Smart and Lightweight DDoS Detection Using NFV

Autores: Talal Alharbi, Ahamed Aljuhani, Hang Liu, Chunqiang Hu

The Catholic University of America

Resumen del paper: Fernando Ostolaza, Milagros Oyague, Gabriel A. Spranger

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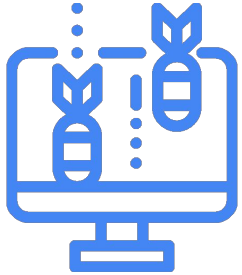

1. Conceptos clave
    a. DDoS
    b. NFV
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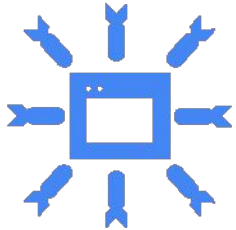
Conceptos clave

DDoS



Es una amenaza a la infraestructura de red que llevará a uno de lo siguientes escenarios:

- Causará interrupción de los servidores y servicios de dicha red.

- Hará que no estén disponibles para usuarios legítimos.

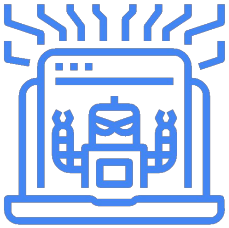
NFV

- Se utiliza para virtualizar servicios de red que tradicionalmente se hace en hardware específico con software específico.

- Se empaqueta como VM en hardware básico, pero no necesita uno exclusivo para cada función de la red.

- Mucho más flexible, fácil de configurar.

Botnet



- Red de dispositivos infectados
- Realizan tareas automatizadas
- Buscan infectar más dispositivos

Objetivo del paper

Smart and Lightweight DDoS Detection Using NFV

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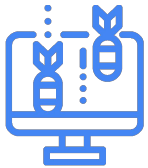
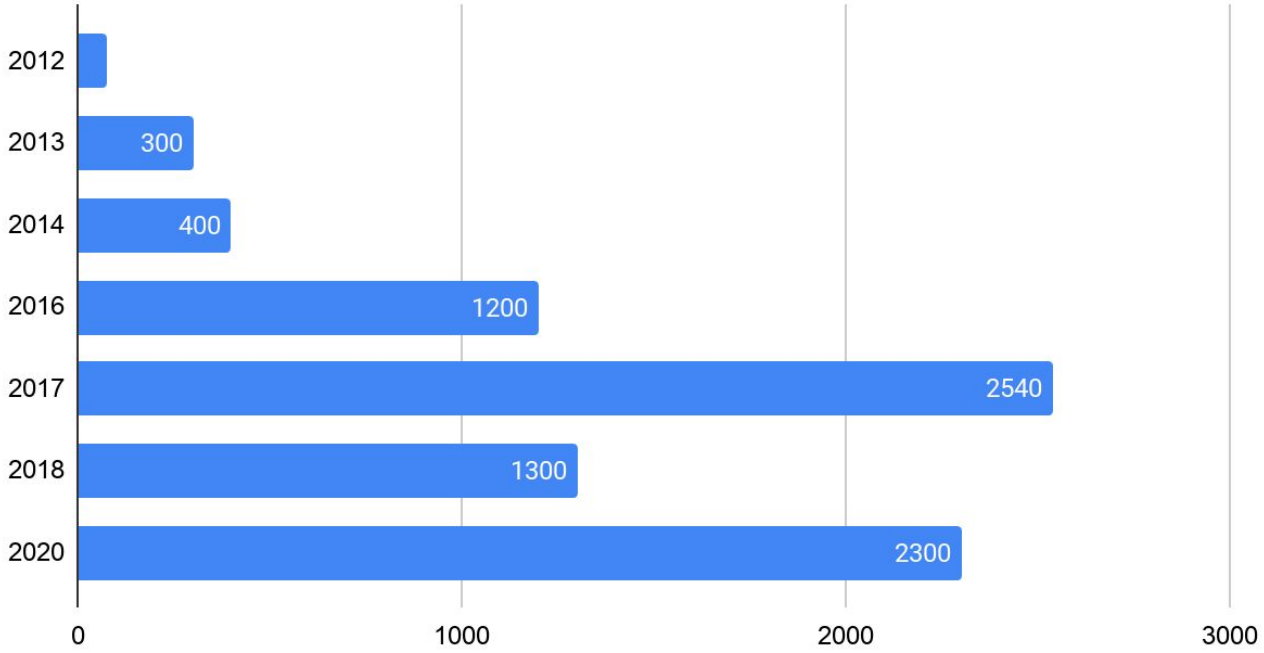
Proponer una solución para...

- Detectar ataques de DDoS mediante distintas técnicas
- Diferenciar tráfico real de tráfico de ataque



Tendencias en ataques DDoS basadas en Botnets

Tráfico Generado (GBPS)

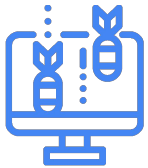


25% del tráfico de botnets viene de dispositivos IoT

Detección de DDoS

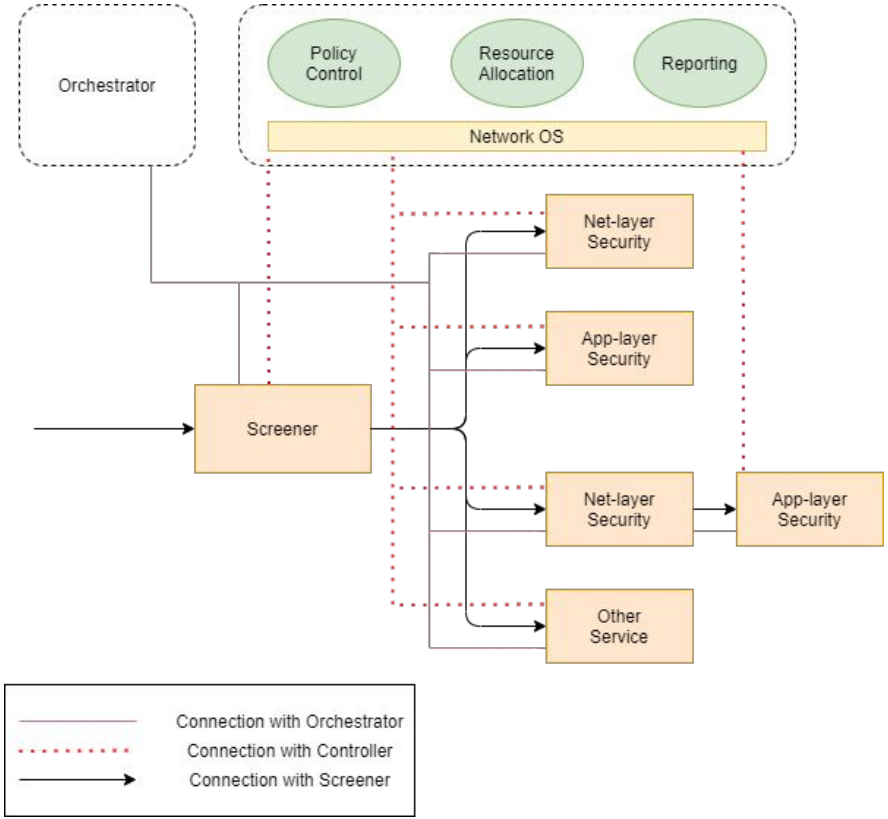
Métodos Relacionados

Método	¿En qué consiste?	Limitaciones
Estadístico	- PCA feature selector - Análisis de tasa, paquetes y protocolo de ataque	- Detecta en near real-time en lugar de real time - Puede causar latencia
Packet sampling	- Categoriza y mide el flujo de entropía de paquetes (uno de cada cinco) - Compara con umbrales (de puerto origen y de paquetes/seg)	- Falta de detección temprana - No menciona la precisión
Detección temprana	- Utiliza entropía para medir la aleatoriedad en los paquetes entrantes - Calcula con umbrales	- No proporciona cómo distinguir entre tráfico legítimo e ilegítimo
Mitigation	- Basado en intervención humana por una lista negra de source IP para filtrar el tráfico	- No puede proteger contra las spoofed source IPs

