UNIVERSITY OF WATERLOO

ERICSSON

A Security Orchestration System for CDN Edge Servers

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Outline

Introduction

Edge Server Security Orchestration

Implementation

Evaluation

Conclusion

Introduction

CONTENT DELIVERY NETWORK (CDN)

CONTENT DELIVERY PROCEDURE

ATTACKS AGAINST CDN EDGE-SERVERS

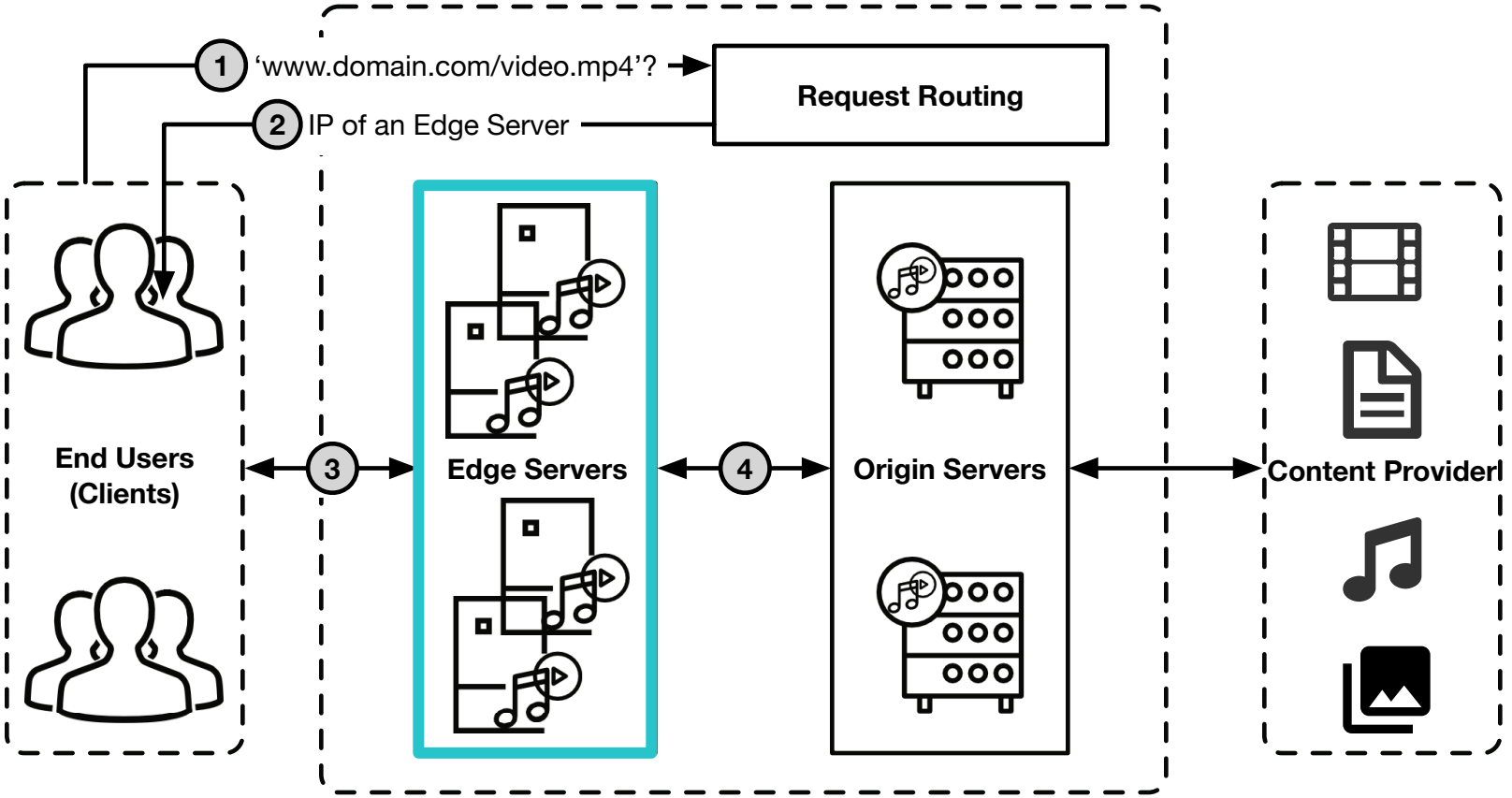
CURRENT DEFENSE MECHANISMS

Content Delivery Network

Content Delivery Network (CDNs) play a critical role in delivering digital content

