

## 程序创坊

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Note: 欢迎发邮件交流

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# 第一章 使用说明

## 环境安装

Debian11	<pre>apt install -y libelf1 libelf-dev</pre>
Ubuntu21.10	<pre>apt install -y zlib1g zlib1g-dev</pre> <pre>apt install -y libcap2 libcap-dev</pre>
Fedora35	<pre>dnf install elfutils elfutils-devel</pre> <pre>dnf install zlib zlib-devel</pre> <pre>dnf install libcap libcap-devel</pre>

## LIBBPF 安装

```
git clone https://github.com/libbpf/libbpf.git
cd libbpf/src
make
make install
```

## BPFTOOL 安装

```
wget https://mirrors.edge.kernel.org/pub/linux/kernel/v5.x/linux-`uname -r` | awk -F'-' '{print $1}'`.tar.gz
tar -zxvf linux-5.15.8.tar.gz
cd linux-5.15.8/tools/bpf/bpftool/
make
mv bpftool /usr/bin/
bpftool --version
bpftool v5.15.8
```

## BPFFS 持久化

```
mount | grep bpf
none on /sys/fs/bpf type bpf (rw,nosuid,nodev,noexec,relatime,mode=700)
-----
mount bpffs /sys/fs/bpf -t bpf
```

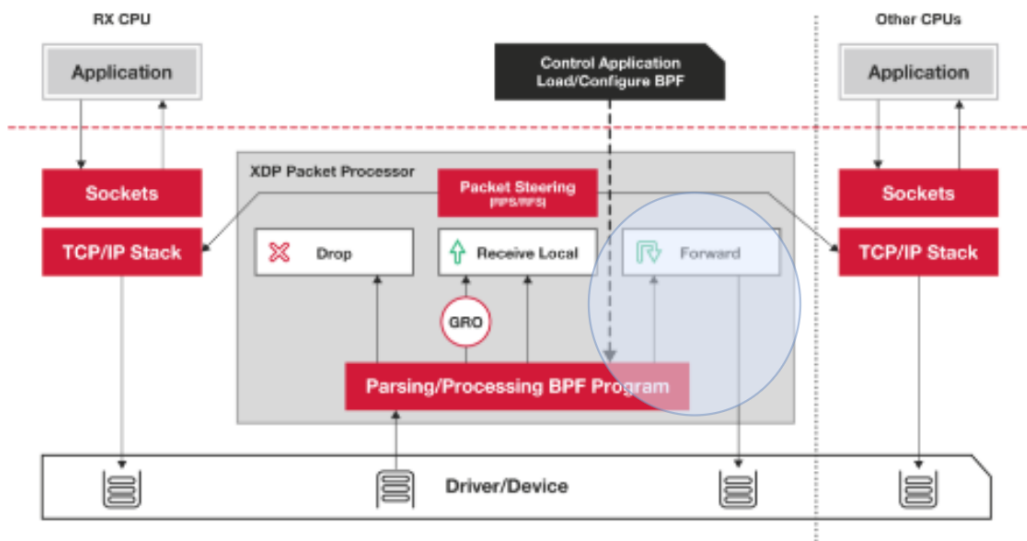
## eBPF/XDP

- bpf\_fib\_lookup: 查询路由表(main 表)

- bpf\_map\_update\_elem: 更新 map 表项
- bpf\_map\_lookup\_elem: 查询 map 表项

## 第二章 项目说明

### 功能目标



传统网络转发路径是从 L2→L3，查询路由表然后转发，中间解析报文且分配 SKB。XDP 转发路径可以下沉 L2，解析报文再封装，无 SKB 分配，高效且快速。

### 安装服务

```
dpkg -i fwd-0.1.0-0-x86_64.deb
rpm -ivh fwd-0.1.0-0-x86_64.rpm
```

### 接口指南

- QueryForward

POST http://192.168.56.4:5555

```
{
  "action": "QueryForward",
  "traceId": "e3e98256-5a75-4bdc-80a5-e26fef7ffcca"
}

{
  "code": 200,
  "traceId": "e3e98256-5a75-4bdc-80a5-e26fef7ffcca",
  "Tables": [
    {
      "Ip": "10.10.3.10",
      "Iface": 4,
      "SrcMac": "08:00:27:13:df:b6",
      "DstMac": "08:00:27:f2:cb:f9"
    }
  ]
}
```

