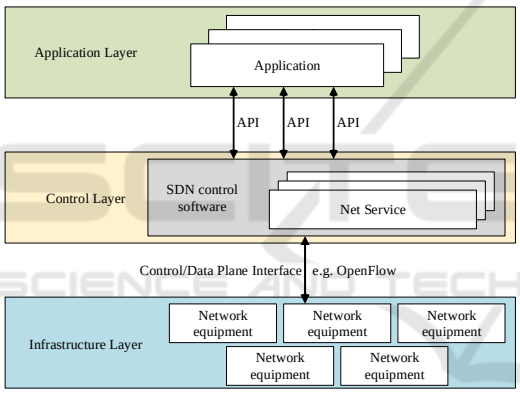


Figure 1: The architecture of SDN.

2.2 Research on Honeynet Based on SDN

Honeynet is a fake network architecture for security defense. The proposed honeynet technology benefits from the active defense theory proposed by the defender in response to the long-term passive situation of the attack. In the traditional honey network architecture, the traffic forwarding function is implemented by HoneyWall. The honey network is connected to the external network, the internal network, and the management server or IDS device. However, such a deployment method requires a lot of manual operation and high-performance hardware. And the software running on the honey wall needs to be constantly updated and re-programmed to meet the different needs of the defender, which greatly restricts the use of the honey wall.

With the introduction and development of SDN technology, many researchers have noticed the flexibility, programmable, and virtualized features of SDN technology. Therefore, many SDN-based honey network architecture solutions have emerged.

Wonkyu Han (2016) proposed the SDN-based smart honeynet HoneyMix, which filters the fingerprint information through controller programming, making the honeypot more difficult to be detected by the attacker and broadcasting the connection request of the attack traffic to other honeypots in the honeynet. Select the honeypot that the attacker is most interested in to respond, to achieve better effect of attracting attackers and prolong the connection time of the attacker.

Stefan Achleitner (2017) designed an SDN honeynet system for intranet scanning spoofing, which forwards all traffic of the intranet to the RDS (Reconnaissance Deceiving Server) via SDN. When the scanning behavior is detected, the fake network topology information is generated by the RDS. Return to the attacker and extend the scan time through the delay and queuing strategy to find the location of the infected host before the attacker completes the scan.

Wenjun Fan (2017) believed that the current traffic redirection mechanism, especially the TCP connection switching, is not hidden and easy to be discovered by attackers. Therefore, an SDN-based hybrid honeypot system network data controller is proposed, which is forged. The serial number of the current TCP session implements the secret switching of TCP, and implements filtering of traffic based on the alarm function of Snort.

Qiuchen Ren (2018) proposed an SDN honey network system based on multi-controller equalization strategy. The system can simulate dynamic routing protocols, routing functions, and virtualize the network topology to achieve the purpose of deceiving attackers. At the same time, the spectral clustering algorithm is improved, and the functions of controller load balancing and flow control are optimized.

2.3 Research on Attack Tree Model

Bruce Schneier (1999) first proposed the attack tree model to describe the attack in 1999. The root node of the tree represents the final intrusion target, and the child node represents the attack method adopted by the parent node. The relationships between child nodes are "or" and "and", as shown in Figure 2:

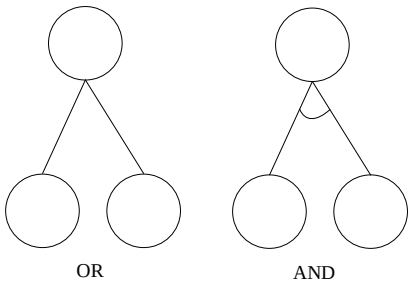


Figure 2: Relationship between child nodes

An "or" relationship means that the completion of any child node means the completion of the parent node, and the "and" relationship means that all child nodes have been completed to indicate that the parent node is completed.

The generation of the attack tree is a process of reasoning backwards from the root node. The specific steps are as follows:

(1) Determine the ultimate goal of the attack, which is the root node of the attack tree.

(2) Using the root node as a starting point, matching the collected attack information for the target with the attack rule in the attack tool library, and if it matches, generating a new child node.

(3) Each node is regarded as a sub-goal, and a new node is generated by the attack method and rule matching the child node in the tool library as a child node of the current sub-goal.