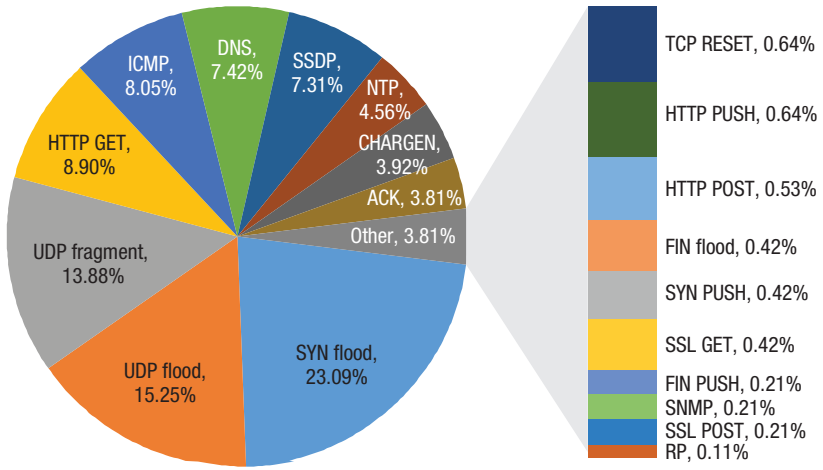
- Open-Connect carries Netflix's content (35.2 of all the traffic across North America)
- Akamai CDN daily delivers more than 30 Tbps of traffic

Content Delivery Procedure

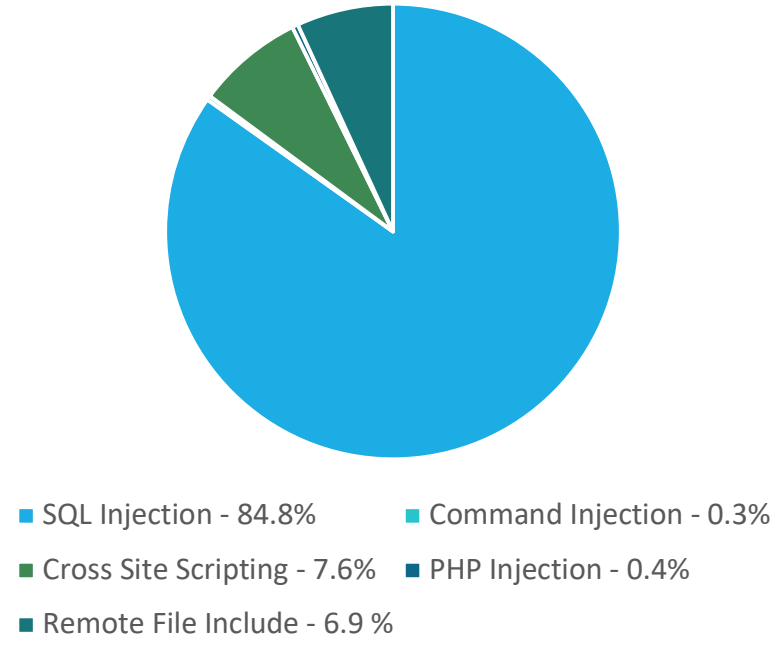


Attacks against CDN Edge Servers

DENIAL OF SERVICE ATTACKS



APPLICATION LAYER ATTACKS



[1] Gillman, D., Lin, Y., Maggs, B. and Sitaraman, R.K., 2015. Protecting Websites from Attack with Secure Delivery Networks. *Computer*, *48*(4), pp.26-34.