- UpdateForward

POST http://192.168.56.4:5555

```
{
  "action": "UpdateForward",
  "traceId": "ad231a4f-49ca-43a1-9194-2671d02874e4",
  "ip": "10.10.3.10",
  "iface": 4,
  "srcMac": "08:00:27:13:df:b6",
  "dstMac": "08:00:27:f2:cb:f9"
}

{
  "code": 200,
  "traceId": "ad231a4f-49ca-43a1-9194-2671d02874e4"
}
```

## 错误码表

错误码	错误信息	错误含义	解决方式
1000	read request body error	读取请求错误	重试
1100	json format error	请求参数格式错误	检查请求发送格式 JSON
1101	not support action error	请求参数错误	检查接口拼写
1200	update error	更新转发表失败	权限不足 需要 ROOT 用户启动
1201	query error	查询转发表失败	权限不足 需要 ROOT 用户启动

## 注意事项

- ⚠ 支持 IPv4 报文
- ⚠ bpftool 加载 EBPF 程序，ip 命令绑定到网络设备

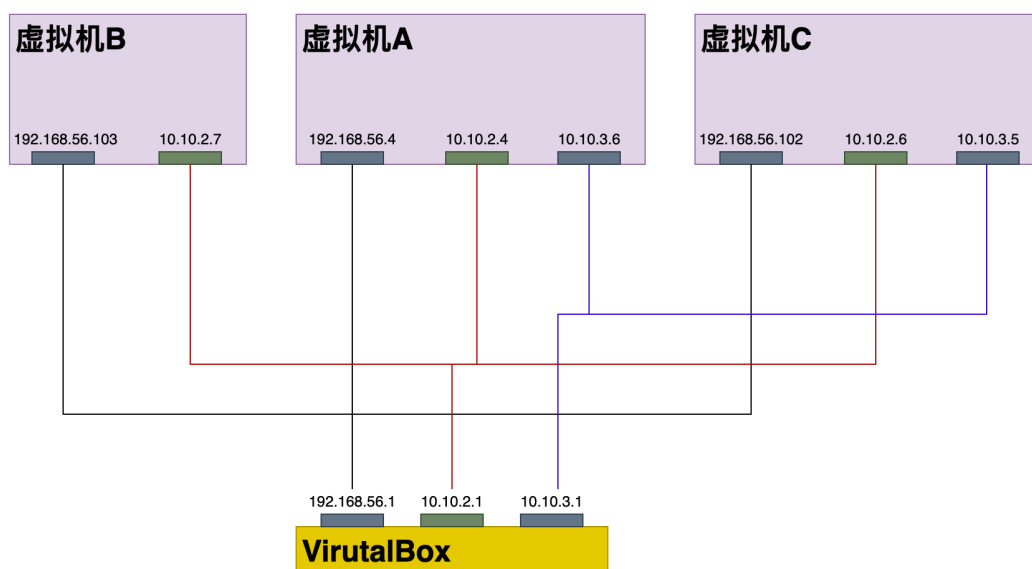
# 第三章 实验示例

## 实验环境

虚拟机 A 转发面节点 Debian11		
lo	127.0.0.1	本地网络设备
enp0s3	10.10.2.4	转发网络设备
enp0s8	192.168.56.4	控制网络设备
enp0s9	10.10.3.6	转发网络设备

虚拟机 B 客户端节点 Ubuntu21.10		
lo	127.0.0.1	本地网络设备
enp0s3	10.10.2.7	转发网络设备
enp0s8	192.168.56.103	控制网络设备

虚拟机 C 服务端节点 Fedora35		
lo	127.0.0.1	本地网络设备
enp0s3	10.10.2.6	转发网络设备
enp0s8	192.168.56.102	控制网络设备
enp0s9	10.10.3.5	转发网络设备