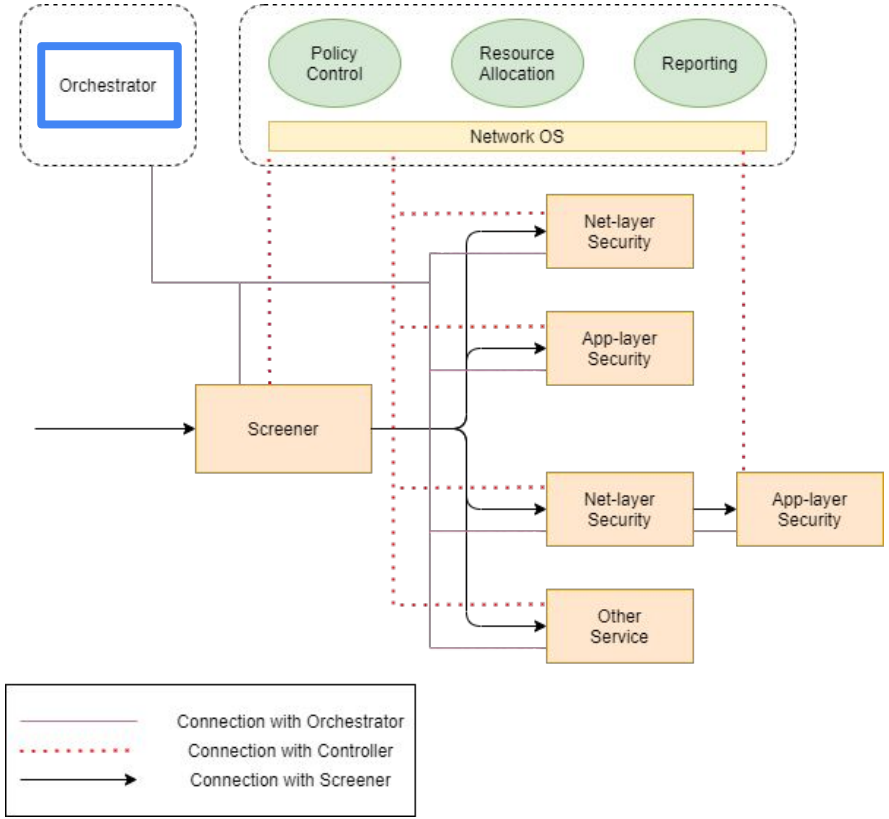


Método Propuesto

Componentes

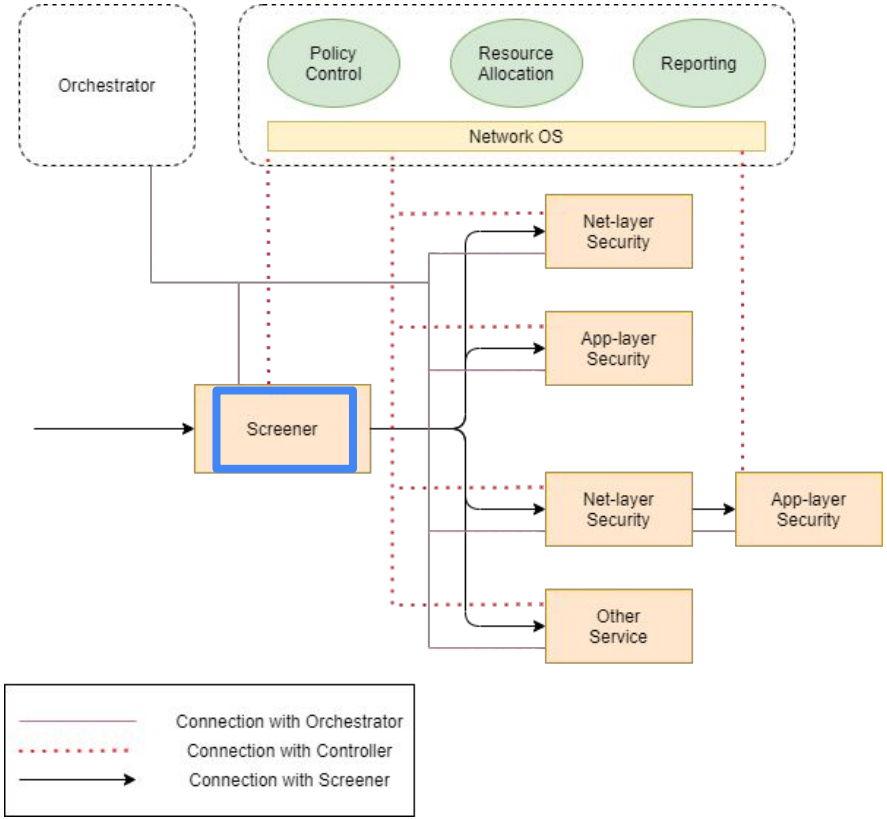


Orchestrator



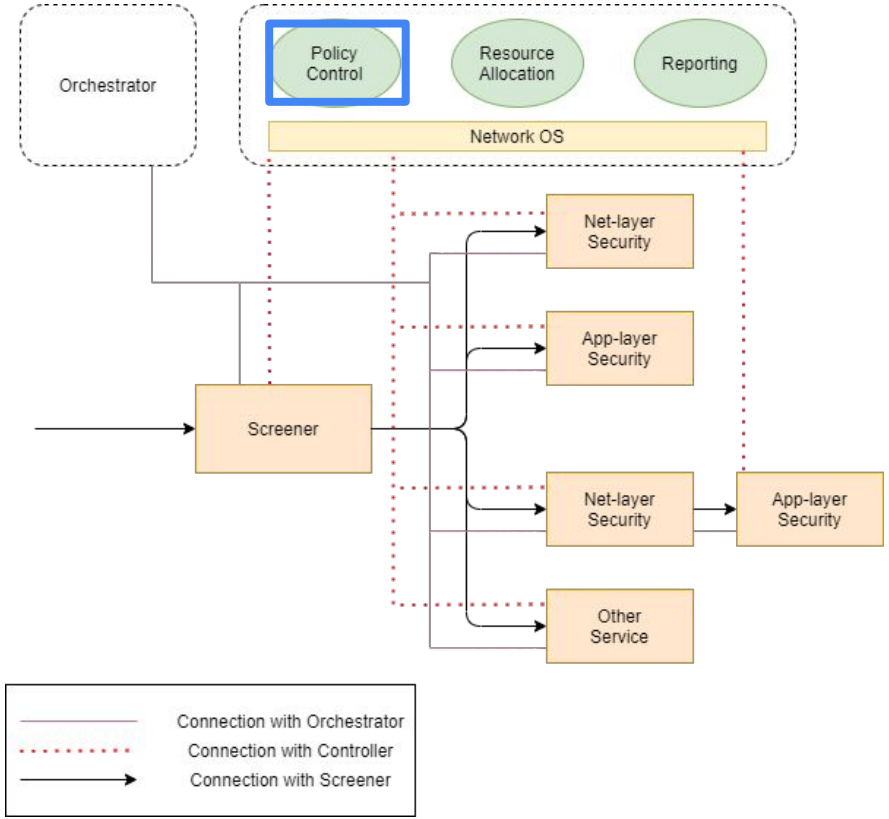
- Se encarga de la escalabilidad y asignación de recursos en tiempo real.
- Maneja todos los componentes (network functions).

