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UNDERGRADUATE THESIS

SYN Flood and Saturation Attack Detection and Mitigation in SDN Networks

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in the

Department of Computer Science and Engineering

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Declaration of Authorship

I, KANISHK PATEL declare that this thesis titled, "SYN Flood and Saturation Attack Detection and Mitigation in SDN Networks" and the work presented in it is my own. I confirm that:

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Abstract

Department of Computer Science and Engineering

Bachelor of Technology

SYN Flood and Saturation Attack Detection and Mitigation in SDN Networks

Recent works have shown that the interaction between control and data plane in the Software Defined Networks can be chocked by an adversary with saturation attack. This attack is generated by sending large number of new flows to a switch exploiting the switch-controller communication. A switch sends a packet-in message to the controller if a new flow is seen. A flux of new flows results in a large number of packet-in messages at the controller. In this paper, we present SaturationGuard which mitigates this attack by adopting an early attack detection method. An anomaly detection method deployed at the controller observes the patterns of packet-in messages and identifies the attack. In particular, we capture normal interaction between switch and controller using the arrival rate of packet-in messages with a probability distribution. To mitigate the attack, we propose to throttle the bandwidth of the affected switch port in proportion to the arrival rate of new flows. We implement a proof of concept solution with Mininet and an external controller and show that SaturationGuard is effective in handling the saturation attacks with early stage detection

Acknowledgements

I would like to thank my B.Tech Project supervisor **Dr. Neminath Hubballi** for his guidance and constant support in structuring the project and their valuable feedback throughout the course of this project. Their overseeing the project meant there was a lot that I learnt while working on it. I thank them for their time and efforts.

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Contents

Chapter 1

Introduction

Networking devices such as routers, switches, and firewalls are commonly used in modern computer networks. To achieve high throughput and performance, such devices handle various sophisticated protocols as well as lists of commands and customizations based on a specific (OS). To respond to a wide range of network events and applications, network managers are confined to a set of predefined instructions and must follow specified protocols and setup regulations. While adapting to changing network conditions, they must manually convert these high-level regulations into low-level configuration commands. They frequently have to complete these extremely difficult tasks with very minimal resources.

Vendor dependence, complexity, inconsistent policies, and the inability to scale are some of the other drawbacks. As a result, network management and performance tweaking are difficult and error-prone tasks. Supporting more protocols and applications would be easier, simpler, and more efficient if network controls could be programmed in a more responsive and flexible manner.

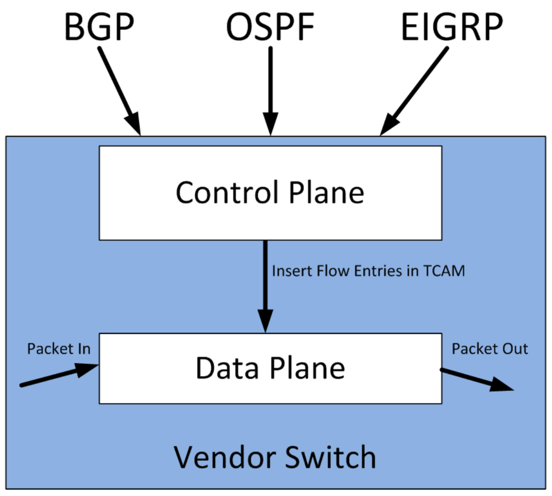
Software Defined Networking (SDN) is a new networking architecture in which control decisions are decoupled from forwarding hardware. It claims to make network management much easier while also allowing for innovation and growth.

SDN security is more challenging than security in traditional networking, and among such challenges are both the denial of service (DoS) and distributed denial of service (DDoS) attacks. We develop and apply novel solutions to these problems as part of our project.

1.1 Background

1.1.1 Software Defined Networking

Software Defined Networking (SDN) simplifies the task of network management by separating the control and data planes in the network. It concentrates the control plane operation into a software entity which has a global visibility of the network. This central entity called the controller makes decisions of what action should be taken on packet(s) at the data plane. The action to be taken is indicated by installing a set flow rules in the relevant switches.Centralized decision making brings several advantages including programmability, resource optimization and also innovative application development.



OpenFlow [1] is the standard interface between the control plane and data plane. SDN has also been used to design new security solutions for the traditional security issues. However, it also brings several new security issues [11] including new DoS attacks. Denial of Service and Distributed Denial of Service attacks have been studied very extensively. Peng etal. [9] argue that several design decisions of TCP/IP network protocols have led to such attacks. More recently these attacks have taken the form of targeting the application layer protocols [14] and also software defined networks [13]. There are methods to detect and possibly mitigate the effects of traditional DoS and DDoS attacks. However the DoS attack on SDN is unique and the conventional methods to handle the DoS attacks will not be effective.