(4) Repeat the above steps until the child nodes can no longer be split.

3 SYSTEM DESIGN

3.1 System Architecture

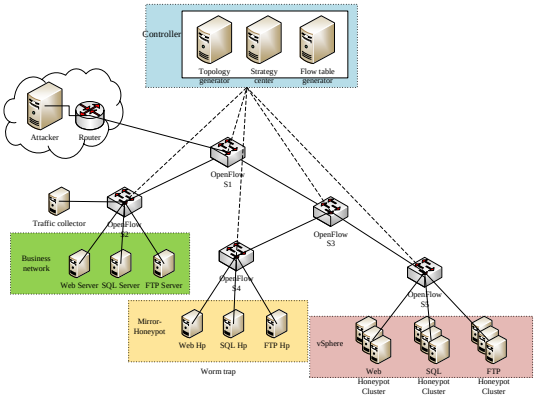


Figure 3: System structure.

The system structure is shown as Figure 3. The controller (including topology generator, policy center and flow table generator) is responsible for the response to the topology scan. The honeypot cluster is responsible for the response of the exploit attack, and the worm trap is responsible for the response of the worm impact. The system contains 5 OpenFlow switches, which are respectively recorded as S1~S5. S1 acts as a master switch and connects directly to the external network. The controller consists of three modules, namely the topology generator, which is responsible for generating the virtual topology of the response scan according to the configuration file. The policy center is responsible for identifying malicious traffic and worms. The flow table generator is responsible for generating the switch flow table and delivering it to the switch. The S2 switch is connected to the service network, and normal traffic is accessed to the service network through the S2 switch. S2 is also connected to a traffic collector. All traffic of S2 is copied by the traffic collector. The traffic collector analyzes the traffic in the domain. If there is any malicious traffic or worm virus that is under-reported, it will feedback to the policy center through S2. The policy center updates its own rule base to match the newly discovered malicious traffic. The S4 switch is connected to the mirrored honeypot. The physical properties of the mirrored honeypot are the same as those of the service network. The service network is cloned. Each service network host has its own mirrored honeypot. The purpose of setting up a mirror honeypot is to attack the implanted third step, the worm or Trojan that the attacker wants to implant into the network, which will be directed to the mirror honeypot, because the mirror honeypot is for the business. The cloning of the network is very similar to the real network environment, so the behavior of the worm or the Trojan can be observed in the mirror honeypot to infer the action and destructive power of the virus in the real network environment, so that the researchers can better Targeted defense. The S5 switch connects honeypots managed by vSphere. These honeypots are classified according to the types of attacks they can respond to and are used to respond to the second step of the attack, namely exploit exploits. For this part of the honeypot, the "honeypot switching" strategy is adopted, that is, for the attack of a certain service, the attacking step is hierarchically split by the attacking tree, and then the honeypots in the same cluster respond to different levels of attacks. When the attack is found to enter the next stage, the attack traffic is imported into another honeypot in the same

cluster, so that the attacker's previous attack will be invalid. In this way, the attacker's attack progress is delayed, and the honeypot is broken to be used as a springboard to continue the attack on the intranet. On the other hand, the attacker's attack time can be prolonged, and the attack behavior can be more easily collected. More attack data. In addition, considering that in the process of honeypot switching, since the response attacks are different hosts before and after the handover, the sequence number may be different in the attacked TCP connection. For this case, the current TCP packet sequence number is copied. The method in the next stage of the attack, so that the switch is not perceived by the attacker. A typical timing diagram is as follows:

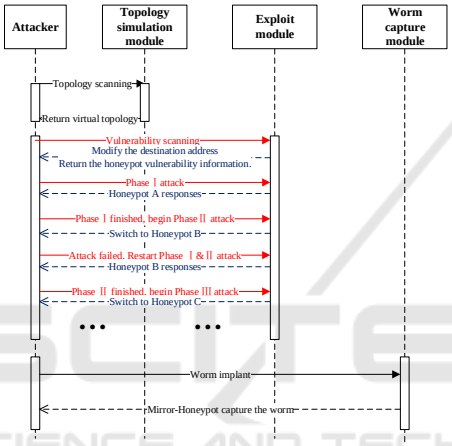


Figure 4: Attack timing diagram.