Screener



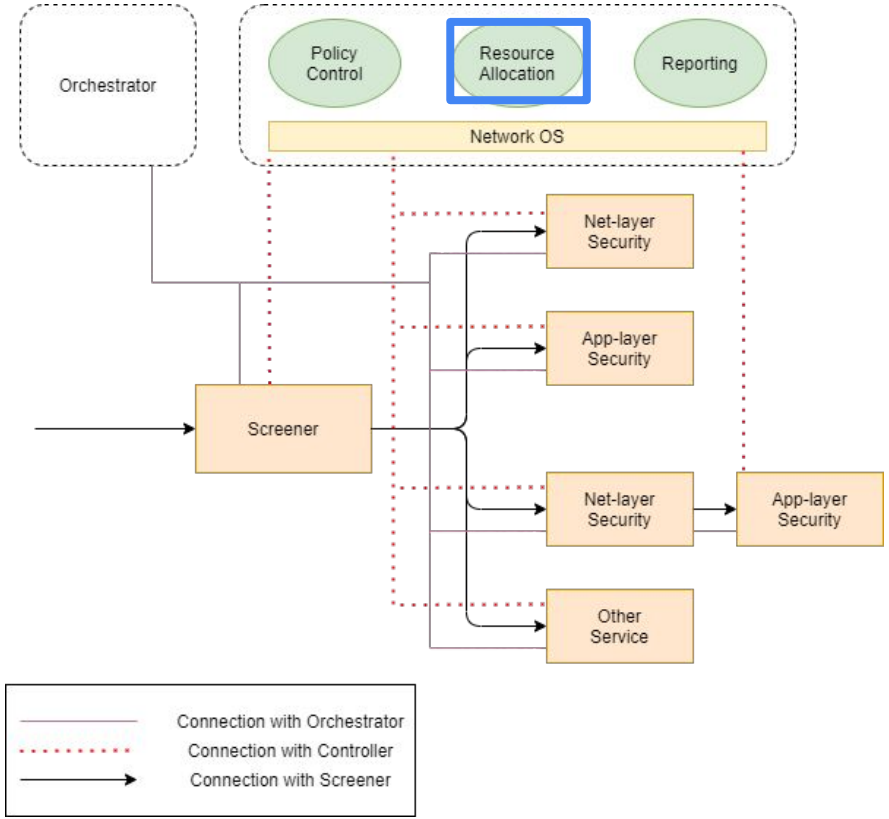
- Analiza el tráfico.
- Usa algoritmos para clasificar el tráfico.
- Toma ciertas acciones dependiendo de la clasificación.

Controller: Policy Control



- Se definen reglas para filtrar el tráfico.
- Se definen umbrales que el screener usa.

Controller: Resource Allocation Protocol



- Protocolo para que el screener se comunique con distintos network functions.

Algorithm 1 Resource Allocation Protocol (RAP)

1: **input:** Service_ID and M, // M is maximum capacity

2: calculate $U = \frac{C}{M}$ // U: used resource, C: current resources

3: **if** $U \geq 70\%$

4: {send alert_message to the screener,

5: send alert_message to the reporting module}

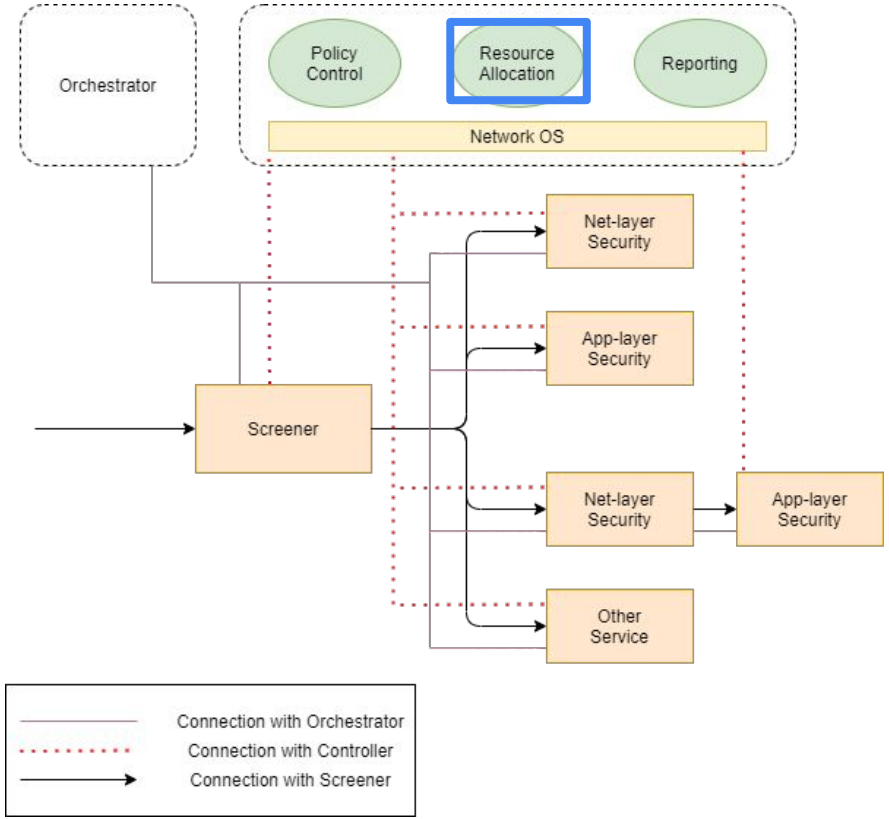
6: **else if** $U \leq 30\%$

8: {send alert_message to the screener,

9: send alert_message to the reporting module}

8: **end if**

Controller: Resource Allocation Protocol



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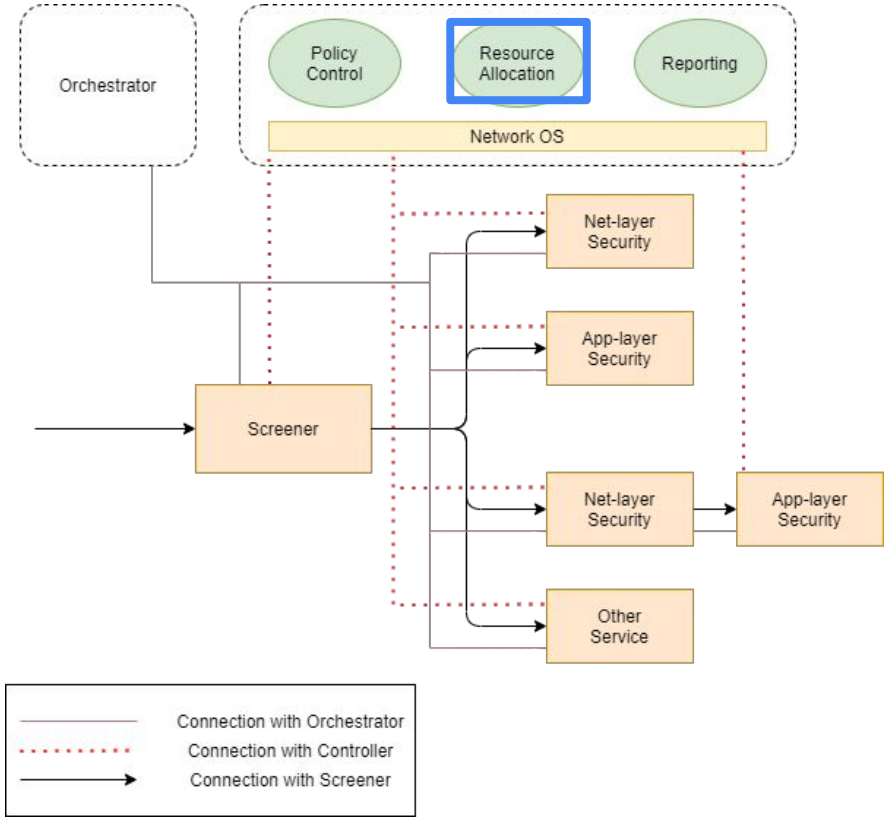