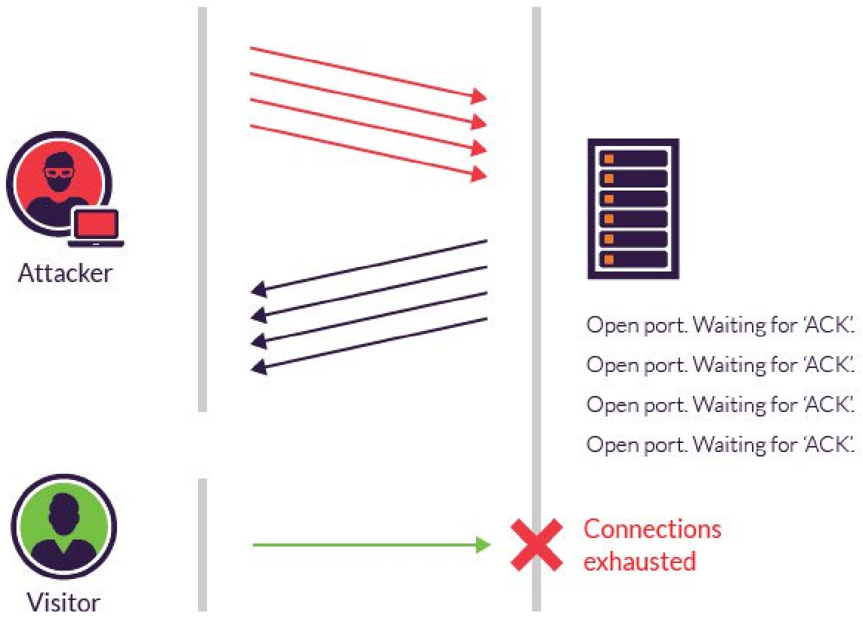
This model differs from that of traditional networks, which use dedicated hardware devices (i.e., routers and switches) to control network traffic. In the traditional DoS attack a specific server, application is targeted. However a single attack can be launched against control plane in SDN affecting the entire network.

SDN is a huge step forward from traditional networking since it allows for the following:

- **Better speed and flexibility with increased control**Instead of manually programming various vendor-specific hardware devices, developers may simply design an open standard software-based controller to control network traffic flow. Network managers also have more options when it comes to selecting networking equipment because they can use a single protocol to communicate with any number of hardware devices via a central controller.
- **Adaptable infrastructure** Administrators can design network services and allocate virtual resources to update the network infrastructure in real time using a software-defined network from a single centralised place. This helps network managers to optimise data flow and prioritise applications that demand higher availability.
- **Robust security** A software-defined network provides a more holistic picture of security threats by offering visibility across the entire network. With the rise of internet-connected smart devices, SDN provides apparent advantages over traditional networking. Operators can construct discrete zones for devices that require different levels of security, or quarantine compromised devices immediately to prevent them from spreading to the rest of the network.

1.1.2 SYN Flood Attack:-

A SYN flood (half-open attack) is a type of denial-of-service (DDoS) attack that uses all available server resources to make a server unavailable to genuine traffic. The attacker can overflow all available ports on a targeted server machine by continuously sending initial connection request (SYN) packets, causing the targeted device to reply to genuine traffic slowly or not at all.


Attacker
Open port. Waiting for 'ACK'.
Open port. Waiting for 'ACK'.
Open port. Waiting for 'ACK'.
Open port. Waiting for 'ACK'.
Visitor
Connections exhausted

SYN flood attacks work by exploiting the handshake process of a TCP connection. Under normal conditions, TCP connection exhibits three distinct processes in order to make a connection.

- First, the client sends a SYN packet to the server in order to initiate the connection.
- The server then responds to that initial packet with a SYN/ACK packet, in order to acknowledge the communication.
- Finally, the client returns an ACK packet to acknowledge the receipt of the packet from the server. After completing this sequence of packet sending and receiving, the TCP connection is open and able to send and receive data.

A SYN flood can occur in three different ways:

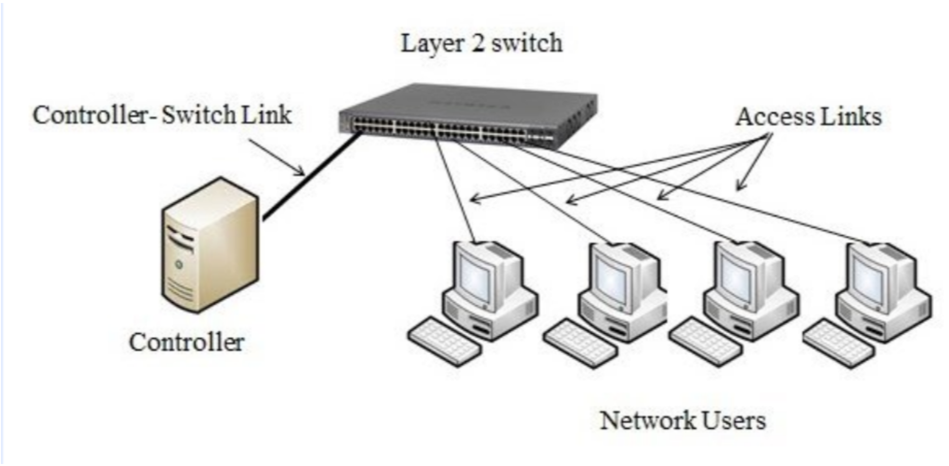
- **Direct Attack:** A SYN flood where the IP address is not spoofed is known as a direct attack. In this attack, the attacker does not mask their IP address at all. As a result of the attacker using a single source device with a real IP address to create the attack, the attacker is highly vulnerable to discovery and mitigation.
- **Spoofed Attack:** A malicious user can also spoof the IP address on each SYN packet they send in order to inhibit mitigation efforts and make their identity more difficult to discover. While the packets may be spoofed, those packets can potentially be traced back to their source.