Current Defense Mechanisms

Hardware Security Functions
- Vertically integrated
- Not Elastic/flexible

Scrubbing Centers
- Redirection latency
- Proprietary mechanisms

Existing Software Defined Solutions
- Not-automated deployment
- Exclusive to DDoS

Edge Server Security Orchestration

OUR APPROACH

ARCHITECTURE

Our Approach

Virtual Security Functions
- Virtual functions running on commodity hardware
- Elastic/flexible

In-house Mitigation
- No redirection latency
- Custom mechanisms

Our Software Defined Solutions
- Automated deployment
- Wide range of attacks

Hardware Security Functions
- Vertically integrated
- Not elastic/flexible

Scrubbing Centers
- Redirection latency
- Proprietary mechanisms

Existing Software Defined Solutions
- Not-automated deployment
- Exclusive to DDoS

Our Approach

Deploying security services on edge servers

Dynamic and automatic deployment of security services

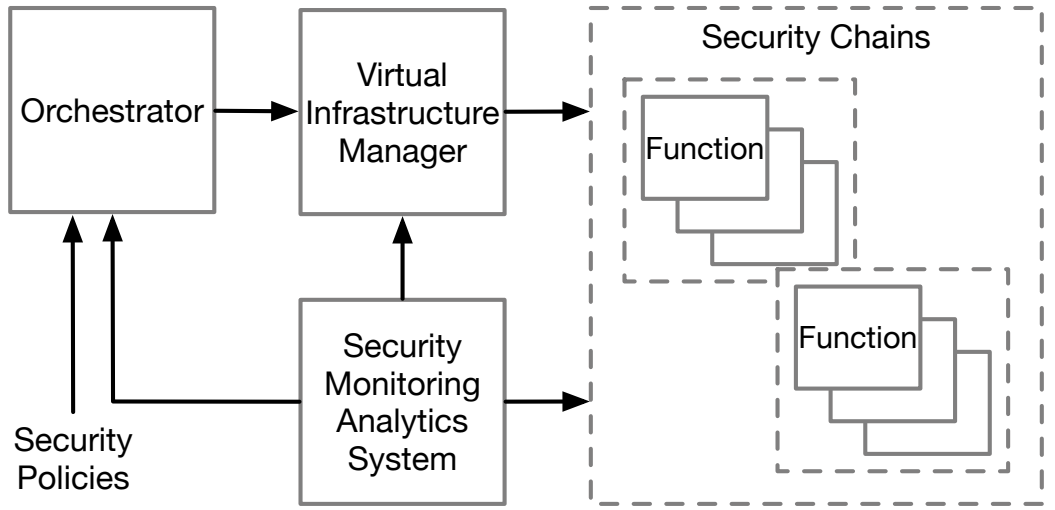
Security services realized through **service function chaining**

Architecture

Orchestrator
- Enforcing high-level policies
- Reacting to environment states and attacks

Virtual Infrastructure Managers
- Creating, updating, querying, and deleting security chains

Security Monitoring Analytics System
- Monitoring and analyzing the collected data
- Feeding the orchestrator with alerts