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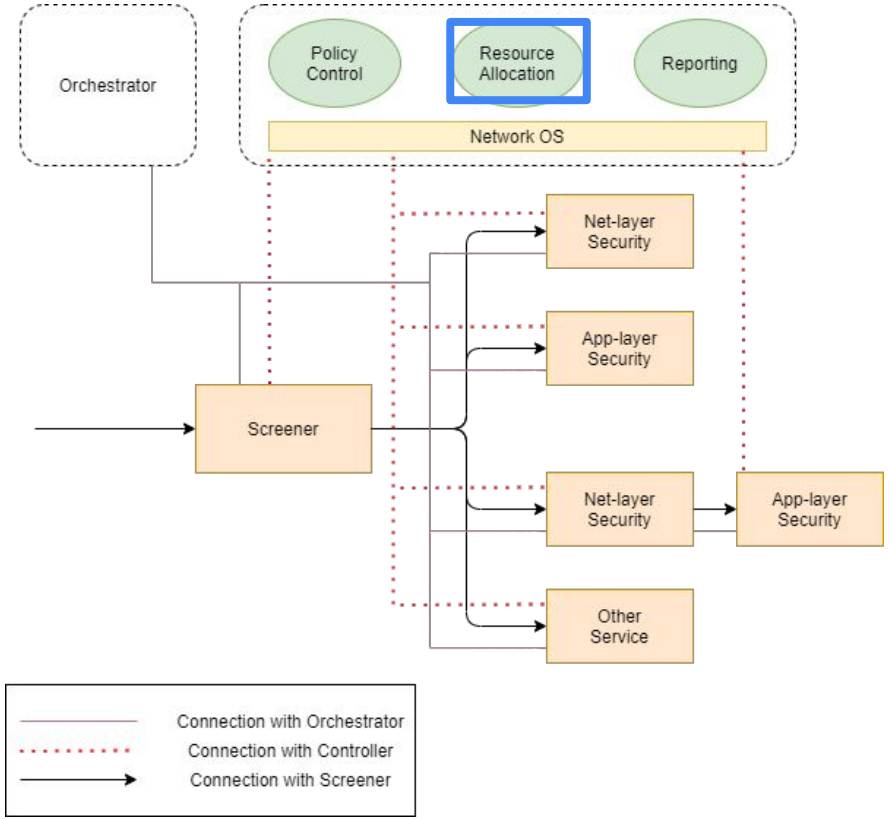

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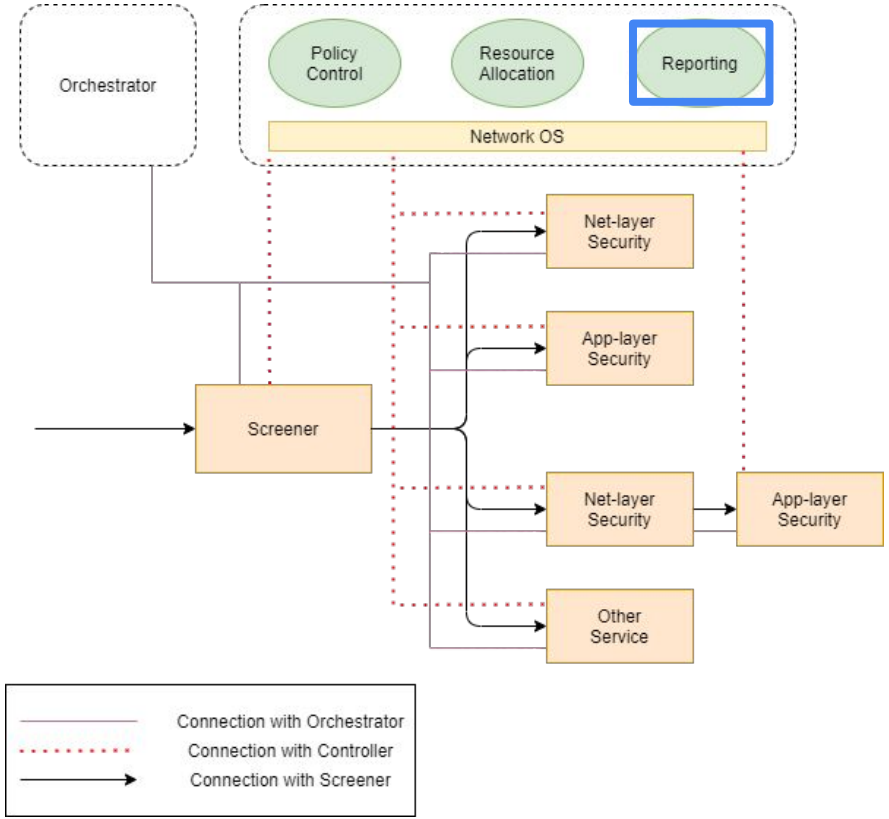
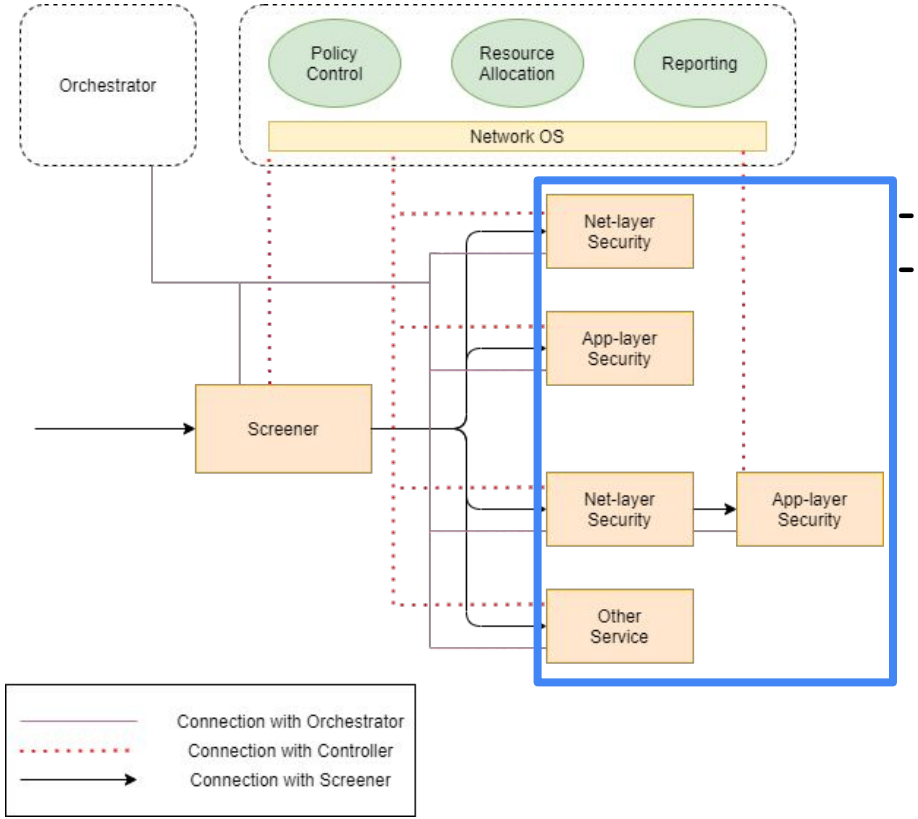
Controller: Reporting



- Guarda todas las acciones y todos los mensajes hechos dentro del sistema.
- Todo lo pone en un log file.