- **Distributed attack (DDoS):** If an attack is created using a botnet the likelihood of tracking the attack back to its source is low. For an added level of obfuscation, an attacker may have each distributed device also spoof the IP addresses from which it sends packets.

For this project we only considered Direct SYN Flood Attack in Software Defined Networking

1.1.3 Saturation Attack:-

This attack is a consequence of scalability issues of OpenFlow. Typically a SDN switch has a set of flow rules installed by the controller and if a new flow is seen for which there is no flow rule, the switch sends a packet-in message to the controller asking for a new flow rule to handle this packet. To mount the attack, an adversary generate a flux of new flows potentially with spoofed addresses which hogs the bandwidth between the switch and controller. This can also overwhelm the controller and switches also become saturated as they have limited buffering ability.



A flow is defined with five attributes namely source and destination IP addresses, source and destination port numbers and layer four protocol. By changing one or more attributes in these fields an adversary can generate a flux of flows and generate the attack. As there are many attributes available for manipulation, the attack can be very easily generated with a program which can craft custom packets and send it.

In this Project we describe a method to detect and subsequently mitigate the control plane DoS attacks. Our proposed model has two sub-modules. The first one detects the attacks against control plane using anomaly detection technique and second one takes remedial action to mitigate the attack. In particular we make the following contributions in this project:-

- We describe an anomaly detection system to detect attacks against controller by modeling the packet-in messages as a probability distribution.
- We propose a method to mitigate the attack or minimize the effect of attack by throttling the bandwidth of the affected port proportinal to the intensity of the attack.

  Perform simulation experiments with Mininet to validate the proposed method.

1.2 Literature Survey

In this section, we present the related works on saturation attack detection and mitigation. The existing works majorly fall into following three categories.

1.2.1 Proxy-based Mitigation:

These works propose to add state information to the switches and convert them to proxies. AVANT-GUARD [13] described a data-plane solution to handle saturation attacks resulting from TCP SYN flood attacks. It proposes to use Connection Migration where the SDN switch acts as a proxy and handles the TCP 3-way handshake without maintaining state information. Only the flows completing 3-way handshake will be notified to the controller. It proposes to delay the notification till a valid data packet arrives on that TCP connection. Unfortunately this introduces another vulnerability called buffer saturation and also has significant limitations as shown by Ambrosin et al. [5]. Alternatively the Authors of [5] suggest to proxy the TCP connection probabilistically on per IP basis which they adopted in their design of LineSwitch to show that it required much less resources.

1.2.2 Anomaly based Detection:

These methods monitor the state of controller and take necessary action which are either in the form of blocking the source of attack or diverting the packets arriving to other switches or buffer them in the switch. Li et al. [8] propose an anomaly based detection system using the arrival patterns of incoming packet-in messages. They argue that the control plane traffic is self-similar and if an anomaly is detected the model installs a flow rule to redirect the packet-in messages to a cache. OFF-Guard [15] uses a threshold to detect saturation attack by counting the number of packet-in messages. FloodGuard [16] proposes to install proactive-rules to mitigate the attack by observing the controller status. FlowRanger [17] detects anomalies in the incoming packet-in messages and uses job scheduling technique to penalize attack sources. FloodDefender [12] installs a flow rule at the affected switch to detour attack flows to the victim's neighbor switches.

1.2.3 Source Validation:

These methods rely on the fact that spoofed source IP addresses are used for launching the saturation attack. Hence they initiate the validation of source addresses. Zhang et al [18] use this method and deploy verification on switches connecting to end hosts. FSDM [7] also invokes a verification method to validate the source IP address when the attack is detected.

From the above discussion, it is clear that proxy based methods require switch to be intelligent and track TCP state information. This requires additional resources at the switch. In addition successive packets may not flow in the same path, they may not be available at the same switch which makes these proxy schemes ineffective. Further source verification also requires maintaining similar state at the switch which can become bottleneck. Both proxy schemes and source verification techniques requires modification to switch functionality and add complexity. Taking motivation from this, we propose an anomaly based attack detection and mitigation technique in this paper.

1.3 Motivation for the work

Because of the programmable components involved, the idea of separating the control plane from the data plane in SDN delivers numerous benefits to the networking environment, but it also poses a number of obstacles. Security, dependability, load balancing, and traffic engineering are just a few of the concerns.

Denial of service (DoS) and distributed denial of service (DDoS) attacks are among the issues that SDN security faces compared to traditional networking security. DoS and DDoS assaults have become important computer network dangers in general. Several services are deactivated and the network's performance is lowered as a result of such attacks, which drain resources. When the attacker consumes resources that prevent hosts from using the targeted service, the attack is considered successful. Network-based tactics, such as flooding through TCP SYN, ICMP, or UDP packets, and host-based approaches, where one or more hosts target specific programmes to abuse their memory structure, authentication protocol, or a specialised algorithm, are examples of DoS/DDoS attacks.

Chapter 2

Design/Proposed Approach

2.1 SYN Flood Attack

Here we describe our proposed method for mitigating SYN Flood Attack in Software Defined Networking. We propose a method to detect the attack and subsequently describe a way to handle this.