## 实验目标

当前实验环境 从虚拟机 B PING 虚拟机 C，即

ping 10.10.3.5

调整前处于网络不可达状态，实验目的是验证 eBPF 程序可以调整转发路径，即

ping 10.10.3.5

网络可达，且 eBPF 路径被调整；

## 网络地址

虚拟机 A 转发面节点 Debian11	
lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000	
link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00	
inet 127.0.0.1/8 scope host lo	
valid_lft forever preferred_lft forever	
inet6 ::1/128 scope host	
valid_lft forever preferred_lft forever	
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000	
link/ether 08:00:27:f0:1e:41 brd ff:ff:ff:ff:ff:ff	
inet 10.10.2.4/24 brd 10.10.2.255 scope global dynamic enp0s3	
valid_lft 594sec preferred_lft 594sec	
inet6 fe80::a00:27ff:fef0:1e41/64 scope link	
valid_lft forever preferred_lft forever	
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000	
link/ether 08:00:27:f3:81:0e brd ff:ff:ff:ff:ff:ff	
inet 192.168.56.4/24 brd 192.168.56.255 scope global enp0s8	
valid_lft forever preferred_lft forever	
inet6 fe80::a00:27ff:fef3:810e/64 scope link	
valid_lft forever preferred_lft forever	
4: enp0s9: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000	
link/ether 08:00:27:13:df:b6 brd ff:ff:ff:ff:ff:ff	
inet 10.10.3.6/24 brd 10.10.3.255 scope global enp0s9	
valid_lft forever preferred_lft forever	
inet6 fe80::a00:27ff:fe13:dfb6/64 scope link	
valid_lft forever preferred_lft forever	
192.168.56.1 dev enp0s8 lladdr 0a:00:27:00:00:00 DELAY	
10.10.2.3 dev enp0s3 lladdr 08:00:27:69:e2:c2 REACHABLE	
10.10.3.5 dev enp0s9 lladdr 08:00:27:f2:cb:f9 STALE	
10.10.2.1 dev enp0s3 lladdr 52:54:00:12:35:00 STALE	



## 虚拟机 B 客户端节点 Ubuntu21.10

```

1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:3b:8d:be brd ff:ff:ff:ff:ff:ff
    inet 10.10.2.7/24 brd 10.10.2.255 scope global dynamic enp0s3
        valid_lft 378sec preferred_lft 378sec
    inet6 fe80::a00:27ff:fe3b:8dbe/64 scope link
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:66:a9:e8 brd ff:ff:ff:ff:ff:ff
    inet 192.168.56.103/24 brd 192.168.56.255 scope global dynamic enp0s8
        valid_lft 378sec preferred_lft 378sec
    inet6 fe80::a00:27ff:fe66:a9e8/64 scope link
        valid_lft forever preferred_lft forever

10.10.2.3 dev enp0s3 lladdr 08:00:27:69:e2:c2 STALE
192.168.56.1 dev enp0s8 lladdr 0a:00:27:00:00:00 DELAY
10.10.2.1 dev enp0s3 lladdr 52:54:00:12:35:00 STALE
192.168.56.100 dev enp0s8 lladdr 08:00:27:68:0a:09 STALE

```

### 虚拟机 C 服务端节点 Fedora35

```

1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:99:cf:ce brd ff:ff:ff:ff:ff:ff
    inet 10.10.2.6/24 brd 10.10.2.255 scope global dynamic noprefixroute enp0s3
        valid_lft 333sec preferred_lft 333sec
    inet6 fe80::a00:27ff:fe99:cfce/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:ac:af:9f brd ff:ff:ff:ff:ff:ff
    inet 192.168.56.102/24 brd 192.168.56.255 scope global dynamic noprefixroute enp0s8
        valid_lft 334sec preferred_lft 334sec
    inet6 fe80::a00:27ff:feac:af9f/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
4: enp0s9: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:f2:cb:f9 brd ff:ff:ff:ff:ff:ff
    inet 10.10.3.5/24 brd 10.10.3.255 scope global dynamic noprefixroute enp0s9
        valid_lft 334sec preferred_lft 334sec
    inet6 fe80::1231:2461:6ebb:7042/64 scope link noprefixroute
        valid_lft forever preferred_lft forever

10.10.3.6 dev enp0s9 lladdr 08:00:27:13:df:b6 STALE
10.10.2.3 dev enp0s3 lladdr 08:00:27:69:e2:c2 STALE
10.10.2.1 dev enp0s3 lladdr 52:54:00:12:35:00 REACHABLE
10.10.3.3 dev enp0s9 lladdr 08:00:27:60:99:95 STALE
192.168.56.100 dev enp0s8 lladdr 08:00:27:68:0a:09 STALE
192.168.56.1 dev enp0s8 lladdr 0a:00:27:00:00:00 DELAY
10.10.3.1 dev enp0s9 lladdr 52:54:00:12:35:00 STALE