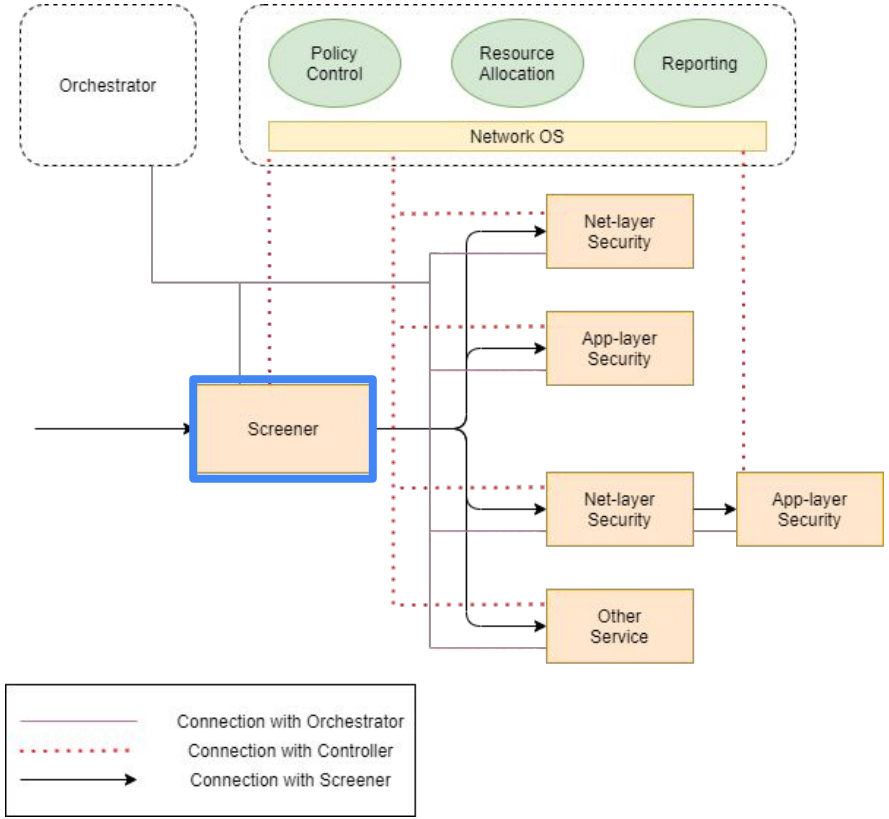
Layers



- Ofrecen los servicios de seguridad.
- Actúan de acuerdo a lo que el screener detecta con sus algoritmos.

Mecanismos de detección

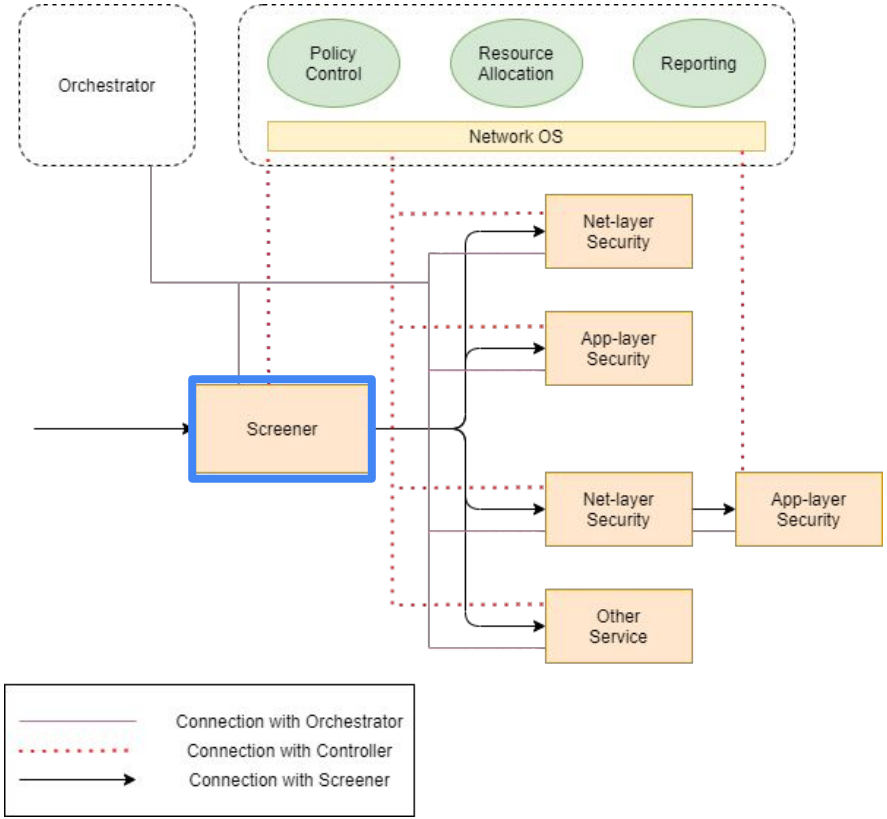
Screening



- Fast Screening
- Deep Screening

Fast Screening

$$traffic\ rate = \frac{No.\ of\ packets}{No.\ of\ seconds}$$



Algorithm 2 Fast Screening algorithm

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1:  input: n: normal rate range
2:  calculate tr // tr: incoming traffic rate
3:  if tr > n
4:     {return  true,
5:      send a message to the reporting module}
6:  else if alert_message with flag=W
7:     if  Service_ID ==VNF
8:           {return  true,
9:           send a resource modification request to Orchestration,
10:             send a message to the reporting module}
11:    else if Service_ID ==VSF or Service_ID == Screener
12:                    {send instantiation or resource
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14:    end if
15: else if alert_message with flag=S
16:           {send a resource modification request to
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18:  else
19:    {return false
20:    capture next packet window}
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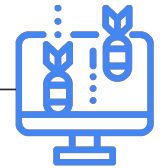

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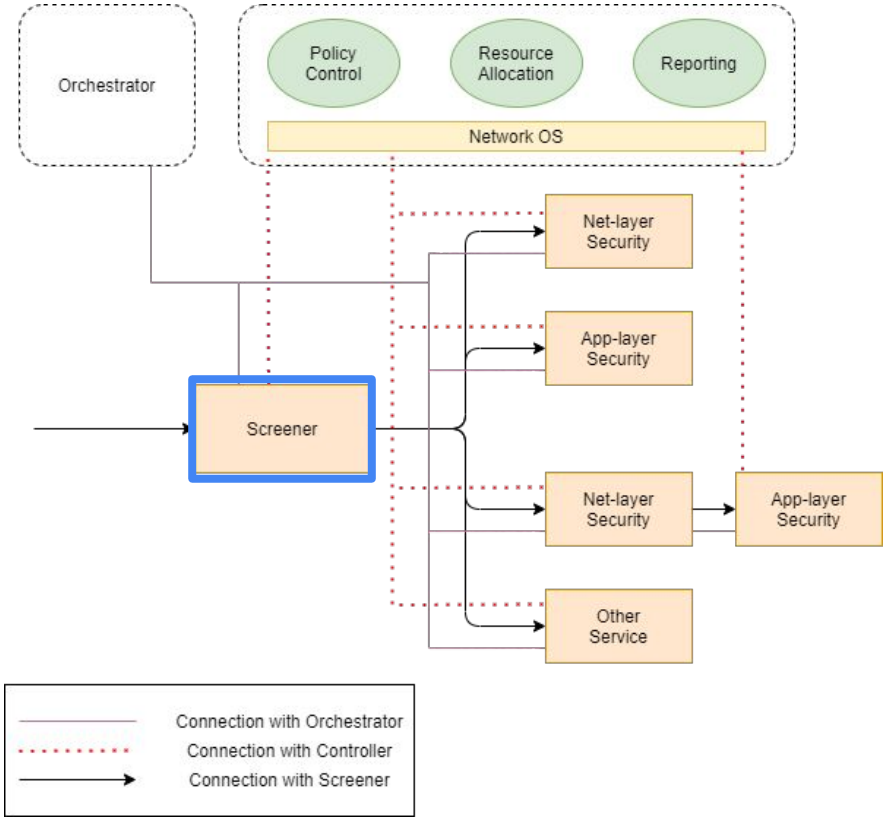