Implementation

ORCHESTRATOR

VIRTUAL INFRASTRUCTURE MANAGERS

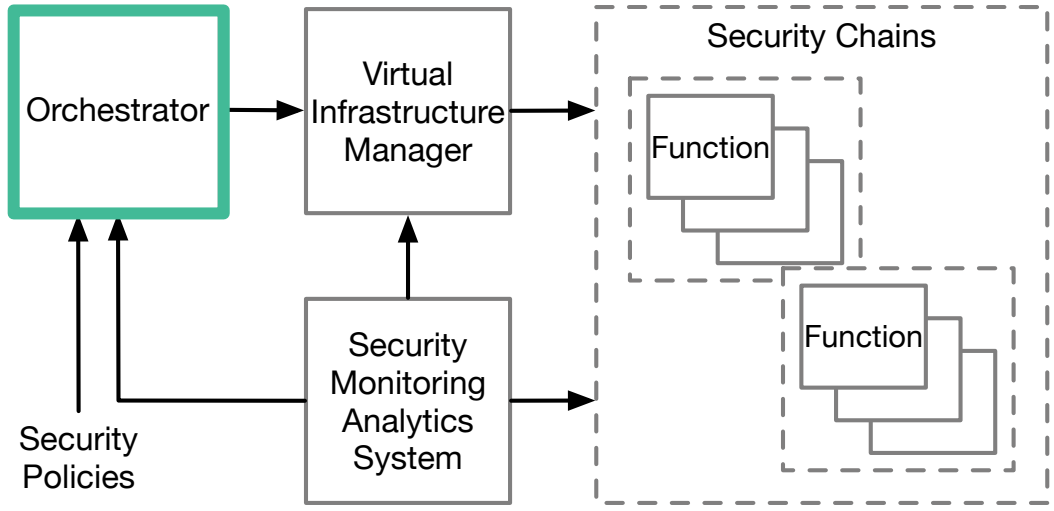
SECURITY MONITORING ANALYTICS SYSTEM

Orchestrator

Adopting $\mathcal{L}_{active}$ language

Event Condition Action paradigm

- Event
  - Security alerts generated by SMAS
  - Internal events
- Condition
  - Time related
  - Service related
  - Traffic related
- Action
  - Creating, deleting, modifying a chain



Orchestrator – Continue

SECURITY POLICIES

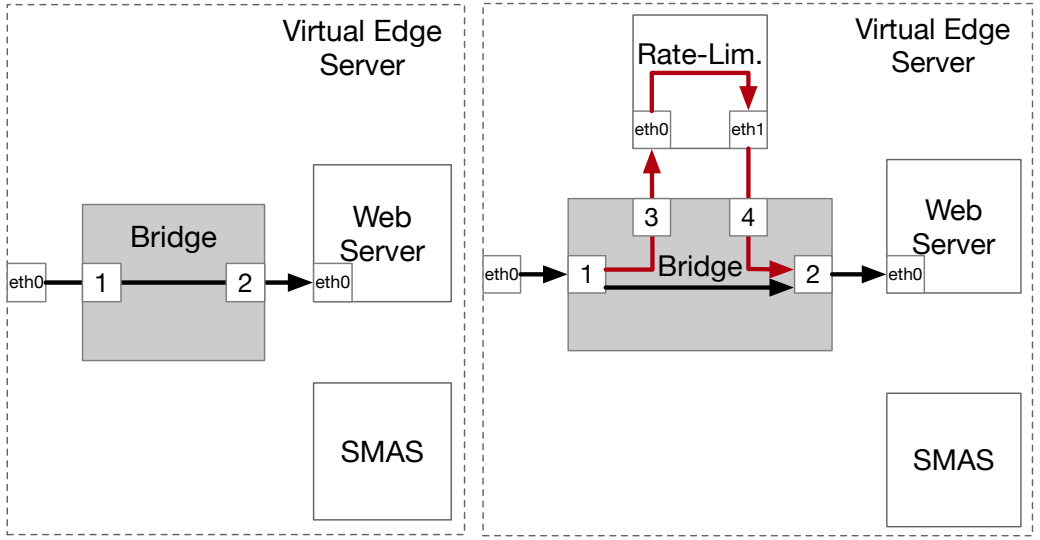
Deploy rate limiting chain in reaction to event *high_rate* happened and there are no rate limiting chain

Trigger event *lim* if the rate limiting chain is deployed

Run `rate_limit.sh` in response to event *lim*

$$
\begin{aligned}
&high\_rate \textbf{ initiates } create\_chain(r: \\
&\quad <\text{“not src net 129.97.124.0/24”}, 1, 2>, \\
&\quad \{f\text{:}Rate\text{-}limit\}) \\
&\quad \textbf{if not } chain(r) \\
&lim \textbf{ after } create\_chain(r) \\
&\quad \textbf{if true} \\
&lim \textbf{ initiates } run(f, \text{“}rate\_limit.sh\text{”}) \\
&\quad \textbf{if true}
\end{aligned}
$$