```

## 实验步骤

- 首 ping，即

ping 10.10.3.5

记录实验现象，并解释其原因；虚拟机 B 抓包结果

```
sudo tcpdump -i enp0s3 -en -c 3 icmp
```

```
08:00:27:3b:8d:be > 52:54:00:12:35:00, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 20, seq 1, length 64
```

```
08:00:27:3b:8d:be > 52:54:00:12:35:00, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 20, seq 2, length 64
```

```
08:00:27:3b:8d:be > 52:54:00:12:35:00, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 20, seq 3, length 64
```

虚拟机 B 路由表

```
default via 10.10.2.1 dev enp0s3 proto dhcp src 10.10.2.7 metric 100
```

```
10.10.2.0/24 dev enp0s3 proto kernel scope link src 10.10.2.7
```

```
10.10.2.1 dev enp0s3 proto dhcp scope link src 10.10.2.7 metric 100
```

```
192.168.56.0/24 dev enp0s8 proto kernel scope link src 192.168.56.103
```

从路由表分析来看，虚拟机 B 无 10.10.3.0/24 段匹配规则，走默认路由，即将报文发送到 10.10.2.1 网关，但是网关 10.10.2.1 与 10.10.3.1 不互通，所以网络不可达。

08:00:27:3b:8d:be: 虚拟机 B enp0s3 mac

52:54:00:12:35:00: 10.10.2.1 网关 mac

- 设置虚拟机 A 为转发节点，将虚拟机 B 的流量引流到虚拟机 A；即

```
ip -c -p ne replace dev enp0s3 10.10.2.1 lladdr 08:00:27:f0:1e:41
```

ping 10.10.3.5

先查看虚拟机 B 邻近表

```
10.10.2.1 dev enp0s3 lladdr 08:00:27:f0:1e:41 PERMANENT
```

```
192.168.56.1 dev enp0s8 lladdr 0a:00:27:00:00:00 REACHABLE
```

```
10.10.2.6 dev enp0s3 lladdr 08:00:27:99:cf:ce STALE
```

.....

虚拟机 B enp0s3 抓包结果

```
06:15:12.492475 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 22, seq 1, length 64
```

```
06:15:12.493386 08:00:27:99:cf:ce > 08:00:27:3b:8d:be, ethertype IPv4 (0x0800), length 98: 10.10.3.5 > 10.10.2.7: ICMP echo reply, id 22, seq 1, length 64
```

```
06:15:13.494000 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 22, seq 2, length 64
```