The attacker first performs topology scan detection on the network, and the topology simulation module generates a corresponding virtual topology according to the previously issued topology file and presents it to the attacker. Then, the attacker performs a vulnerability scan on the terminal node in the collected topology. Since the IP address in the virtual topology is forged, the virtual IP needs to be reverse mapped to the honeypot IP, and the honeypot responds to the vulnerability of the attacker's scanning. After finding out the vulnerabilities on the honeypot, the attacker exploits the vulnerability to attack. According to the stage of the attack tree's vulnerability attack, each time the attack reaches a new stage, a new honeypot is switched to respond to the attack. Some attacks rely on the results of the previous attack. Such a switch causes the attacker to abandon the attack and needs to restart the attack. The multiple switch will cause the attacker to slow down and give up the attack. For the honeypot, both the attacker's attack information is collected and the self-protection effect is achieved. When the attack progresses to the worm implant, the worm is identified by the controller's policy center, and is directed to the mirrored honeypot for worm capture by sending the flow table. Because the mirror-honeypot is a clone of the business. With the height simulation of the web host, the researchers can observe the behavior of the worm in the mirror honeypot to assess its destructive power in the real environment.

3.2 Topology Simulation Module

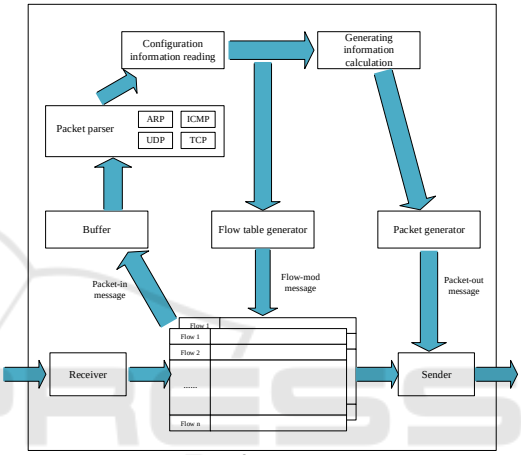


Figure 5: Block diagram of Topology simulation module.

The topology simulation module is shown in the Figure 5. For the network traffic received by the switch, the switch flow table is matched first, and the matched data packets are directly forwarded according to the rules specified in the flow table. If the matching fails, the packet-in message is used. The form is sent to the controller's packet buffer. The controller first parses the data packet, and according to the protocol of the data packet, it is processed by different modules. Then the configuration file is read to obtain the structure of the network topology to be generated and the information such as the IP address and the MAC address of each node is used to calculate the packet information based on the information. Finally packet generator generates a packet to reply the requester in the form of a Packet-out message.

If the traffic that does not need to be responded to by the topology simulation module, for example, the traffic that is used for the first time to access the normal service, the flow table generator generates a response flow table and sends it to the switch to facilitate fast matching and processing of subsequent traffic.

To complete the response to the network topology scan, mainly to spoof ping and traceroute (Windows system is tracert) command detection, these two commands mainly rely on ICMP protocol, and the premise of ICMP protocol is that the attacker knows the physical address of the destination host, That is, the ARP protocol. As long as you can simulate the ARP and ICMP protocols, you can respond to basic ping and traceroute probes. The principle of topology simulation is described below:

3.2.1 ARP Simulation

The ARP (Address Resolution Protocol) protocol is used to obtain the physical address based on the IP address. The OpenFlow switch is a Layer 2 device. It does not have an IP address and cannot answer ARP requests. The system uses the ARP response method from the controller. When the controller receives the ARP request, it searches for the MAC address of the corresponding IP according to the content of the configuration file, and constructs a response packet according to this, and returns it to the requesting party.