2.1.1 SYN Flood Attack Detection and Mitigation

We have implemented a topology in which a switch is connected to a number of different hosts. Due to the fact that it is an SDN, the switch is connected to the controller. A monitor in our topology keeps a constant eye out for unusual patterns in the traffic. When our traffic monitor spots something out of the ordinary in the flow of traffic, it logs the event. After reading the logs, the controller will implement a flow rule that will prevent any communications from being sent from the attacker's IP address.

2.2 Saturation Attack

Here we describe our proposed method SaturationGuard for mitigating the control plane saturation attack. Precursor to the mitigation is the detection of attack. We propose a method to detect the attack and subsequently describe a way to handle this. We consider a reference architecture shown in the figure below to present our detection and mitigation methods. This has three SDN switches (can be any number), a controller, an attacker and a web server. Dotted lines in the graph indicate a logical connection between the switch and the controller and the normal lines indicate a direct connection. As mentioned earlier, every time a new flow (new combination of packet attributes) is detected the switch sends a packet-in message to the controller. In SaturationGuard the attack detection module runs on the controller and for mitigation it communicates an action to be taken to one or more switches. In the following two sub-sections the detection and mitigation techniques are elaborated.

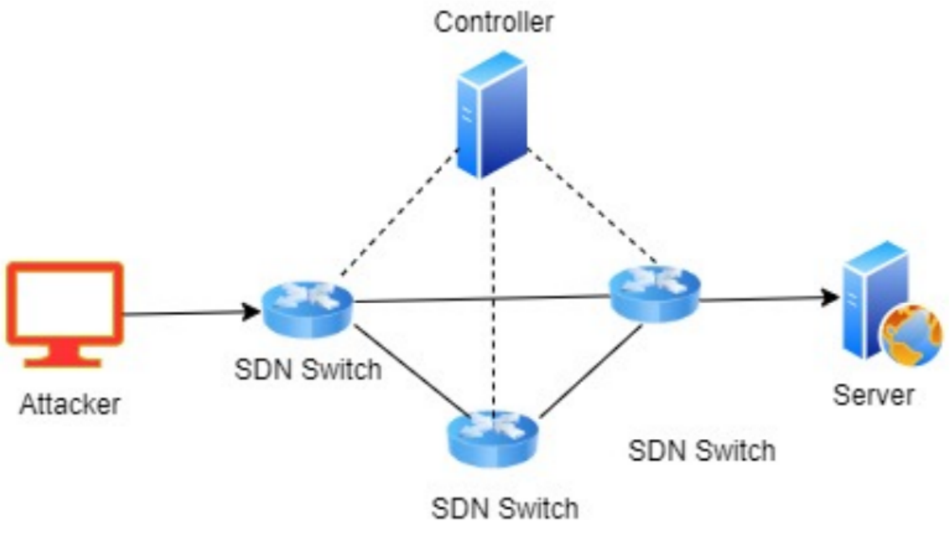


Fig. 1: Control Plane Saturation Attack Mitigation Setup

2.2.1 Saturation Attack Detection

In order to detect the attack, we model the communication between the switch and controller as seen in a normal condition. There are two ways to model this communication, first is where individual switches communication with controller is modelled and the second is modelling the aggregated communication of all switches. First one can not scale to large networks. Later one has the advantage of being simpler and one model suffices for the entire network. It serves our purpose as it does not matter whether the packet-in messages are coming from a single switch or many switches.

In SaturationGuard, we represent the arrival of packet-in messages as a probability distribution. The idea is to capture the probability or the likelihood of packet-in message ranges and identify the deviations. In particular, we model it as a Poisson probability distribution [10]. The choice of using this distribution is motivated by the fact that this distribution captures the average number of such messages in an interval and represent the normal behavior. We want to identify the abnormal behavior or deviations particularly large number of packet-in messages using this distribution.

Poisson probability distribution is a discrete probability distribution which uses mean number of events λ obtained from N observation intervals. In our case this is the number of packet-in messages as observed by the controller. The probability distribution function of Poisson distribution is given by Equation 1.

$$P(X = n) = \frac{e^{\lambda} \times \lambda^{n}}{n!} \tag{1}$$

In this equation, X is a discrete random variable, n is a non negative integer value. P(X = n) represent the probability of random variable X taking the value n. An important feature of this discrete distribution is that, the maximum probability value is around the mean λ. The probability value of random variable decrease on either side of mean. Figure below is a sample distribution generated with a λ value of 4.5. By taking the mean number of packet-in messages as seen in the controller, we generate a distribution and to detect the attack, we identify an event which has a low probability value with increased number of packet-in messages. The value of n at this probability will become the threshold for detecting the attack. If the number of packet-in messages are larger than this threshold number, saturation attack is detected. In order to set this threshold value, we use chebyshev's one sided inequality which is given by:-

$$P(X \geq \lambda + C) \leq \frac{\sigma^2}{\sigma^2 + C^2} \tag{2}$$

In Equation 2 σ is the standard deviation and C is a positive constant. We set this value of $\lambda +$ C as a multiple of λ i.e. $\gamma \times \lambda$ such that a major portion of the probability distribution is covered under normal case and rare events falling in the tail of distribution are detected as saturation attack.