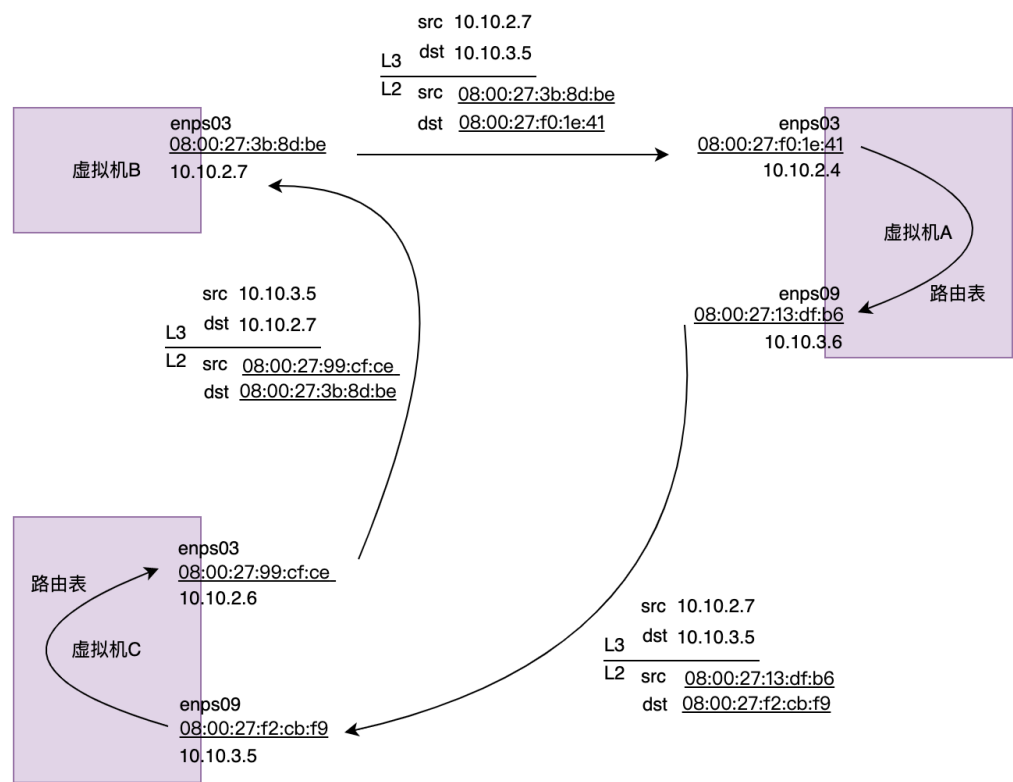
```
06:15:13.494746 08:00:27:99:cf:ce > 08:00:27:3b:8d:be, ethertype IPv4 (0x0800), length 98: 10.10.3.5 > 10.10.2.7: ICMP echo reply, id 22, seq 2, length 64
```

虚拟机 A enp0s3 抓包结果

```
13:07:36.589396 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 22, seq 1, length 64
13:07:37.590898 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 22, seq 2, length 64
13:07:38.591745 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 22, seq 3, length 64
```

虚拟机 A enp0s9 抓包结果

```
13:15:17.917318 08:00:27:13:df:b6 > 08:00:27:f2:cb:f9, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 23, seq 1, length 64
13:15:18.914365 08:00:27:13:df:b6 > 08:00:27:f2:cb:f9, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 23, seq 2, length 64
13:15:19.915532 08:00:27:13:df:b6 > 08:00:27:f2:cb:f9, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 23, seq 3, length 64
```



● eBPF 程序挂载到虚拟机 A enp0s3 网络设备 XDP

```
POST http://192.168.56.4:5555 //服务接口由 fwd 后台服务支持
{
  "action": "UpdateForward",
  "traceId": "1fabb3c6-bd56-48a7-ac41-132c8228f421",
  "ip": "10.10.3.5",
  "iface": "4",
  "srcMac": "08:00:27:13:df:b6",
  "dstMac": "08:00:27:f2:cb:f9"
}

bpftool prog load /usr/local/fwd/xdp/fwd.bpf.o /sys/fs/bpf/fwd map name hfw pinned /sys/fs/bpf/hfw

ip link set dev enp0s3 xdp pinned /sys/fs/bpf/fwd
```

即：（虚拟机 A）

```
enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 xdpgeneric/id:39 qdisc pfifo_fast state UP group default qlen 1000
```

```
link/ether 08:00:27:f0:1e:41 brd ff:ff:ff:ff:ff:ff
```

```
inet 10.10.2.4/24 brd 10.10.2.255 scope global dynamic enp0s3
```

```
valid_lft 520sec preferred_lft 520sec
```

```
inet6 fe80::a00:27ff:fe00:1e41/64 scope link
```

```
valid_lft forever preferred_lft forever
```

```
39: xdp name xdp_handle_fwd tag 24c0c136d96b2e7e gpl prog
```

```
loaded_at 2022-04-02T17:55:37+0800 uid 0
```

```
xlated 1752B jited 950B memlock 4096B map_ids 13
```

```
btf_id 20
```

```
13: lru_hash name hfwd flags 0x0 map
```

```
key 4B value 16B max_entries 10000 memlock 983040B
```