3.2.2 ICMP Simulation

The Internet Control Message Protocol (ICMP) protocol is often used to test network connectivity. Scanning the network topology is based on ICMP. ICMP is generally used for two commands: ping and traceroute. When the controller receives the ping request, the configuration file is read, and the connectivity between the target host and the request source and the hop count are determined according to the network topology defined by the configuration file, and the response packet is constructed according to the configuration, and returned to the requesting party. The principle of detecting the network topology by using traceroute is that the attacker first sends a packet with a TTL of 1 to the destination. When the first router on the path receives it, the TTL is decremented by 1. At this time, the TTL is 0. The router will discard the packet and return a Time Exceed message. Upon receiving the message, the attacker knows that there is a router on the path, and then sends a packet with a TTL of 2 to probe the second route. Repeat the above actions until the data packet is sent to the destination host. Since the traceroute command generally sends UDP packets, the destination port is 33434~33534. The general application will not use this range of ports, and the host will reply to ICMP after receiving it. Port Unreachable message, after the attacker receives it, it can judge that the destination has arrived. The traceroute command can send UDP, TCP, and ICMP packets separately using different parameters. The system processes all three traceroute requests and can respond to traceroute probes under different parameters.

3.3 Exploit Module

In the exploit response module, we used a honeypot switching strategy based on attack tree phase detection. The attack that may be suffered is represented in the form of an attack tree. The attack is divided into multiple paths. Each path is regarded as a phase of the attack. The IDS is configured to detect the alarm rules of each phase. When the IDS sends the next phase. When the attack is alerted, the attack as the previous stage is completed. At this time, the IDS reports the attack information to the SDN controller, and the controller modifies the flow table to switch the honeypot traffic that is communicating with the attacker to another honeypot, in such a manner that the attacker is in the previous stage. The attack is invalid, which will slow down the attack and protect the honeypot.

According to the attack tree generation method, we created an attack tree model that represents a general network attack (as shown in the Figure 6). Due to the variety of actual attacks, it is difficult to display all attacks on one attack tree. This paper selects the experimental part. The privilege escalation attack is detailed and analyzed, and other forms of attack are similar.

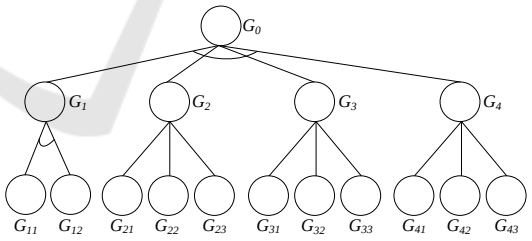


Figure 6: Normal attack tree.

The main sub-target symbols and meanings are shown in the Table 1:

Table 1: Symbol & Meaning of Normal attack tree.

Symbol	Meaning	Symbol	Meaning
G_0	Fully attack a host	G_{22}	Configuration error
G_1	Scanning	G_{23}	Guess weak password
G_2	Get general permissions	G_{31}	Penetration attack
G_3	Get root permission	G_{32}	Known system vulnerabilities
G_4	Damage a host	G_{33}	Unknown system vulnerabilities
G_{11}	Ping	G_{41}	DOS
G_{12}	Other scanning tools	G_{42}	Backdoors
G_{21}	Vulnerability attack	G_{43}	Jumper

3.4 Worm Capture Module

Worm is a malicious program with a high degree of harm. It can infect the target node and use the infected node as the source of infection to scan the network where the node is located, further infect other nodes in the network, and achieve independent reproduction and propagation. Once a node in the network is infected, the entire network may be compromised by the worm. At present, honeynet is a main defense method for worms. However, the traditional honeynet has great limitations on the behavior of malicious programs such as worms. It is difficult to study the destructiveness of worms in the real environment. On the other hand, the detection of worms relies too much on the feature library and feature matching algorithms. Detection and feedback of missing worms. In order to solve these problems, the system makes full use of the network traffic control capability of SDN technology, and designs a worm capture module that can track the entire life cycle of the worm, including generation, propagation, propagation, detection and detection feedback, and simulate the real environment. It is convenient for researchers to study the behavior and destructive power of worms in real environments. The structure of the module is shown as Figure 7:

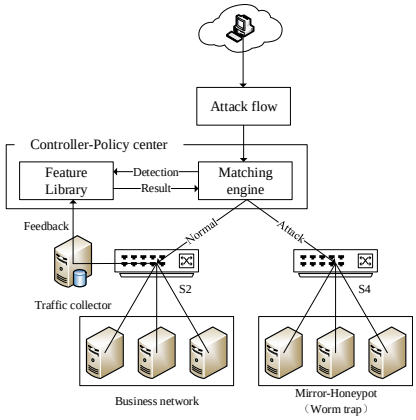


Figure 7: Block diagram of Worm capture module.