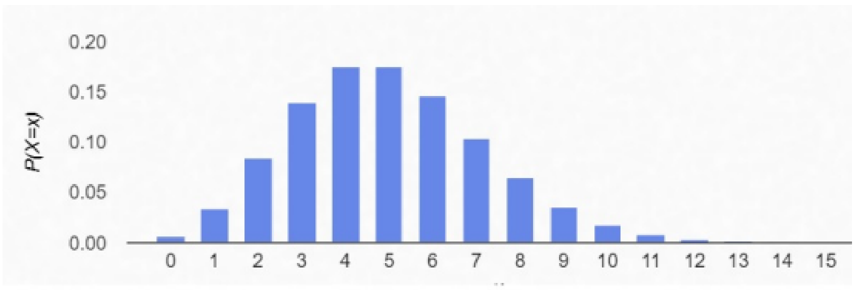


Fig. 2: Poisson Probability Distribution

2.2.2 Saturation Attack Mitigation

Once the attack is detected (by the method in the previous stage) the next step is to minimize the effect of the attack. There are many options one can think of. If the attack is generated using a single source (one source IP address) by modifying the other attributes like destination IP address, layer 4 port numbers, etc mitigation is very easy which is to just block that source. However if the attack is generated with spoofed address (which is likely the case), then blocking is not the solution. We propose to handle this by looking at the port number of switch from which the packet-in messages have originated and reduce the bandwidth of the particular port on that switch proportionately using traffic policing techniques. This we estimate by calculating a probability value which indicates by what factor the bandwidth needs to be reduced. The probability value is calculated as in Equation 3.

$$prob = 1 - e^{\frac{threshold - observed}{threshold}} \tag{3}$$

In this equation threshold is the value used to detect the saturation attack as calculated in the previous phase. SaturationGuard requires the bandwidth reduction to be proportional to the probability value calculated in Equation 3. The choice of Equation 3 is motivated by a similar use-case in handling network congestion with Random Early Detection [6] where the packets arriving at a router are dropped based on the queue length which indicate what fraction of the input queue is full. As the probability value ranges between 0.0 to 1.0 and there are infinitely many values in between. For easier handling, we divide the range for probability values into K blocks as shown in Figure 3. Depending on which block the probability value prob falls, the bandwidth of the port from which these packets are originating is throttled. This is done by defining different transmission rate corresponding to every block and setting the switch to operate at that rate. In the diagram low probability values indicate less aggressive transmission and probability value close to 1 indicate aggressive transmission. Thus if the value is above 0.8 which falls in the last block T5, transmission on that port is completely blocked for a fixed duration.

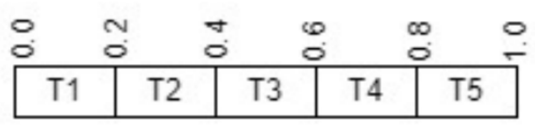


Fig. 3: Probability Ranges

Chapter 3

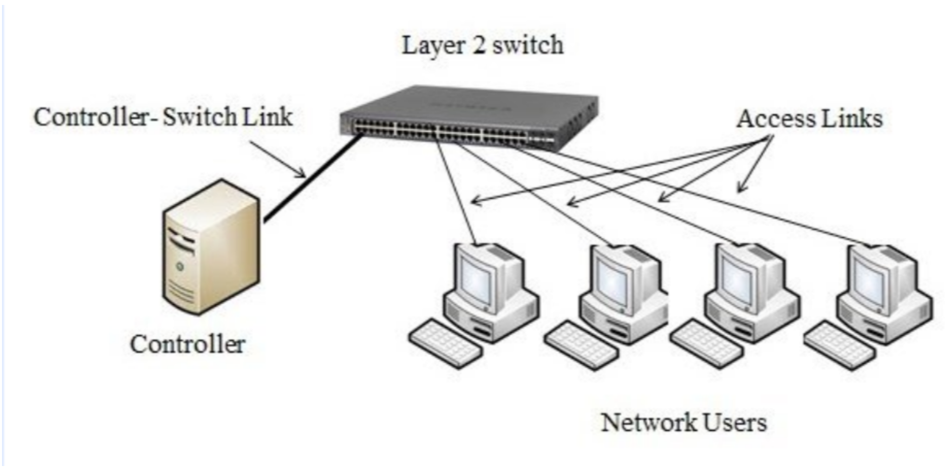
Experiments and Evaluation

In this section we describe the experimental setup and evaluations done with our proposed method SaturationGuard.

3.1 SYN Flood Attack

3.1.1 Experimental Setup

Mininet is going to be utilised so that we can simulate a Software-defined network. In our configuration, we will make use of a switch to connect a number of hosts to. The connection between this switch and a centralised controller established. In our configuration, one of these hosts will take on the role of Monitor. The topology is shown below.



3.1.2 Detection and Mitigation

First of all we will Mirror all of the traffic that is coming to our monitor from the switch (In our case we are using a host as a monitor). Snort is what we've chosen to use for our Intrusion Detection System. On the monitor, we need to configure Snort (an intrusion detection system) with the proper rules, and then we need to start the programme in the background so that it may continuously check traffic for unusual behaviour. We need to setup Snort so that it logs it in the log.txt file. We are using hping3 to mimic a SYN flood attack in order to test our defences. Hping3 is a highly powerful tool that not only enables the creation of packets from scratch but also has the capability of transmitting such packets at any frequency we choose. Python code that we wrote is currently being executed on the controller where it was stored. This script does a periodic go through of the Log files to look for potential attacks. After it has determined that an attack has occurred, it will take the attacker's IP address from the log file. After that, it utilises this IP address to locate the Attacker's port information. After we have identified the attacker's port, controller will apply a flow rule that will prevent any communication from coming from that port.