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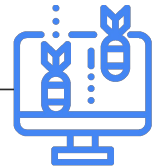

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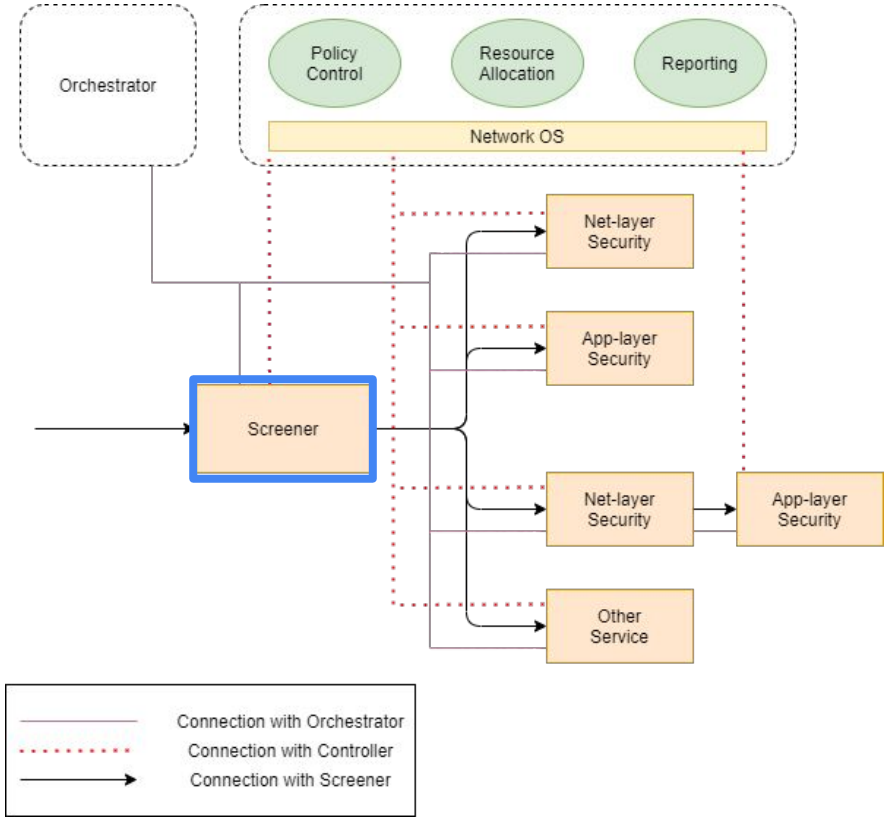

Service_ID: ID de la VM
VNF: Virtual Network Function

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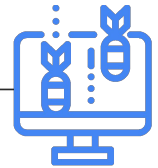

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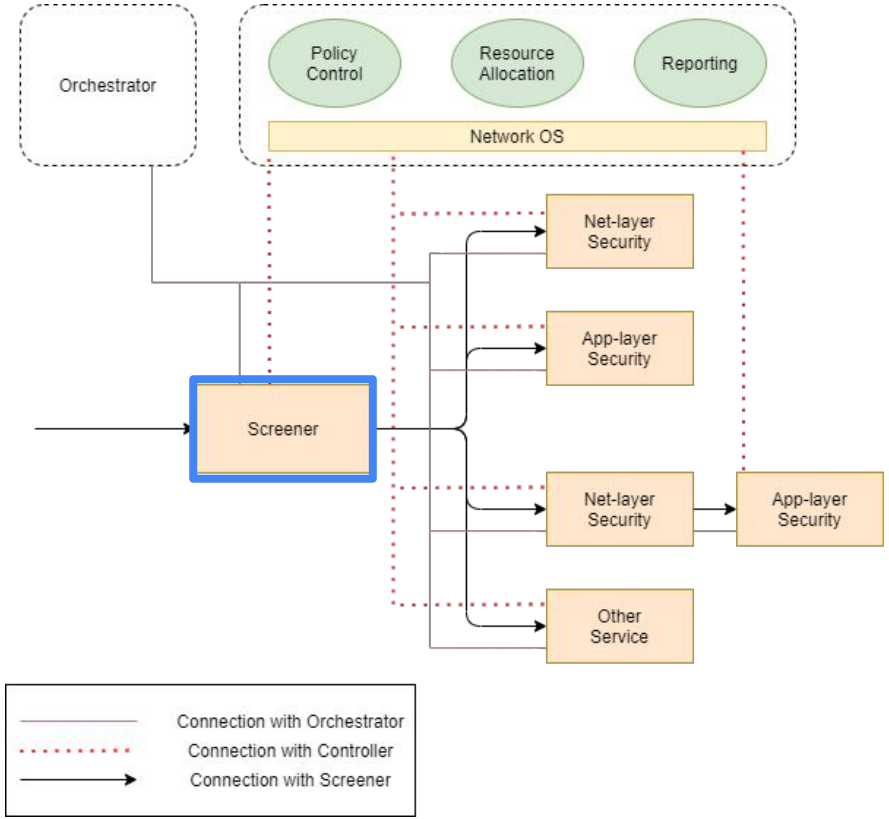

VSF: Virtual Security Function

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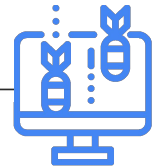

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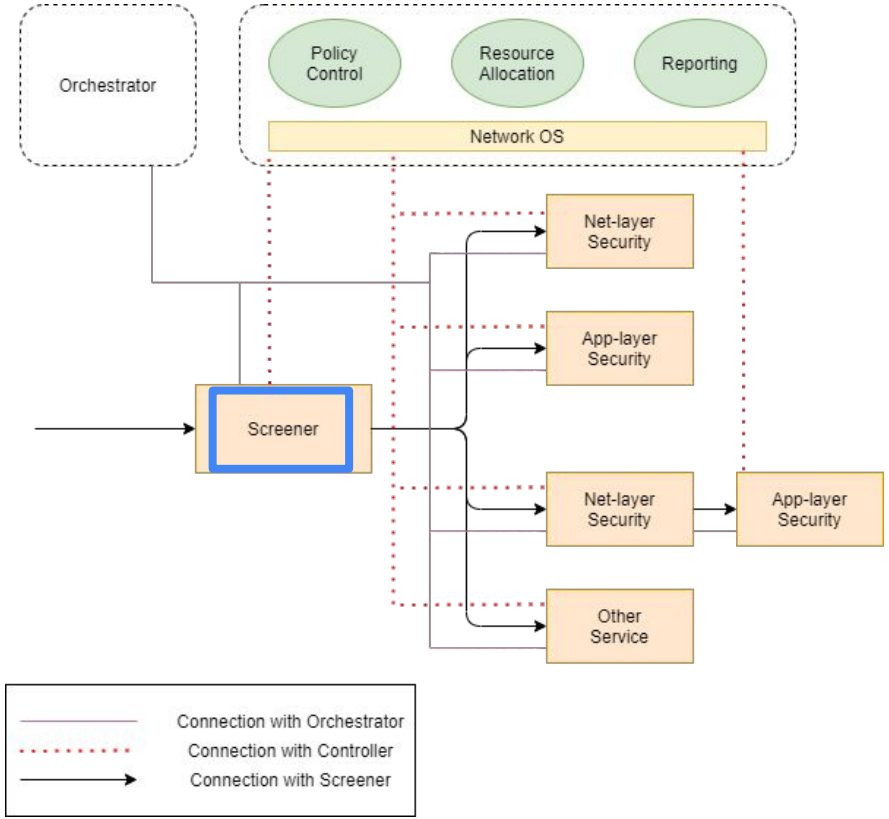