The policy center module of the SDN controller consists of a matching engine and a feature library. The feature database records the characteristic information of the known worm, and has the characteristics of fast detection speed and low false alarm rate. However, only the known worm can be detected. The traffic collector can collect and abnormally detect the traffic in the service domain. The anomaly detection module uses an anomaly detection algorithm based on network entropy for detection (Gu Yu, 2005). The network entropy is generated by the IP quintuple, and the normal traffic sample is trained to obtain the maximum network entropy model of the normal traffic. When the anomaly detection is performed, the entropy difference between the network entropy of the traffic to be detected and the normal traffic is calculated, and the threshold is about to be detected. The flow rate is judged to be abnormal. The attacker's operation of worm implantation is regarded as an attack flow. The matching engine performs feature matching on the load field of the traffic, that is, performs matching search in the feature database. If the result is matched, the traffic is regarded as abnormal traffic, and the SDN controller is passed. The flow table is sent, and the traffic and all subsequent traffic of the source IP are introduced into the mirror honeypot through the OpenFlow switch S4. A mirrored honeypot is a clone of a service network host. It has the same topology, physical attributes as the service network. Researchers can cultivate and observe worms in mirrored honeypots. If the signature database fails to match, it is regarded as normal traffic, and traffic is introduced to the service network providing normal services through OpenFlow switch S2. All the traffic in the service network is copied by the traffic collector. The traffic collector collects the

abnormality of the traffic in the domain based on the statistics. If the worm is missing, the feature database is updated to the signature database of the policy center. To improve the accuracy of feature detection. In addition, since the worm has infected the service network node when a missed report is detected, the researcher is required to manually remove the worm from the infected node.

4 EXPERIMENT & ANALYSIS

4.1 Environment

The environment of experiment is shown as Figure 8 and Table 2. Use one server to run SDN application layer software and three servers to simulate real business network host, use one server to accommodate honeypot cluster and run three honeypots to simulate exploit module. We manage them through vSphere. Another server was used for the worm capture experiment.

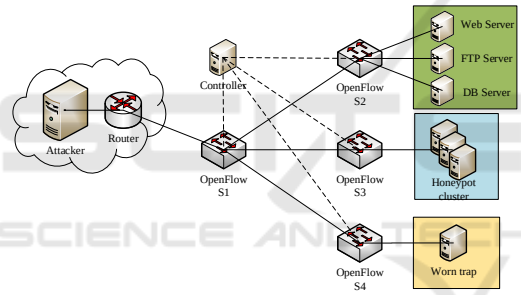


Figure 8: Environment of experiment.

Table 2: Equipment model and configuration.

Name	System	IP Address	Note
Controller	Ubuntu 16.04	192.168.8.8	Run SDN application
OpenFlow Switch S1~S4	OpenWRT 14.07	-	Embed OpenWRT on Home router. Run OVS 2.5.2
Web Server	Ubuntu 16.04	172.16.0.101	Run HTTP service
FTP Server	Ubuntu 16.04	172.16.0.102	Run IIS service
DB Server	Ubuntu 16.04	172.16.0.103	Run Mysql 5.6
Honeypot Cluster	Windows Server 2008	212.16.0.101-103	Run HTTP service
Worm trap	Ubuntu 16.04	192.168.1.1	Clone of Server

4.2 Experiment of Topology Simulation Module

A topology file is sent to the module. The topology is as shown as Figure 9:

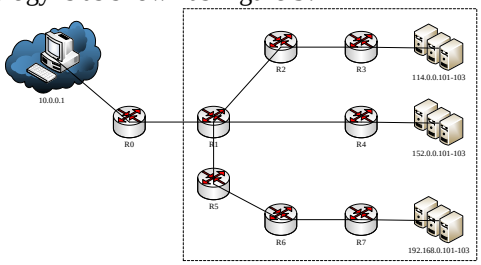
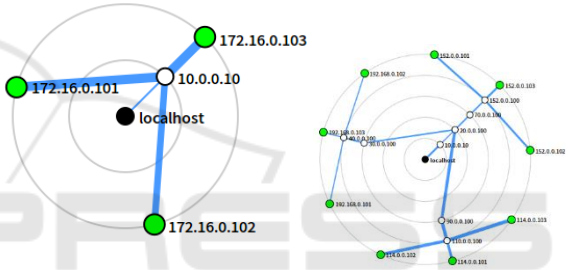


Figure 9: Topology of the configuration file.

