Hounterfeit
A virtual self-defending infrastructure with transparent relocation to honeypots

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- Education
  - University: ACS-UPB – BE, Master, PhD student
  - Certs: OSCP, MPT

- Penetration Tester 3+ years

- CTF Challenge Author 3+ years

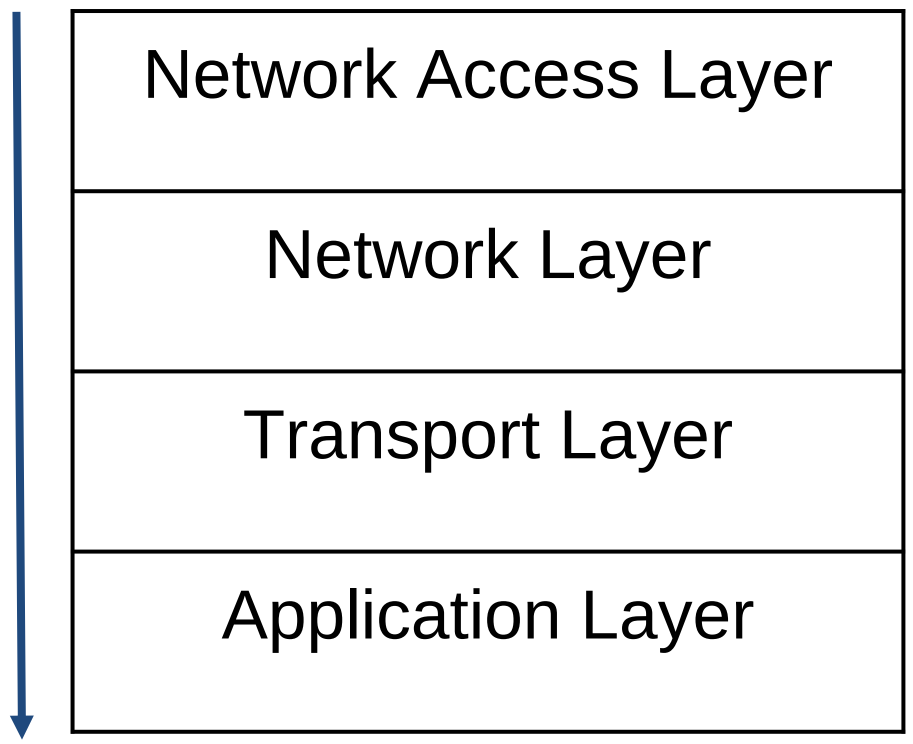
Problem

Advanced Persistent Threats

- Where/when to block the attack?
  - IDS/IPS
- How to keep up?
  - Rules
  - Behavior
  - ML
- Deceive? - Honeypots
  - Usually not representative