Our tests showed that our solution was capable of detecting and preventing SYN flood Attacks with a hundred percent degree of accuracy.

3.2 Saturation Attack

3.2.1 Experimental Setup:

We used two systems running Ubuntu 20.0 having 8 GB RAM with Intel i5 processor. In one of the machine we setup Mininet [2] emulator and in the other machine we setup pox controller. The controller was able to install flow rules in the Mininet switch. We designed a network topology with ten systems and emulated it in Mininet. The topology is shown in Figure 4. It has a SDN switch and all the hosts connect to this host in a star topology. In the diagram clients are denoted as Cn's and Servers are marked as Sn's. Out of five servers in two we ran web servers, other two were accessed with iperf tool and the remaining one is pinged by clients. In this setup all the servers also act as clients connecting to other servers. In our experiments, we limit the bandwidth between the switch and controller to 2 Mbps using Netem tool [3] installed on the controller.

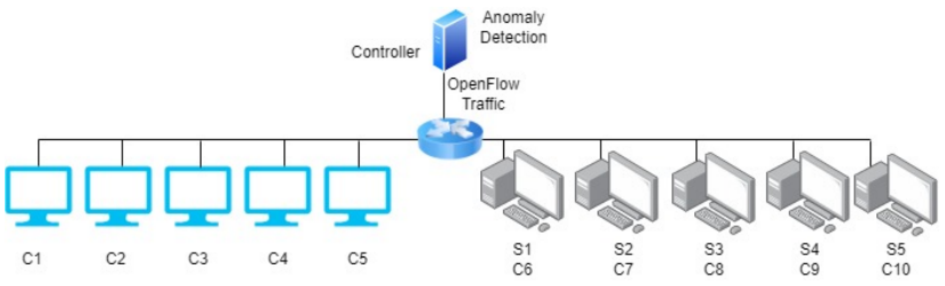


Fig. 4: Experimental Setup

3.2.2 Simulating the Normal Traffic

In order to mimic the normal operation in the network, we generated traffic by setting up interaction between different clients and servers. Algorithm 1 shows the connection and service accesses established. Every client randomly chose a server to connect to and establishes a connection request for some service and subsequently sleep for a random amount of time. These interactions between the systems generate some number of flows. The controller installs rules in the switch for those flows. We used a timer of 10 seconds for rule expiry after which the rule will be flushed from the switch. We collected the packet-in messages and calculated the average number of such messages in a window period of 5 seconds. Using this mean number (λ), we generated the probability distribution as shown in Figure 5. As the mean number of packet-in messages were around 30, the distribution graph has the highest probability at this value.

Algorithm 1 Generating Normal Traffic

```
Input: $\eta$ - Total Number of Servers
Input: $t_1$ and $t_2$: Minimum and Maximum Time Delay

1: while not interrupted do
2:     $K_1 \leftarrow$ RandomNumber(1,$\eta$)
3:     ConnectToServer($K_1$)
4:     AccessService($K_1$)
5:     $K_2 \leftarrow$ RandomNumber($t_1$,$t_2$ )
6:     Sleep($K_2$)
```

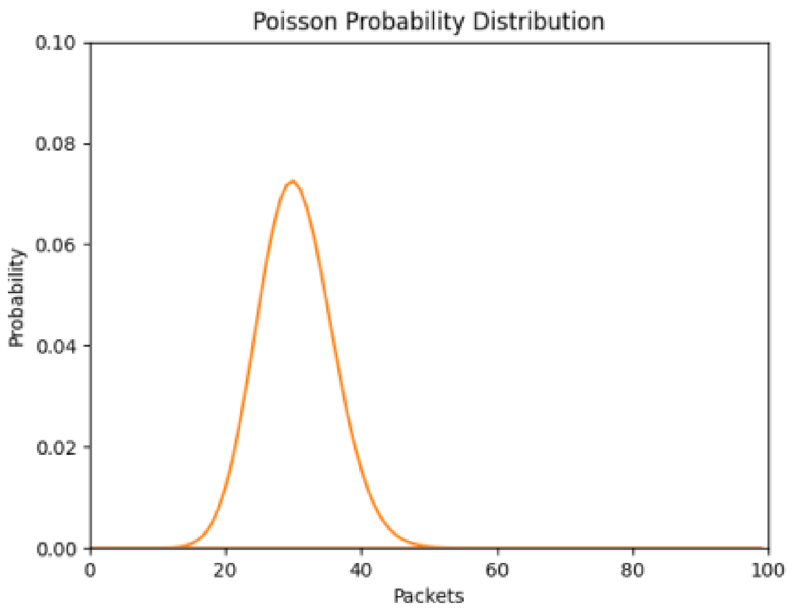


Fig. 5: Probability Distribution of Packet-In Messages

3.2.3 Generating the Saturation Attack

Saturation attack requires generating packets which belong to different flows such that each one of them results in a packet-in message to the controller. This can be generated by changing the source anddestination addresses, source and destination port numbers. We used a tool named hping3 [4] to generate the attack. This tool has the ability to send different packet types and using different protocol types. It can also send the packets by randomizing the source and destination addresses.