Before starting the topology simulation function, we use Nmap on the attack host to scan the business network. Then we start the simulation



function and repeat the above step. The result is Figure 10:

Figure 10: Before & after start topology simulation function.

The results of pinging are shown as Figure 11:

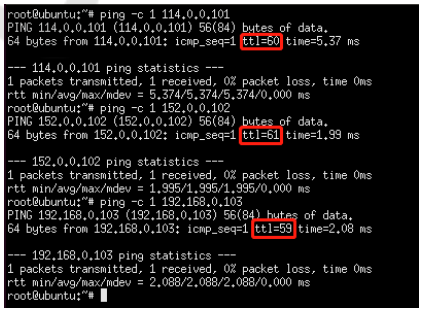


Figure 11: TTL of three virtual subnets.

The results show that the system can respond effectively to the attacker's detection behavior. By sending the configured topology file, the deceptive network topology is presented to the attacker. The system can hide the topology of the real network and protect the hosts in business network.

4.3 Experiment of Exploit Module

After the scan detection, the attacker obtains a false network topology, and then can attack the network nodes in the topology. We construct an attack tree model of the privilege escalation attack (as shown in the Figure 12, other attacks are similar), and use the privilege escalation attack as an example to verify the exploit module response function.

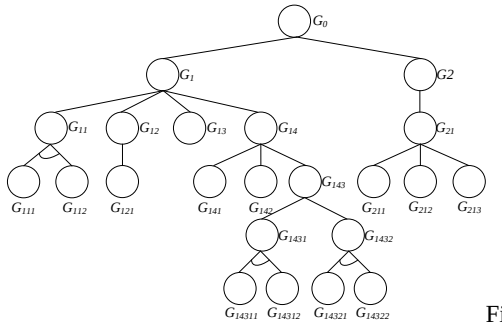


Figure 12: Attack tree of privilege escalation attack.

The main sub-target symbols and meanings are shown in the Table 3:

Table 3: Symbol & Meaning of Privilege escalation attack.

Symbol	Meaning	Symbol	Meaning
G_0	Complete penetration attack	**G_{143}**	rlogin/rsh from trusted host
G_1	Get shell	**G_{211}**	phf.cgi
G_2	Excute shell	**G_{212}**	php.cgi
G_{11}	Hijack TCP session	**G_{213}**	test-cgi
G_{12}	Daemon buffer overflow	**G_{1431}**	FTP Bounce
G_{13}	Modify configuration files	**G_{1432}**	Spoof trusted host and connect
G_{14}	Login via authorized method	**G_{14311}**	ftp-rhost
G_{21}	Vulnerabilities in CGI	**G_{14312}**	rsh login
G_{111}	TCP spoofing packet attack	**G_{14321}**	Spoof DNS
G_{112}	Sniff TCP sequence number	**G_{14322}**	Rcmd connect without password

According to this attack tree, an attack path can be expressed as G_{14311}-G_{14312}-G_{1431}-G_{143}-G_{14}-G_1-G_0. That is, the attacker first establishes the .rhost file in the root directory of the remote ftp server through the ftp_rhost vulnerability, obtains the trust relationship with the target host, and then uses the rsh vulnerability to secretly log in to the remote host, and uses the local-setiud-bof vulnerability to raise the right. Attack, get root privileges, and then use the root privileges to get the shell of the target host to complete the penetration attack. The system performs phased detection for different phases of the attack path. When snort detects the next step of the attack, it sends information to the controller. The controller modifies the flow table on the switch according to the result of the Snort detection, selects one of the honeypot clusters that provide the same service, and migrates the attack traffic to the new honeypot host and use the same TCP session number. Through such switching, the attacker's previous attack is invalid, delaying the attack progress, prolonging the attacker's attack time, facilitating more attack information, and reducing the attacker's use as a springboard after the honeypot is broken. The possibility of machine utilization.