Firewalls & Honeypots

Firewalls
- Packet Filters
- Stateful Filters
- Next-Generation Firewalls



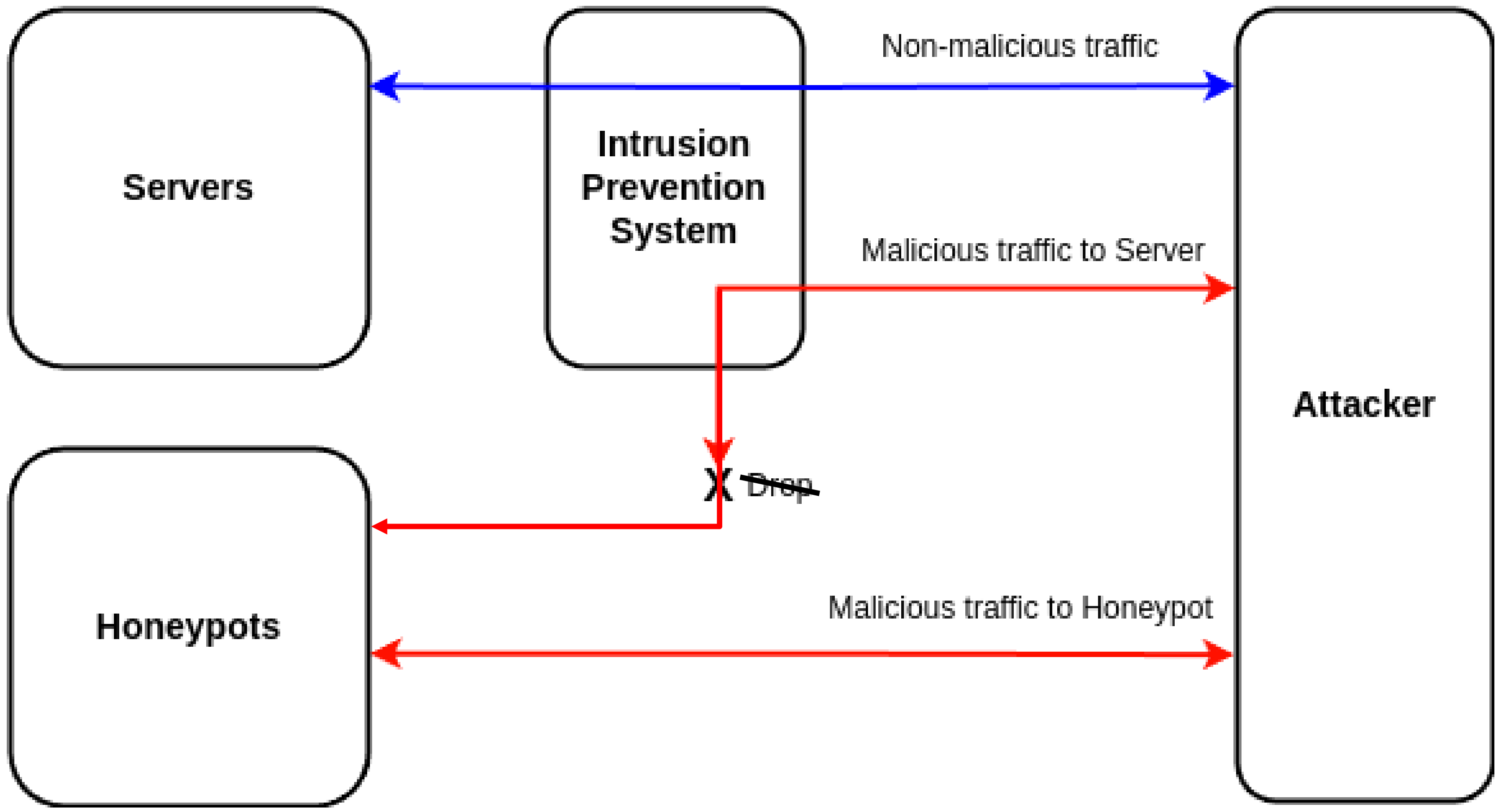
Honeypots
- Low-Interaction Honeypots
- High-Interaction Honeypots

Intrusion Prevention System (IPS)

Pros:
- Attacks are blocked before causing impact

Cons:
- Race between trial and error on obfuscating payloads and patching application