3.2.4 Impact of Attack on Controller CPU Utilization

We generated the attack by sending packets with random addresses (source and destination) from client C1 with different intensity by scheduling the time delay between successive packets in hping3. These packets generated packet-in messages to the controller. We measured the CPU utilization on the controller when the attack was on. Figure 6 shows the variation of CPU utilization with attack intensity. The X axis in the graph shows the number of packets per second and Y axis is the percentage of CPU utilization. We can notice that, as the attack intensity increases the CPU utilization also increases almost linearly and saturates at about 500 packets per second rate nearly with 100This observation is consistent with other works [16].

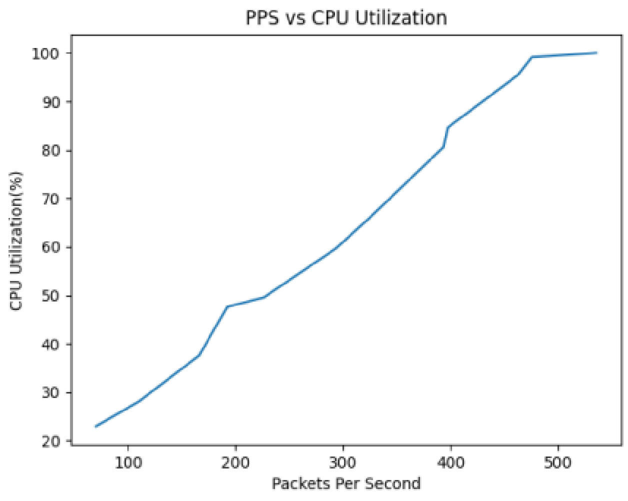


Fig. 6: CPU Utilization

3.2.5 Impact of the Attack on RTT

In order to assess the impact of the attack on the communication of other hosts connected to the switch, we measured Round Trip Time (RTT) variation with attacks of different intensity. In particular two client machines (C2 and C3) and one client (C4) and server machine (S1) connected to the switch. This we measure with and without SaturationGuard. For the attack detection we use a probability threshold which is 20 times the mean (). Figure 7 shows this variation of RTT values. We can notice that till the saturation point is reached the RTT values are very low and more or less constant and when the saturation occurs (which is about 500 PPS) the RTT values increase significantly in the absence of SaturationGuard. The low RTT values even when the attack is on is due to the fact that, a small amount of bandwidth available at the switch is good enough to establish a communication. When the saturation attack is peaked, the switch is no longer able to handle the new flows that's when the RTT increases significantly. However, when the proposed mitigation method is used, the RTT values are still maintained around the same range as in the previous case. This is becuase SaturationGuard throttled the bandwidth (using traffic policing techniques) of the corresponding input port early on which enabled the flows corresponding to RTT measurement handled successfully.

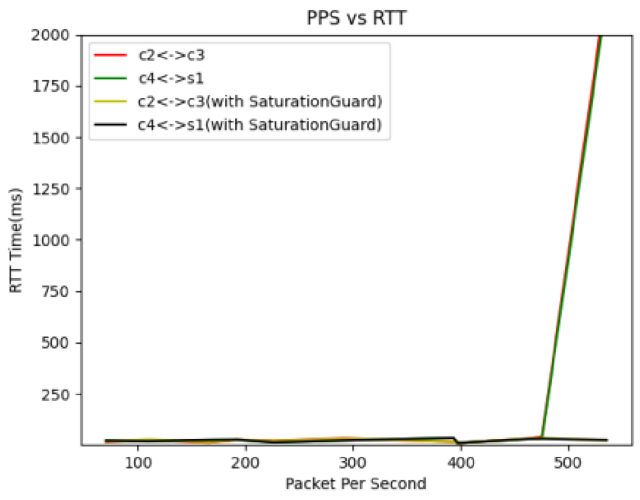


Fig. 7: RTT Variation with Attack

3.2.6 Availability of Bandwidth

SaturationGuard throttles the bandwidth of the affected switch based on the intensity of the attack. In order to assess the impact of this when the saturation attack is on, we conducted a study by measuring the available bandwidth between the switch and the controller. We measure this bandwidth by successively generating the attack with different intensities as in the previous case. Figure 8 shows the variation of available bandwidth between switch and controller. We can notice that for lower intensity attacks the available bandwidth difference is small, however as the attack intensity increases, SaturationGuard preserves the available bandwidth between switch and the controller and the difference is significant. This is due to the fact that SaturationGuard throttles the bandwidth proportionate to the attack intensity. For higher intensity attacks, the rate of throttling is also higher which preserves bandwidth between the switch and the controller.