ENFORCED SECURITY CHAIN

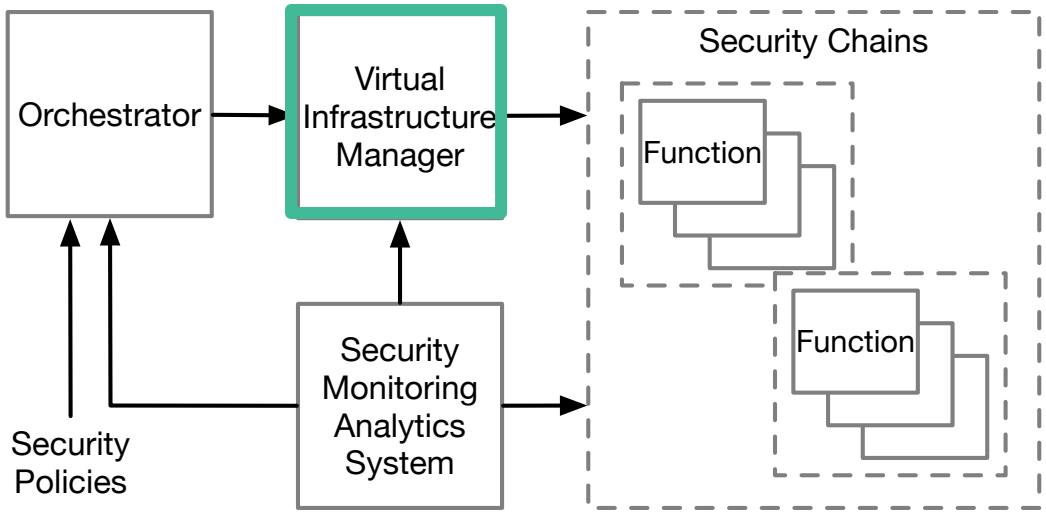


Virtual Infrastructure Manager

Docker
- Containers as service functions

Network Service Header (NSH)
- IETF standard for service function chaining
- Realizing service function paths
- Supporting carrying metadata

Open Virtual Switch
- Software based switching



Virtual Infrastructure Manager – Cont.

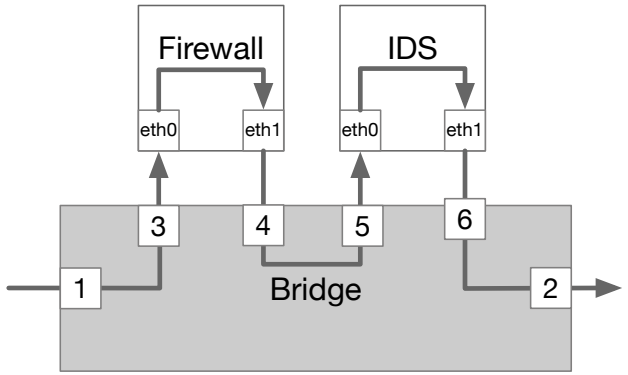
VIM APIs

```
def create_chain(chain_sp)
def delete_chain(chain_name)
def insert(chain_name, func_sp)
def delete(chain_name, func_name)
def run(func_name,cmd)
def chains()
def chain(chain_name)
def chain_functions(chain_name)
def functions()
def function(func_name)
def steered(bpf,chain_name)
```

Chain Specification

```
{
  "chain_name": "ch",
  "ingress": "1",
  "egress": "2",
  "classification_rules": "ip",
  "functions": [
    {
      "function_image": "Firewall",
      "function_name": "firewall",
      "nsh_aware": false
    },
    {
      "function_image": "IDS",
      "function_name": "ids",
      "nsh_aware": false
    }
  ]
}
```