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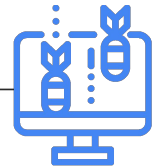

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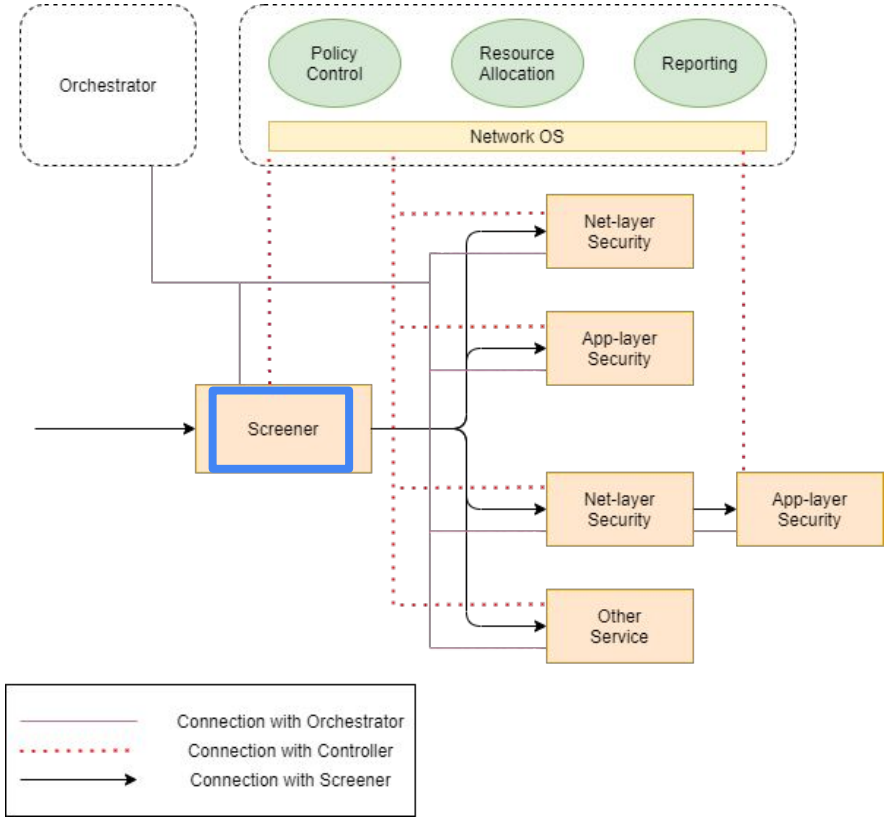

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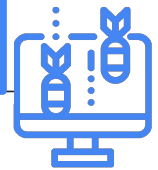
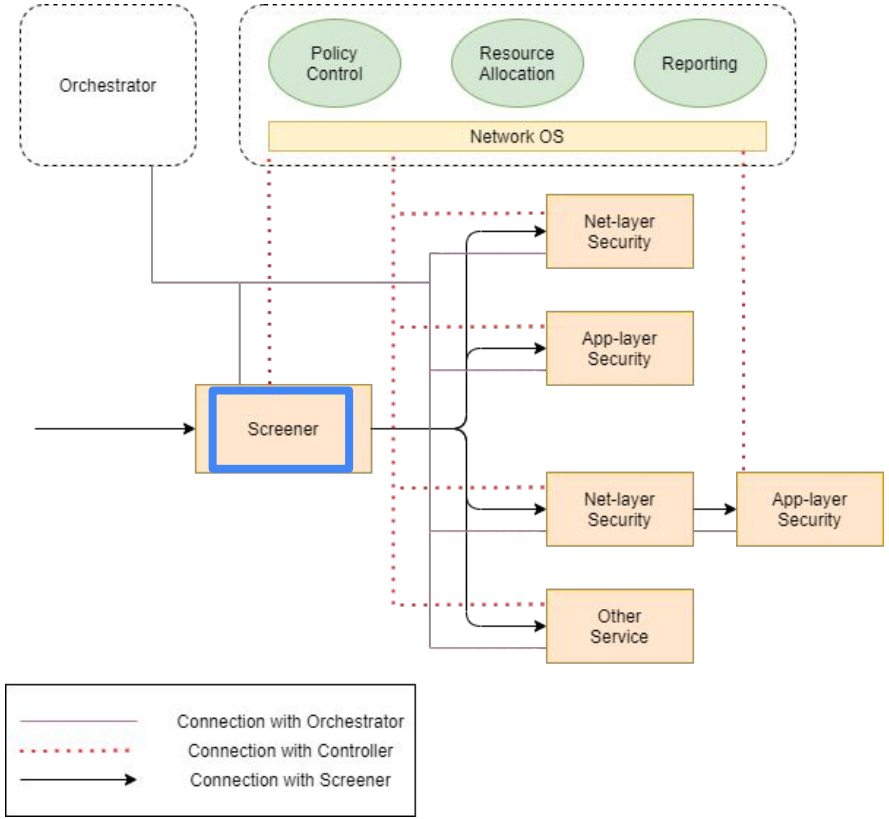


Deep Screening



- Solo se ejecuta si el **tr > promedio** o si se detecta un mensaje con el **flag=W.**
- Distinguir entre tráfico elevado benigno o maligno.
- Un tráfico elevado tiene varias posibles causas.
- Uso de algoritmos para detectar distintos ataques.

Algoritmos de Deep Screening

Algoritmo: Amplification Attack

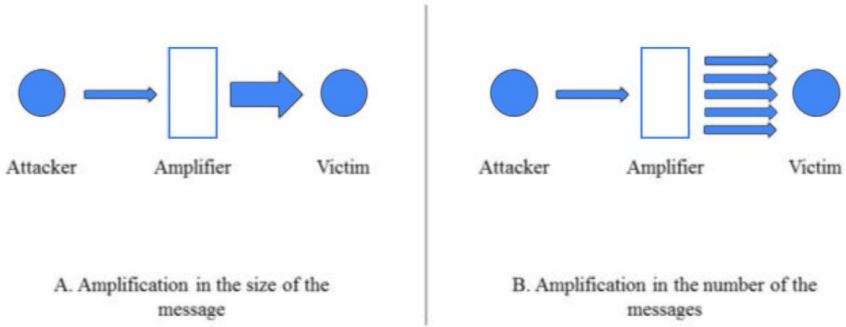


Figure 2. Types of DDoS amplification attacks.

Amplifica un mensaje inicial.
Dos tipos: cantidad y tamaño.
Uso de servidores como los DNS o NTP.

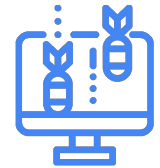
Algoritmo: Amplification Attack

Algorithm 3 Amplification in message size attack check

```
1: input: Server_IP // Server that reached the warning limit
2: while VNF is still drowning do
3:   for every incoming UDP packet
4:   if packet IP destination == Server_IP && packet_size >
     threshold
5:       if source_port==53 //DNS amplification
6:         DNS++
7:       elseif source_port ==123 //NTP amplification
8:         NTP++
9:       elseif source_port ==161 // SNMP amplification
10:        SNMP++
11:      elseif source_port ==1900 //SSDP amplification
12:        SSDP++
13:      end if
14:   end if
15: end for
16: for Amp_set
17:   if any element> threshold
18:     call mitigation
19:   else
20:     benign packets
21:   end if
22: end for
```

Amp_set {DNS,NTP,SNMP,SSDP}.