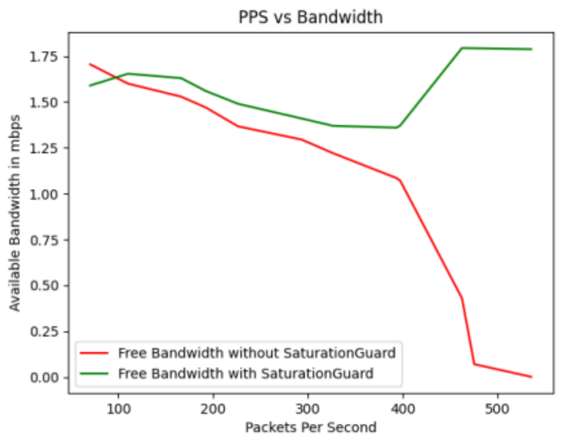


Fig. 8: Bandwidth Available between Switch and Controller

3.2.7 Impact of Detection Threshold on Attack Detection Time

It is worth noting that probability threshold used for detecting the attack determines when the attack is detected. If the threshold is too small, then the attack is detected quickly and bandwidth is throttled quickly. On the other hand if the threshold is high then the attack is detected very late and by that time the attack might have caused significant damage. We study the sensitivity of threshold on the latency in the attack detection. For this we fixed the attack PPS at 500 and measured the delay in the detection of attack i.e. first throttling of bandwidth by varying the threshold used for detecting the attack between 10 times of */lambda* to 80 times of the */lambda*. Figure 9 shows the variation of delay in detecting the attack. We can notice that as the probability threshold increases the delay also proportionately increases.

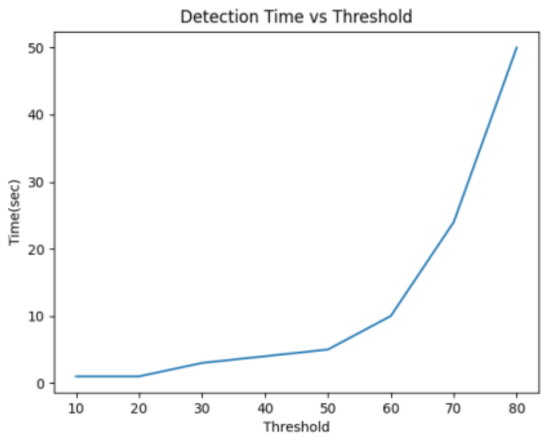


Fig. 9: Attack Detection Time Variation with Threshold

3.2.8 Impact of Blocking the Switch Port

When the attack intensity is very high then the probability of throttling will be close to 1. This in our case is mapped to blocking the port(s) of impacted switch(es). Once a port is blocked, it is blocked for a duration of 30 seconds. Subsequently even if the source is continuing with the attack those packets will not impact the controller. Infinitely blocking a port is not a feasible solution either. In order to validate how a continuous high intensity attack is handled by SaturationGuard, we performed an experiment by flooding the switch with randomly generated flows. As the rate is quite high, it triggered blocking of the port. Figure 10 shows (few initial seconds) the on-off periods during which there were some packet-in messages generated or not to the controller. We can see that when the attack is detected for the next 30 seconds there is no communication (indicated with blank) generated and once the port is unblocked the communication is restored for a very short duration of 2 seconds. This is the time lag for detecting the attack at the threshold which is 20 times the mean as seen in Figure 9.

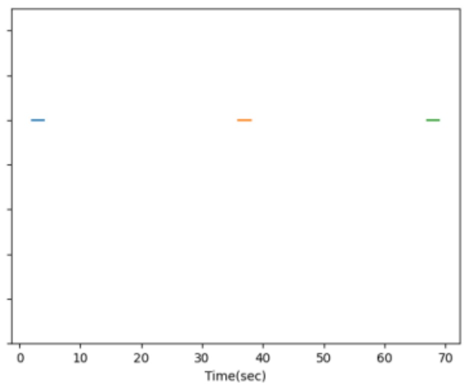


Fig. 10: Port Active Time with Flooding

3.2.9 Collateral Damage of SaturationGaurd

The proposed solution SaturationGaurd can be easily used with switches deployed at the edge of the network where the hosts directly connect to the switch. In this deployment scenario there is no collateral damage of blocking the port of the switch. However, when the packet-in messages are observed from a switch located in the backbone of the network then blocking a port can cause collateral damage impacting other communications passing through that port. We argue that, this is a rare case and happens when the intensity is very high. Otherwise bandwidth throttling at the worst will reduce the available bandwidth to other communications as well. In addition, if the solution is used with every switch it is the edge switch which is likely to report all the packet-in messages rather than a switch in the backbone. In order for a switch in the backbone to generate these many packet-in messages, an adversary has to intelligently craft an attack such that switches at the edge do not generate packet-in messages, which we believe is not easy to achieve.

Chapter 4

Conclusion

Saturation attack chokes the communication between a SDN controller and switch by sending large number of new flows. This can cause Denial of Service to other legitimate traffic and services as these connections are affected. In this paper, we described the working of SaturationGuard which can mitigate the effect of such attacks by throttling the rate of transmission at the affected switches. An anomaly detection system running at the controller observes the rate of arrival of packetin messages and detects the attack. By identifying the infected ports of switch, it throttles the bandwidth available at the switch in proportion to the attack intensity. We implemented and evaluated a working prototype of SaturationGuard with Mininet and an external controller.

A DoS or DDoS attack poses a significant risk to the resources and availability of a network. It is extremely crucial for any company or organisation to be able to identify and stop these kinds of attacks. DoS and DDoS attacks can be detected and mitigated in the SDN, as shown in our demonstration.

Chapter 5

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