Deployed Chain

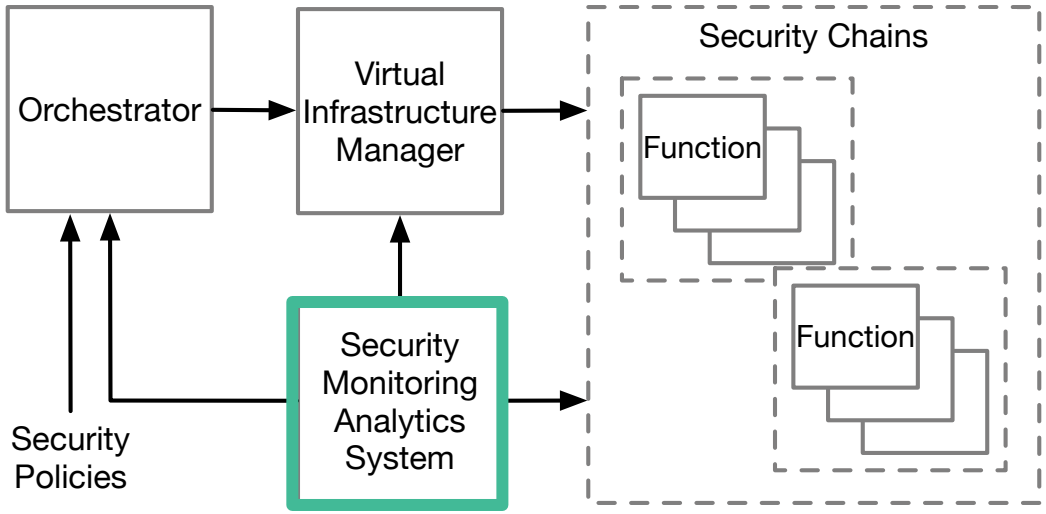


Security Monitoring Analytics System

Periodic resource monitoring
- Network-bandwidth
- CPU
- Memory
- Storage

Event generation
- Based on predefined thresholds

Standard Linux commands
- `/proc/stat`
- `free`
- `iostat`



Evaluation

ENVIRONMENT SETUP

PERFORMANCE EVALUATION

RESPONSIVENESS

DYNAMIC SECURITY SERVICE

Environment Setup

A cluster of servers
- 16 GB RAM
- 8-cores 3.30 GHz Xeon CPU
- 10 Gbps NIC

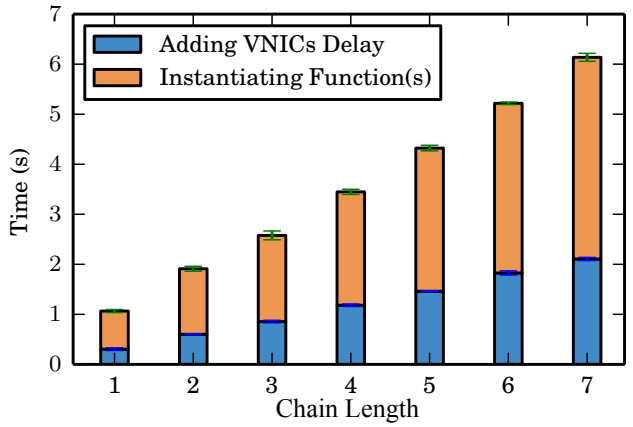
Device under test
- Hosting security chains
- Hosting an active daemon of our system

Traffic sink
- `iperf` server
- `Apache` Web Server

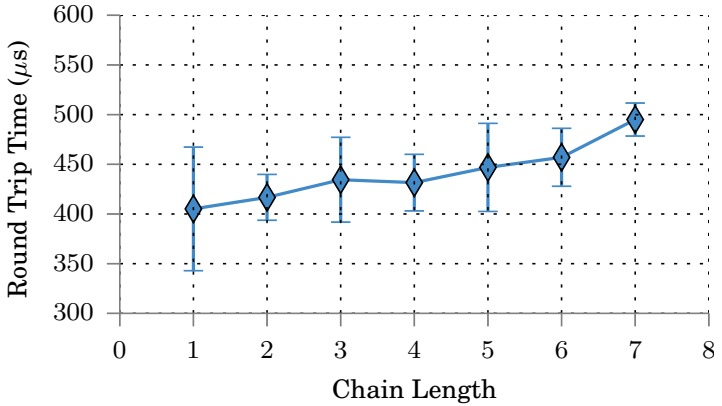
Traffic generator
- `iperf` client
- `HTTPERF`