Solution:
- Migrate attacks to Honeypots
- Honeypots built from Server template

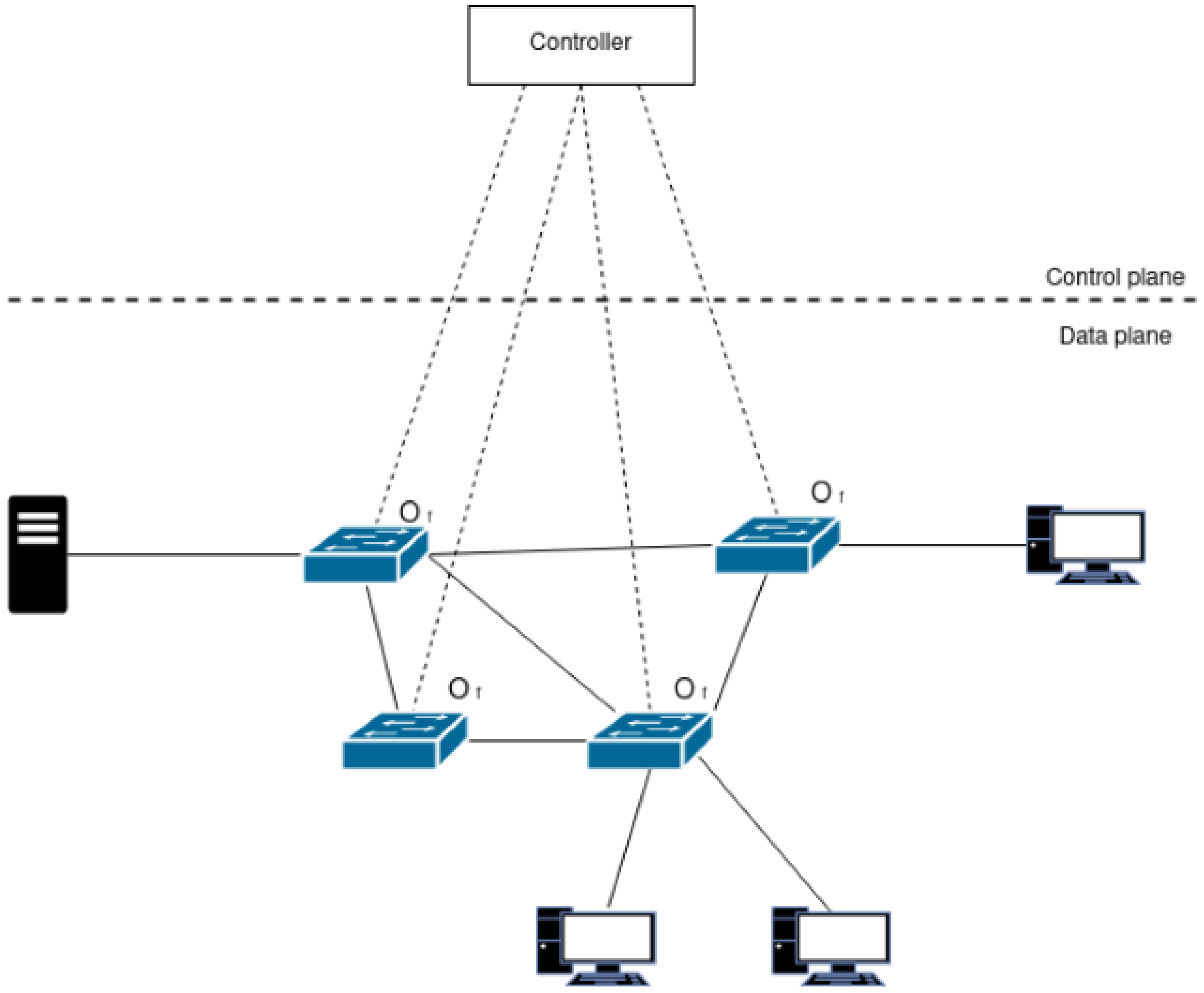


Software Defined Networking (SDN)

- Programmable network control

- Planes
  - Data
    - Switches
    - Servers/Applications
  - Control
    - SDN controller('s)

- Rules
  - Proactive
  - Reactive



State of the Art

Network level:

- OFSoftswitch
  - Advanced OpenFlow Switch for redirection
- Honeydoc
  - Controller level TCP-proxy

Process level:

- Linux Functions
  - TCP repair
- MfHoney
  - CRIU images modify sockets to LIH-HIH

Article	Mitigation Focus	SDN Controller	Deployment	Honeypot Type	Forwarding	Year
[6]	APT	No	Adaptive	N/A	No	2023
[7]	LIH/HIH + TCP Fingerprinting	No	Reactive	HIH	Transparent (CRIU - local)	2022
[8]	Detect Anomaly	Ryu	Proactive MTD	Not specified	No	2022
[9]	APT	Yes	Reactive at Pivoting	HIH	No	2022
[10]	Generic Decoy	ONOS	Reactive	Hybrid	No	2020
[11]	TCP Fingerprinting	Ryu	Proactive	HIH	Transparent (At Proxy)	2020
[12]	DDoS	ONOS	Reactive	HIH	Yes	2020
[13]	APT	Yes	Reactive	Container Replicas	Transparent (Container Clone)	2019
[14]	LIH/HIH + TCP Fingerprinting	Ryu	Reactive	Hybrid	Transparent (At Controller)	2019
[15]	Scans, DDoS	Ryu	Proactive MTD	MIH	No	2019
[16]	Integrity attacks, Zero-day	Yes	Proactive	VMs Replicas	Yes	2019
[17]	LIH/HIH Fingerprinting	Floodlight	Proactive	Hybrid	Yes	2019
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[19]	Generic Decoy	Yes	Proactive	Hybrid	No	2017
[20]	LIH/HIH Fingerprinting	POX	Proactive	Hybrid	Yes	2017
[21]	LIH/HIH Fingerprinting	Yes	Proactive	Hybrid	Yes	2016
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[9] C. S. Bontas, I.-M. Stan, and R. Rughinis, "Honeypot generator using software defined networks and recursively defined topologies," in *2022 21st RoEduNet Conference: Networking in Education and Research (RoEduNet)*, pp. 1–5, 2022.

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Problem

Advanced Persistent Threats

- How to keep up?
  - Rules
  - Behavior
  - ML

✓ Where to block the attack?
  - Relocate instead of blocking

✓ Deceive? - Honeypots
  - TCP/IP level relocation to Honeypots
    - Application state?