The attack tree in the above figure is an example. The attacker attacks the server (114.0.0.101). This IP is virtual IP, and the actual response honeypot is 212.16.0.101. The SDN controller sends the flow table to S1, and the flow table with the destination address of 114.0.0.101 is modified to the destination address of 212.16.0.101, forwarded to the switch S3, and the source IP of the packet sent to the attacker by 212.16.0.101 is changed. It is 114.0.0.101, so the attacker will think that the host IP with which it communicates is 114.0.0.101.

The ftp-rhost vulnerability (CVE-2008-1396) is used to attack the target host. A .rhost file is uploaded to the root directory of the server to establish a trust relationship with the target host. The alarm is generated by the IDS. The alarm information is shown as Table 4:

Table 4: Alarm info on IDS.

Information	msg:"PROTOCOL - FTP.rhosts"; flow:to_server,established; content:".rhosts"; metadata:policy max-detect-ips drop, service ftp; classtype:suspicious-filename-detect;
Result	Upload success
Attack time	2018-12-15 14:12:45
Src_ip	10.0.0.1
Dst_ip	212.16.0.101

At this point, the switching policy takes effect, and the attacker is unaware of it. The attacker wants to use the trust relationship established in the previous step to log in to the host without a password, so he tries to log in using the rsh login vulnerability (CVE-1999-0180). IDS generates the following alarms as Table 5:

Table 5: Alarm info on IDS.

Information	msg:"PROTOCOL-FTP Login Request"; flow:to_server,established;nocase; content:"NEWER"; metadata:policy max-detect-ips drop, service ftp; classtype:suspicious-filename-detect;
Result	Login failed
Attack time	2018-12-15 14:13:13
Src_ip	10.0.0.1
Dst_ip	212.16.0.102

It can be seen that the attack attempted to log in has not been successful, and the address of the destination IP has changed to 212.16.0.102. This is because after the host of 212.16.0.101 is attacked and alerted, according to the honeypot switching policy, the attack is considered to be in the next stage, in order to delay the attacker's attack progress, Controller modified the switch S3 flow table. The traffic that communicates with the attacker changed from 212.16.0.101 to 212.16.0.102. This honeypot does not have the .rhost file uploaded by the attacker. the attacker would like to use the trust relationship established by the previous attack to perform rsh-free login. At this point, the switch S3 flow table is shown as Table 6:

Table 6: Flow table on switch S3.

Packet	Action
Input:1 Src_IP:10.0.0.1 Dst_IP:212.16.0.101	Mod_Dst_IP:212.16.0.102 Output:3
Input:3 Src_IP:212.16.0.102 Dst_IP:10.0.0.1	Mod_Src_IP:212.16.0.101 Output:1

4.4 Experiment of Worm Capture Module

The expected result is that after detecting the worm, the attack traffic is forwarded to the S4 switch, which is captured by the worm capture. The researcher can cultivate and observe the worm's behavior. In the experiment, the eigenvalues of the Sasser worm have been pre-stored in the feature matching database of the strategy center. The Sasser worm is implanted into the host with the IP address of 114.0.0.1, and the related flow entries of the switch S1 are observed, as shown in the Table 7:

Table 7: Flow table on switch S1.

Packet	Action
Input:1 Src_IP:10.0.0.1 Dst_IP:114.0.0.1	Output:4

The S1 switch just forwards the packets to the S4 switch with an output of 4. Continue to observe the related flow entries of S4, as shown in the Table 8:

Table 8: Flow table on switch S4.

Packet	Action
Input:1 Src_IP:10.0.0.1 Dst_IP:114.0.0.1	Mod_Dst_IP:192.168.1.1 Output:2

The worm's destination IP is modified to the worm's IP and sent to its port, thus enabling the capture of the worm.

5 CONCLUSION

In this paper, the combination of SDN technology and honeynet technology is studied. A new type of SDN-based modular honeynet system is proposed, which fully utilizes the flexibility of SDN to realize the method of responding to attacks by sub-modules, making up for the past. The traditional honey net is attacked and has many shortcomings such as alarm logs and difficult analysis. In the exploit module, the honeypot switching strategy based on the detection of the attack tree phase is adopted, which reduces the risk that the honeypot is completely broken and becomes the attacker attacking the intranet's springboard, delaying the attacker's progress and facilitating the researcher to collect. More attack data is analyzed. Based on the above content, the experiment is designed to verify the feasibility of the sub-module response attack.

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