Performance evaluation

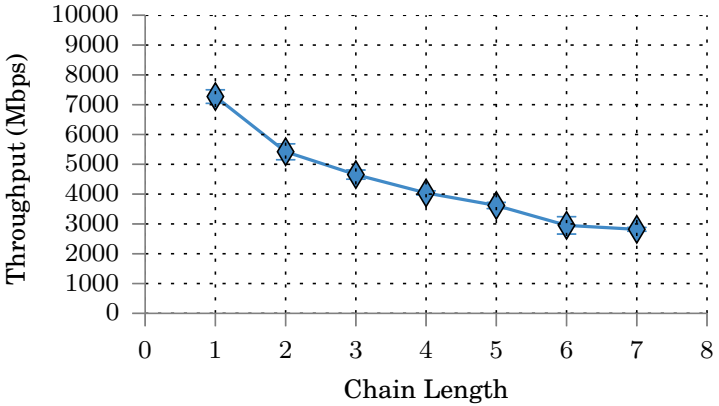
Chain Deployment Time



Traffic Round Trip Time



Throughput vs. Chain Length



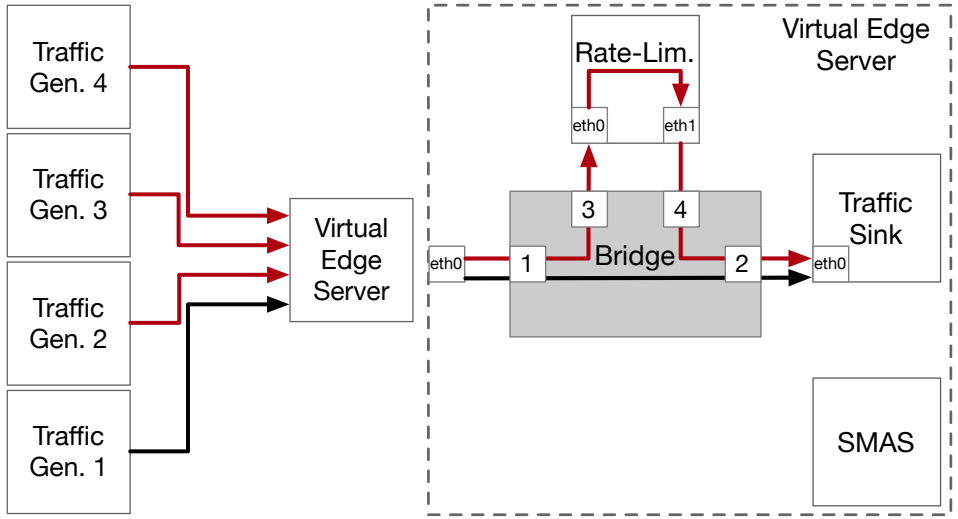
Responsiveness

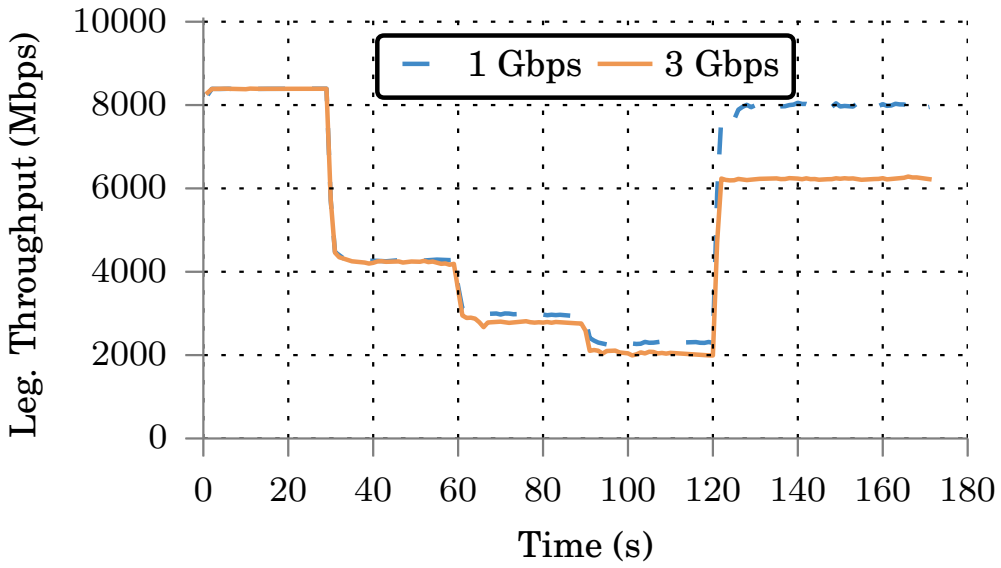
Traffic

- TCP flooding attacks

Defense

- Network layer rate-limiting





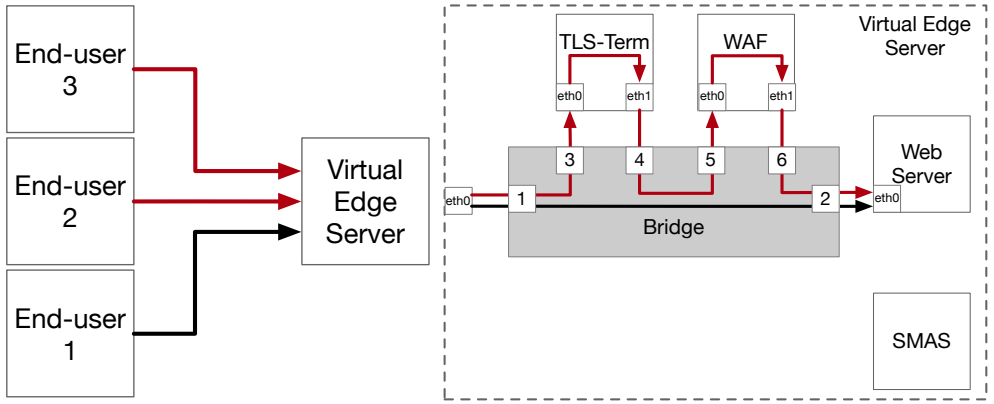
Dynamic Security Service

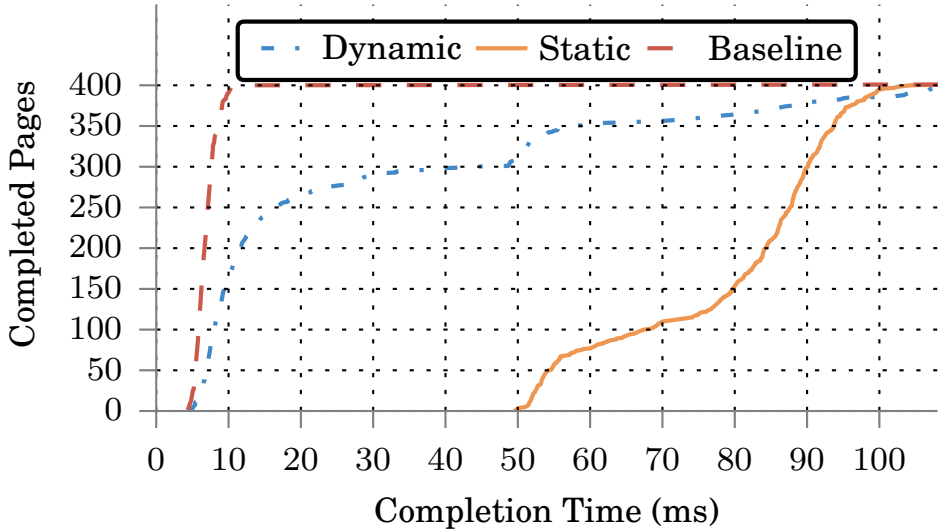
Traffic

- 300 legitimate requests
- 100 suspicious requests

Defense

- Application layer mitigation





Conclusion

SUMMARY

FUTURE WORK

Summary

Software defined security orchestration for CDN edge-servers

Governed by high-level policies

Dynamic and automatic security function chaining

Future Work

NSH compatible SFs

- Passing the metadata between functions

Ensuring security policy consistency through formal verifications

- Free of conflicting rules

Reduce the signaling overhead in the Orchestration process

- Delegation of part of the SF chain management

Q&A