State of the Art

- INTERCEPT+
  - VM-level
- Sandnet & Warp
  - Docker-level
- Hounterfeit
  - Process-level

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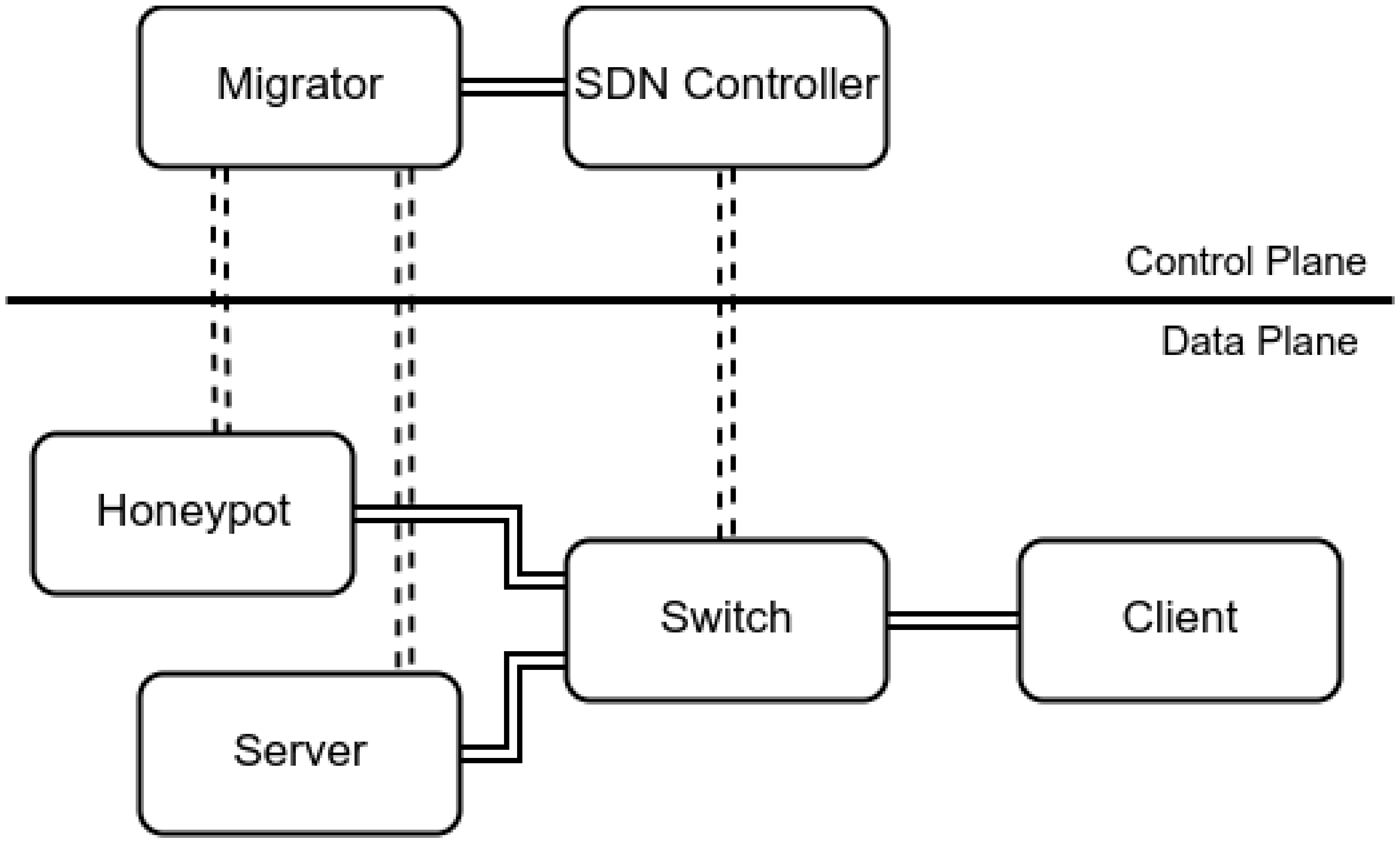
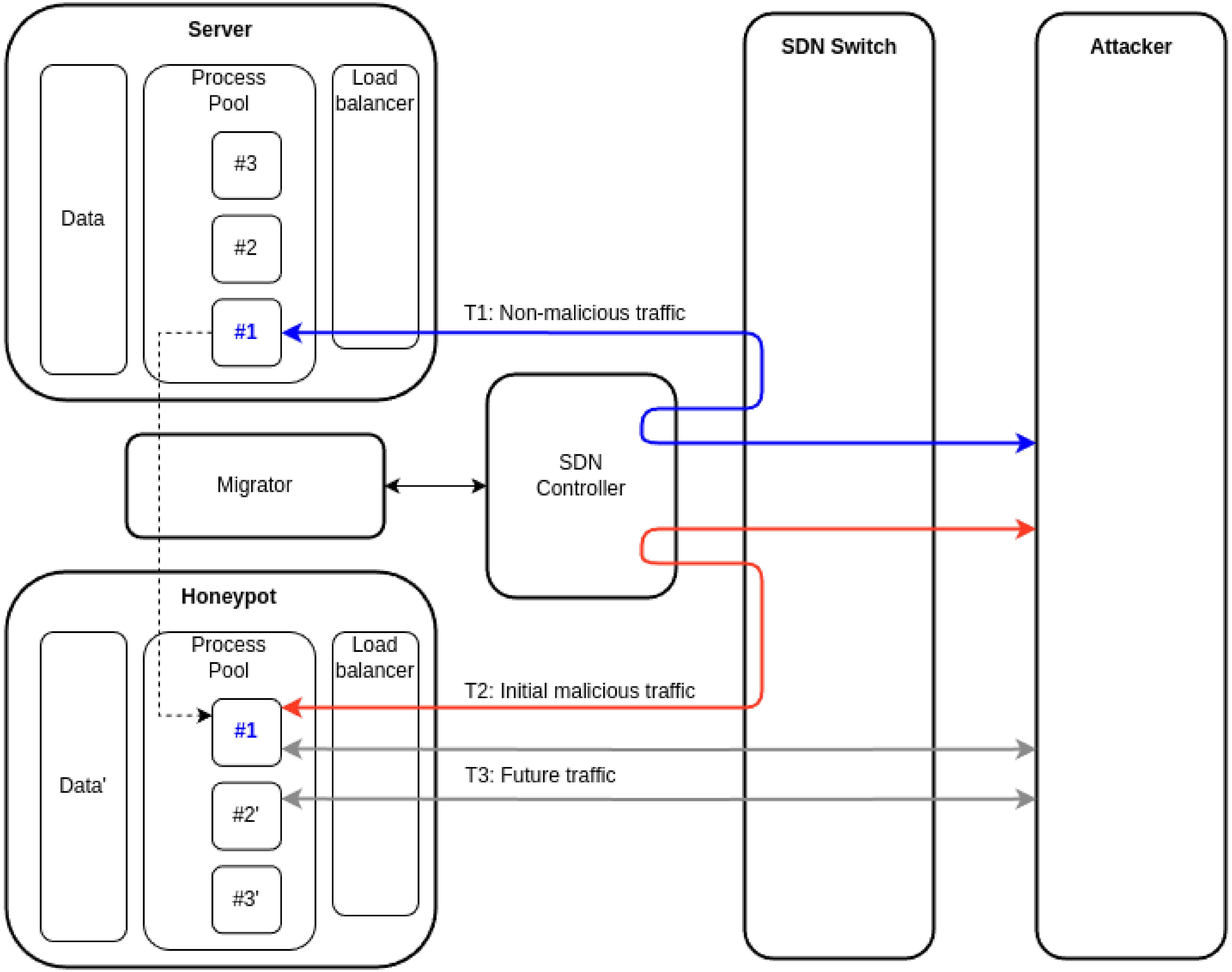
Checkpoint/Restore in Userspace