- Server_IP sería la IP de la VM que mandó el mensaje con flag=W mediante RAP.



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5:       if source_port==53 //DNS amplification
6:         DNS++
7:       elseif source_port ==123 //NTP amplification
8:         NTP++
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10:       SNMP++
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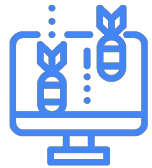
12:        SSDP++
13:      end if
14:   end if
15:  end for
16: for Amp_set
17:   if any element> threshold
18:     call mitigation
19:   else
20:     benign packets
21:   end if
22:  end for
```

Amp_set {DNS,NTP,SNMP,SSDP}.

- Mientras el VNF siga con una alta utilización de recursos, se analizan los paquetes UDP.



Algoritmo: Amplification Attack

Algorithm 3 Amplification in message size attack check

```
1: input: Server_IP // Server that reached the warning limit.
2: while VNF is still drowning do
3:   for every incoming UDP packet
4:    if packet IP destination == Server_IP && packet_size >
      threshold
5:        if source_port==53 //DNS amplification
6:          DNS++
7:        elseif source_port ==123 //NTP amplification
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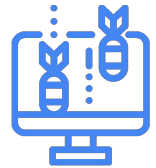
```

Amp_set {DNS,NTP,SNMP,SSDP}.

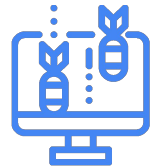
- Para cada tipo de servidor, contar paquetes que cumplieron criterio.
- Mayor a umbral, significa que hay un DDoS.



Algoritmo: Reflection Attack

Algorithm 4 Reflection attack check

```
1:  input: Server_IP // Server that reached the warning limit.
2:  while VNF is still drowning do
3:      for every incoming packet
4:          detect source_IP range (subnet)
5:              if packet IP destination == Server IP &&
                source_IP_address within same subnet
6:              call mitigation
7:          else
8:              legitimate packet
9:          end if
10:     end for
```



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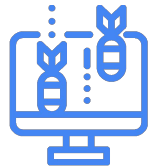
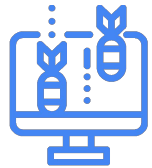


Algoritmo: Volumetric Attack

Algorithm 5 Volumetric attack check

1: **input:** Server_IP // Server that reached the warning limit.
2: **while** VNF is still drowning **do**
3: **for** every incoming packet
4: **if** packet = = TCP
5: **for** every TCP connection
6: TCP_set{ SYN++ , ACK ++}
7: **end for**
8: SYN_rate = $\frac{No.of\ SYN\_packets}{No.of\ seconds}$
9: ACK_rate = $\frac{No.of\ ACK_{packets}}{No.of\ seconds}$
10: **for** TCP_set
11: **if** any element is in linear or exponential increase
12: call mitigation
13: **else**
14: benign packets
15: **end if**
16: **end for**
17: **end if**



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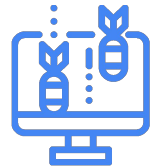

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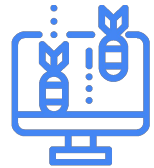

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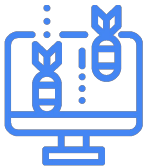

Algoritmo: Volumetric Attack

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18:   if packet==UDP
19:       if packet_size > threshold // check for UDP Garbage
          flood
20:       Garbage++
21:       elseif destination_port==53 //DNS amplification
22:         DNS++
23:       elseif destination_port==123 //NTP amplification
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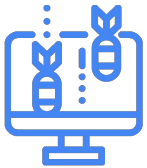

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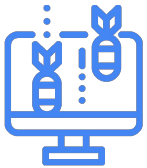

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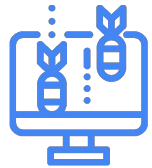
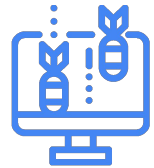


Algoritmo: Volumetric Attack

38: **if** packet==ICMP
39: ICMP++
40: **end if**
41: ICMP_rate = $\frac{No.of\ ICMP_{packets}}{No.of\ seconds}$
42: **if** ICMP_rate is in linear or exponential increases
43: call mitigation
44: **end if**
45: **end for**



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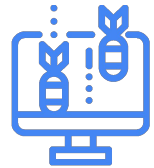
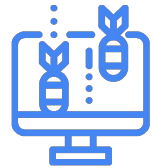


Algoritmo: High rate application attacks

Algorithm 6 High-rate attack check

```
1:  input: Server IP // Server that reached the warning limit.
2:  while VNF is still drowning do
3:  for every TCP incoming packet
4:    for every source_ IP
5:      Http_flood{http_get++, http_post++}
6:    end for
7:  end for
8:  for Http_flood
9:     if any element> threshold
10:     return true //call mitigation
11:   else
12:     return false //benign packets
13:   end if
14:  end for
```

Http_flood{(source_IP, http_get++), (source_IP, http_post++)} contains the total number of packet_requests per IP_source address.



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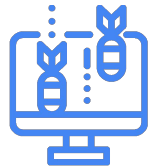

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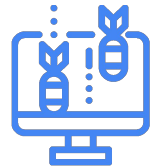

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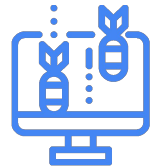
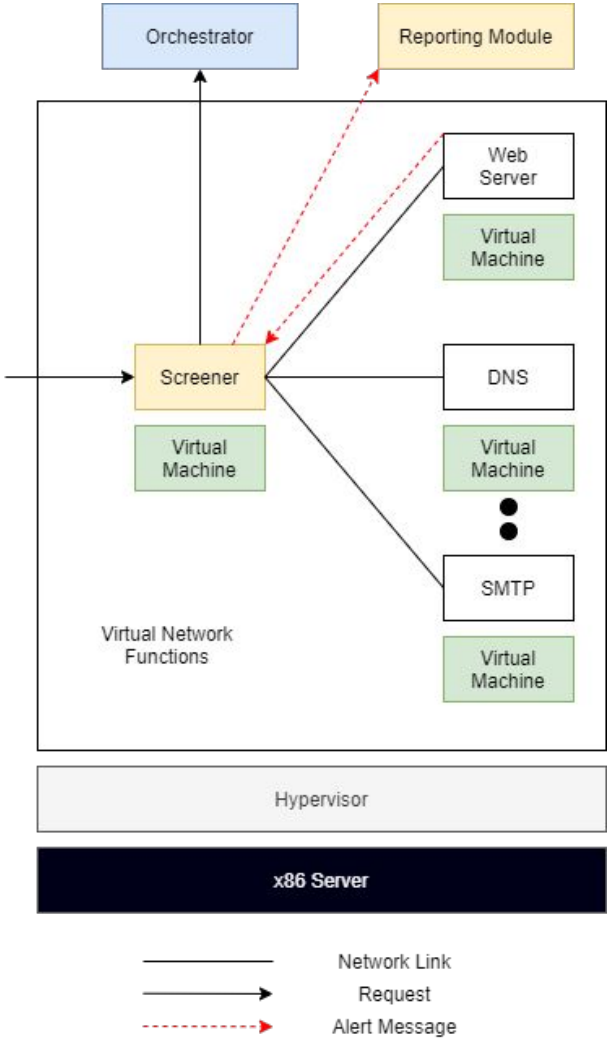


Conclusiones



Conclusiones