Digital Investigation in OpenFlow Networks with ForCon

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Your job ... wiretap the red VM
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- Identify the target
- Install your equipment
- Capture traffic
- Wait
- Analysis
Your job … wiretap the red VM
Research Questions

- How can you capture the entire network traffic of the SOI?
  - How can you determine the migration of the SOI?
  - How can you reconfigure the capture process as fast as possible?
  - How can the network traffic be reduced to the relevant information?
Overview

- A new challenge
- SDN and OpenFlow
- Virtual Network Forensic Process
- ForCon
- Evaluation
A new challenge

- Migration of VM is managed autonomous by the environment
  - Cloud controller manages the VM
  - SDN controller manages the network
    - Traffic control
    - Routing policies
    - ACLs
SDN with OpenFlow

- Most notable protocol for southbound api
- Uses flows to process the packets
- Flows are stored in flow table on the OF-switch
SDN with OpenFlow

- Most notable protocol for southbound api
- Uses flows to process the packets
- Flows are stored in flow table on the OF-switch
- A flow is a combination of header fields

```
SKB_PRIORITY(0), IN_PORT(2), ETH(SRC=00:1B:11:B4:DE:FC, DST=FF:FF:FF:FF:FF:FF), ETH_TYPE(0x0800), IPV4(SRC=172.20.10.4/0.0.0.0, DST=255.255.255.255/0.0.0.0, PROTO=17/0, TOS=0/0, TTL=64/0, FRAG=NO/0xff), ACTIONS=OUTPUT:3
```
A new challenge

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Highly dynamic environment
A new challenge

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Highly dynamic environment

- But:
  - Traditional network forensic investigation is static
How to capture traffic in virtual environments

- Find the SOI
- Find the relevant OF-switch
How to capture traffic in virtual environments

- Find the SOI
- Find the relevant OF-switch
- Extract needed information
- Manipulate flows in relevant OF-switch
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- Capture and store the traffic

Identification
Preparation
Capture
Recording
How to capture traffic in virtual environments

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- Monitor the environment
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- Monitor the environment
- React on relevant changes

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- React on relevant changes
- Adapt relevant flows

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Virtual network forensic process

Process model for network forensic investigation in virtual networks

Circuit of different phases
Repetitive use of phases
ForCon

• (still a proof-of-concept)
• Forensic Controller
• Based on the VNFP
• Implements network forensic investigation in virtual networks

• Central server, distributed agents
  • SDN-agent (1/host)
  • Mirror-agent (1/network)
• Extract and manipulates OpenFlow-Flows
ForCon Workflow I

• Agents connect to ForCon
  Connection from agent 172.16.40.129 established
  Connection from mirror-agent 172.16.40.122 established

• Agent transmits the local flows to ForCon

  I;s1;00:00:00:00:00:03;00:00:00:00:00:01
  I;s1;00:00:00:00:00:01;00:00:00:00:00:03

• ForCon analyses these flows and searches for the identifier of the target
• Decision:
  • Hit: Create vxlan-tunnel between mirror agent and involved vswitch
  • Miss: Just wait for newer flows (send by agents)
ForCon flow manipulation

- Ingress
  cookie=0x0, duration=11965.378s, table=0,
  n_packets=10120, n_bytes=975632,
  priority=2, in_port=1, dl_dst=00:00:00:00:00:03
  actions=output:2,99

- Egress (Destination-MAC is needed)
  cookie=0x0, duration=1604.682s, table=0, n_packets=0, n_bytes=0,
  priority=2, dl_src=00:00:00:00:00:03, dl_dst=00:00:00:00:00:01
  actions=output:1,output:99
ForCon - just a shallow dive

• Use of existing tools: `ovs-ofctl dump-flows`
• Format of flows deterministic, but vendor specific
• Classification of fields
  • Priority
  • Action
  • Group
  • Timer
    • Hard-TO
    • Idle-TO
• Split the flow
• Store relevant data
• Adaptation regarding to the given situation
In detail
Even virtual
Evaluation

- How is ForCon operating in different situations?
  - Limiting resources are cpu-load, CAM, network bandwidth

- Does ForCon capture all network packets?
  - Compare number of transmitted and received data
    - regarding to target VM and capture system

- Are the captured packets „correct“?
Result

- High CPU load (*stress*)
- CAM (*vNICs*)
- Network usage (*iperf*)
- Integrity

- 100% packet match
- 100% packet match
- 100% packet match
- Extracted payload matches

```
md5 *.pcap
MD5 (ChunkedFile.pcap) =
ed96fa2fba48ade3f7d2e8a7dc20f9d4
MD5 (ChunkedFile_mirror.pcap) =
ed96fa2fba48ade3f7d2e8a7dc20f9d4
```
Conclusion

- SDN (and network virtualization) increase flexibility and dynamic in nowadays data centers
- OpenFlow as the most notable protocol provides no forensic capabilities
- Migration of VMs is most critical
- ForCon eradicates the static implementations and provides an ongoing capture process even by moving of the SOI
- Distributed agents monitor and manipulate flows
- Evaluation of ForCon validates the correctness of the process
Thank you

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