"It can freeze a running container (or an individual application) and checkpoint its state to disk. The data saved can be used to restore the application and run it exactly as it was during the time of the freeze..." [CRIU.org Wiki]

Infrastructure

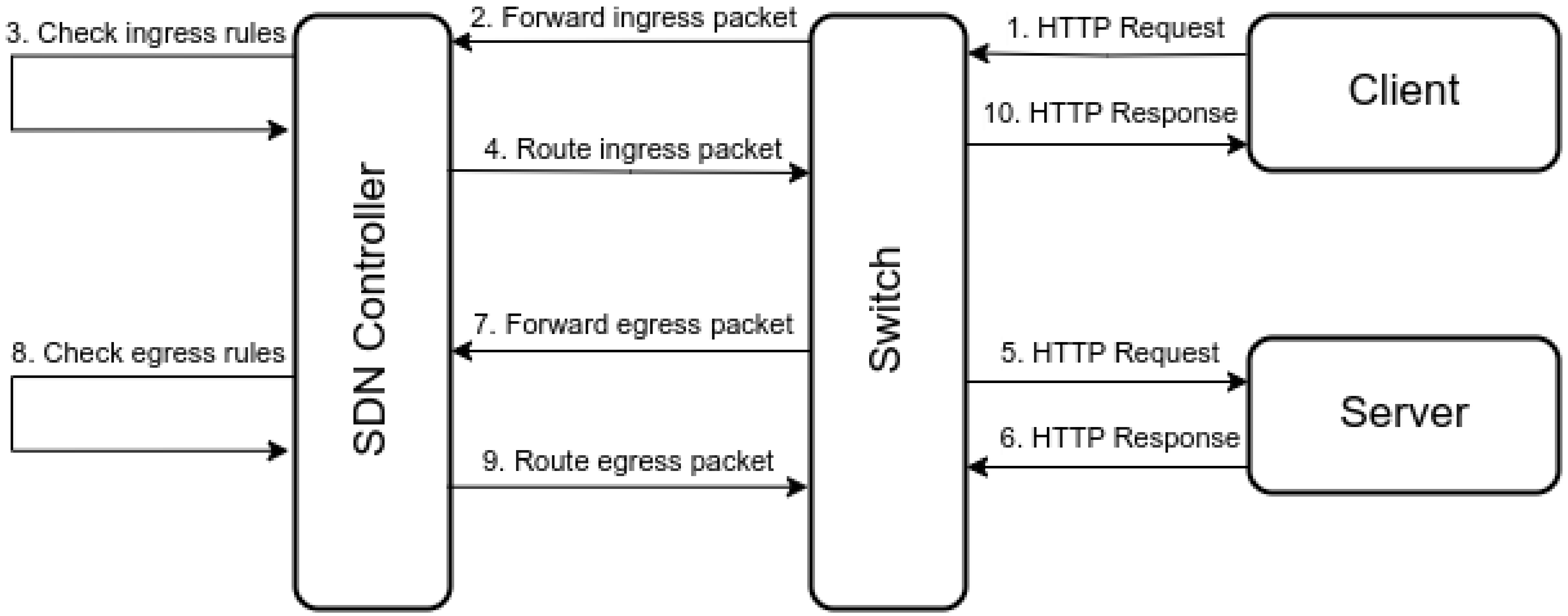



Server
Data
Process Pool
#3
#2
#1
Load balancer
T1: Non-malicious traffic
SDN Switch
Attacker
Migrator
SDN Controller
Honeypot
Data'
Process Pool
#1
#2'
#3'
Load balancer
T2: Initial malicious traffic
T3: Future traffic

Communication Flow

Detect:

- Ingress for payloads
  => migrate*
- Egress for sensitive data
  => drop
  => redirect



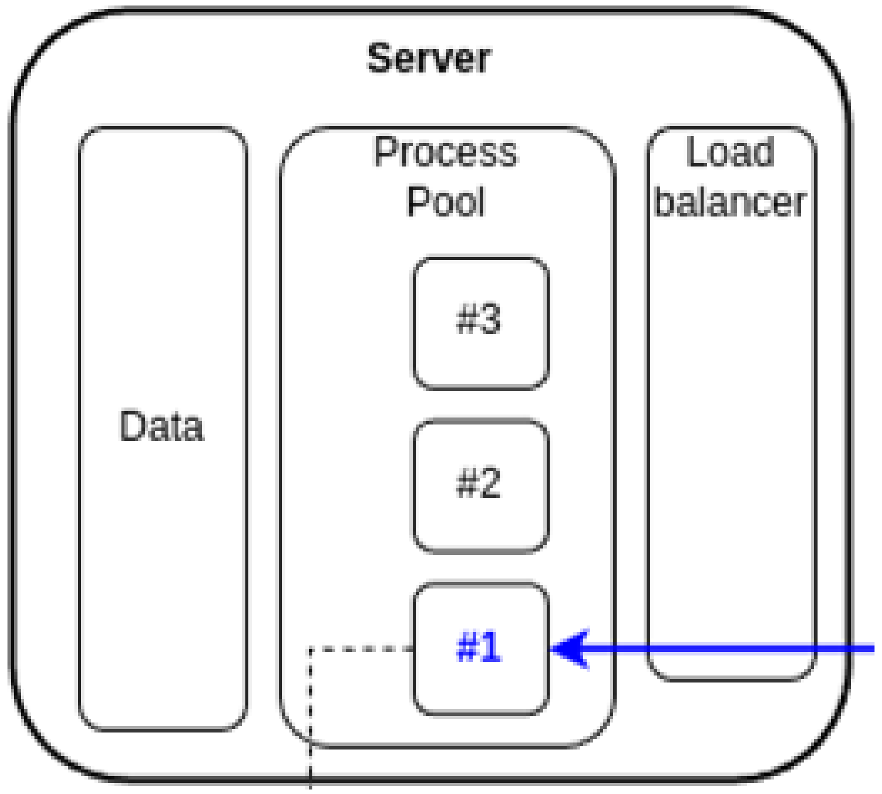
Sockets

TCP session - unique 4-tuple:

- Source IP + Port
- Destination IP + Port

Server side:

- Lifecycle: create,*bind*,listen,accept,..
- Listening address blocks
  - Bypass: socket option ***SO_REUSEPORT*** (Linux +3.9)
    - OS responsible for load-balancing



Sockets

What if program does not support ***SO_REUSEPORT*** ?

- Binary option: ***LD_PRELOAD***
  - Grab socket call
  - Add socket option

```c
typedef int (*socket_t)(int, int, int);

int socket(int domain, int type, int protocol)
{
    socket_t original_socket = (socket_t)dlsym(RTLD_NEXT, "socket");
    int sockfd = original_socket(domain, type, protocol);

    if (sockfd < 0)
    {
        return sockfd;
    }

    int opt = 1;
    setsockopt(sockfd, SOL_SOCKET, SO_REUSEPORT, &opt, sizeof(opt));

    return sockfd;
}
// gcc - shared - fPIC - o reuseport_wrapper.so so_reuseport_ld.c - ldl
```

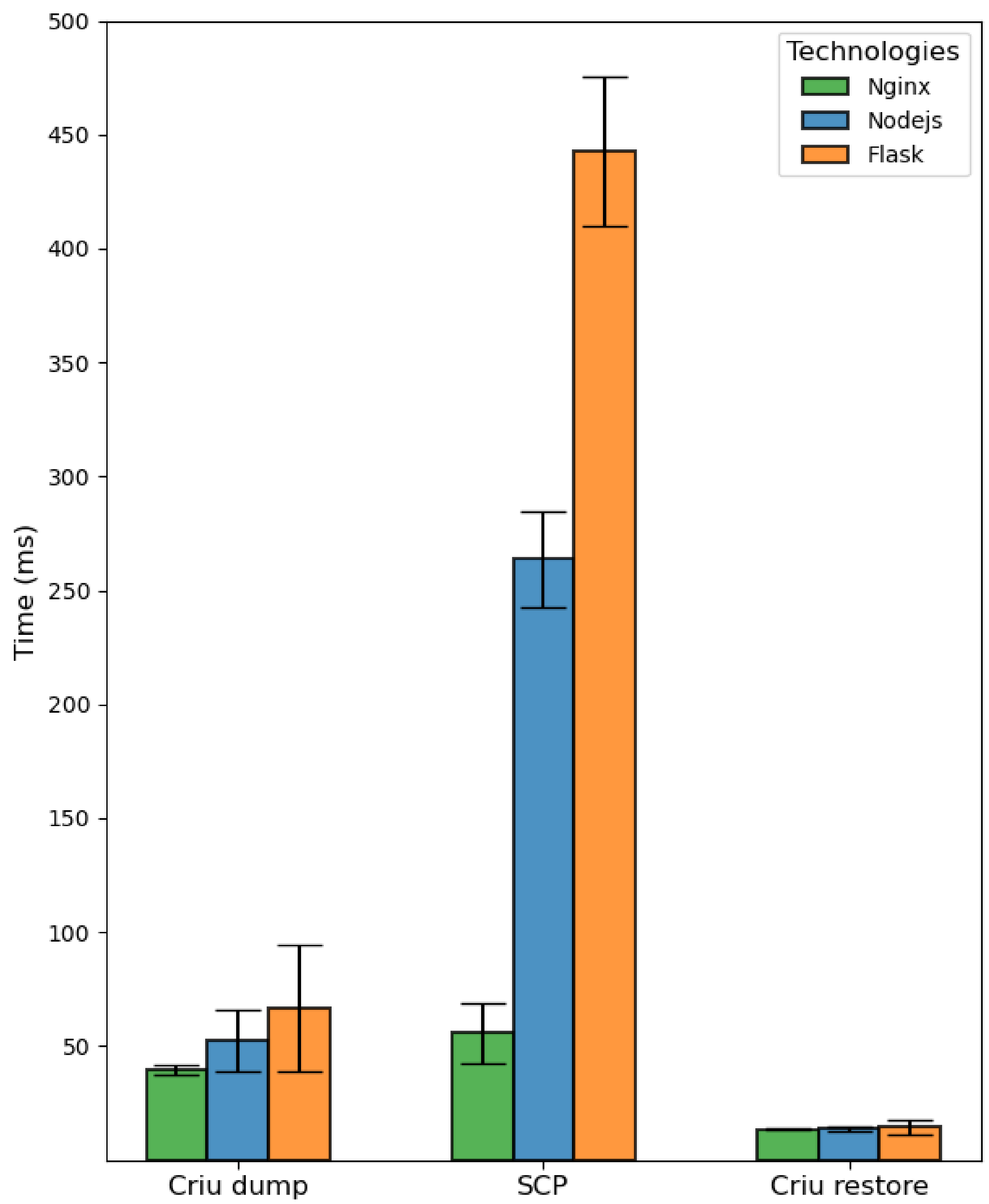
Metrics

Under test (HTTP):

- Nginx
- Nodejs
- Flask

Service	Criu dump	SCP transfer	Criu Restore	Total
Nginx	39.57 | 2.16(σ)	55.82 | 13.19(σ)	13.47 | 0.22(σ)	108.87 | 13.39(σ)
Node	52.40 | 13.62(σ)	263.72 | 20.92(σ)	13.63 | 0.93(σ)	329.76 | 23.01(σ)
Flask	66.70 | 27.53(σ)	442.40 | 32.78(σ)	14.40 | 3.31(σ)	523.50 | 38.65(σ)

Table 1: Mean and Standard Deviation of step per technology, measured in ms.

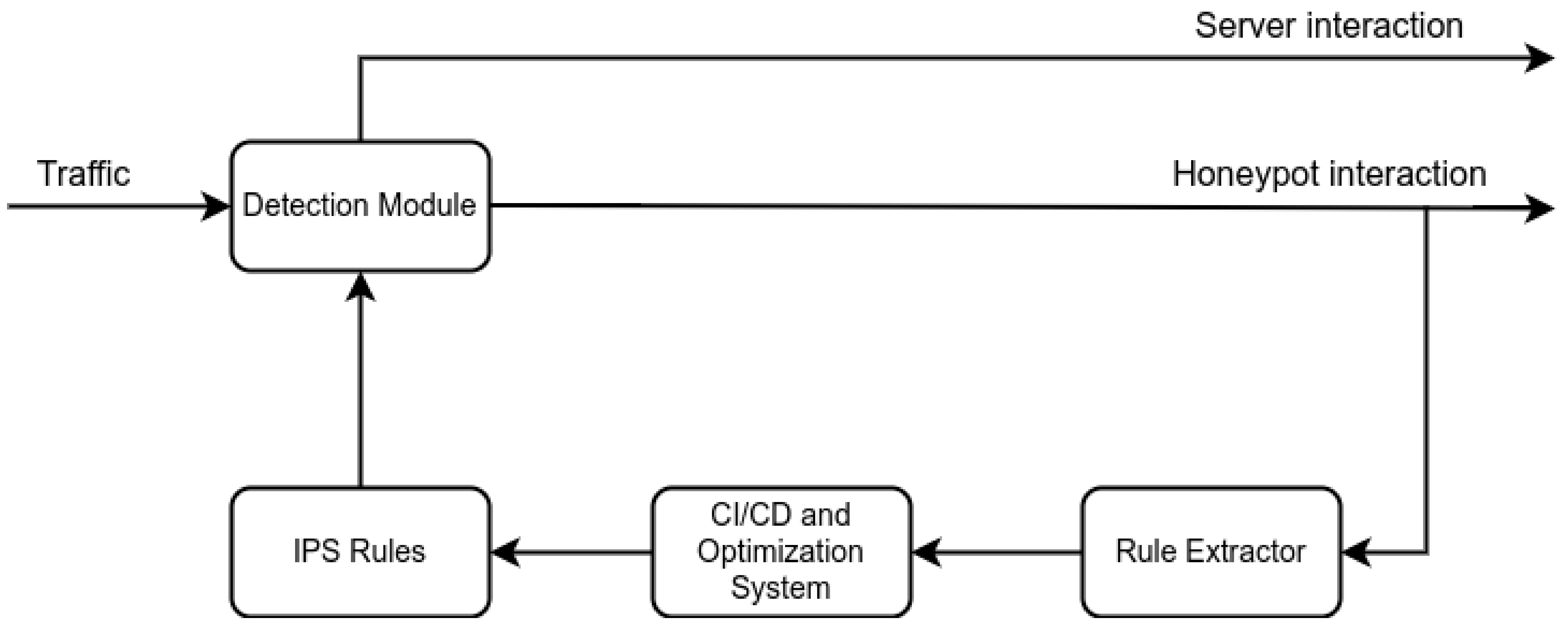


```
root@ubuntu-focal:/home/vagrant#
```

Limitations

- Encrypted traffic
- Multi-process migration
- NAT clients backfire
- Truncated packets
- Client-Side attacks

Next steps


Server interaction
Traffic
Detection Module
Honeypot interaction
IPS Rules
CI/CD and Optimization System
Rule Extractor

Conclusions

- Live attack redirection
- Transparent relocation
- Within standard network timeouts
- Scalable architecture
- Customized IDPS rules:
  Free payloads from attacks without impact!*

Thank you!