由于 XDP 处理报文位置比 tcpdump 抓包位置靠前，所以设置 XDP 后 tcpdump 抓不到报文。  
但是虚拟机 B 可以 PING 虚拟机 C。

```
PING 10.10.3.5 (10.10.3.5) 56(84) bytes of data.
```

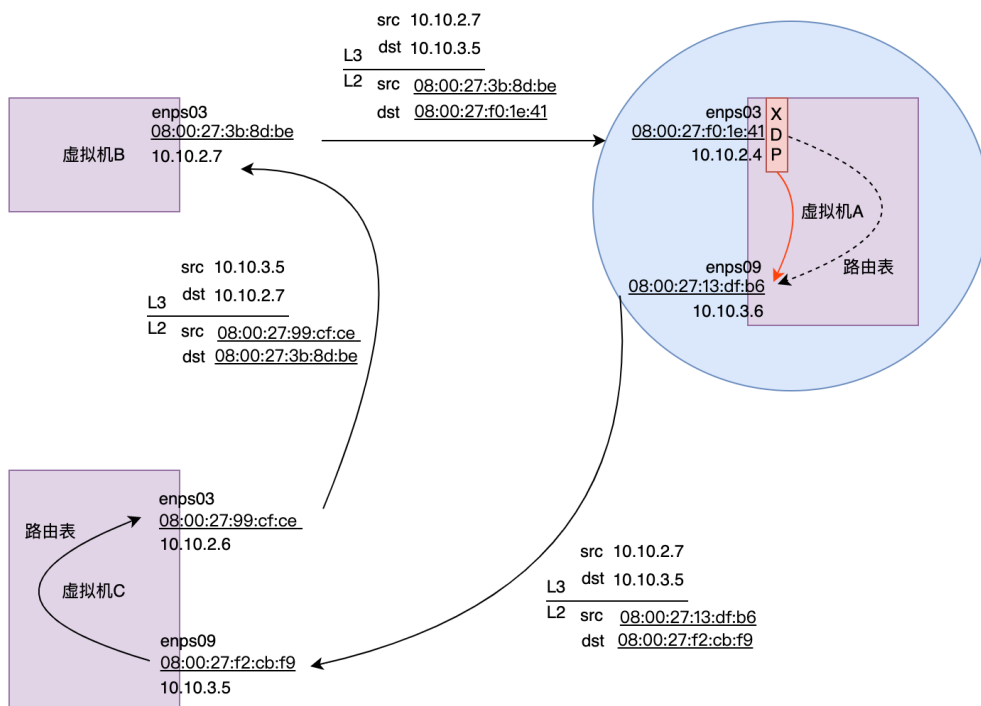
```
64 bytes from 10.10.3.5: icmp_seq=1 ttl=64 time=1.07 ms
```

```
64 bytes from 10.10.3.5: icmp_seq=2 ttl=64 time=1.04 ms
```

```
64 bytes from 10.10.3.5: icmp_seq=3 ttl=64 time=0.909 ms
```

```
64 bytes from 10.10.3.5: icmp_seq=4 ttl=64 time=0.886 ms
```

```
.....
```



## 虚拟机 A 的 XDP 调试信息

```
cat /sys/kernel/debug/tracing/trace_pipe
```

```
<idle>-0      [000] d.s.  8637.706822: bpf_trace_printk: fast fwd dstIp=5030a0a
<idle>-0      [000] d.s.  8638.708359: bpf_trace_printk: fast fwd dstIp=5030a0a
<idle>-0      [000] d.s.  8639.710464: bpf_trace_printk: fast fwd dstIp=5030a0a
<idle>-0      [000] d.s.  8640.712425: bpf_trace_printk: fast fwd dstIp=5030a0a
*****
```

## 虚拟机 B 的抓包信息

```
2022-04-02 10:16:23.707571 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 9, seq 1, length 64
2022-04-02 10:16:23.708285 08:00:27:99:cf:ce > 08:00:27:3b:8d:be, ethertype IPv4 (0x0800), length 98: 10.10.3.5 > 10.10.2.7: ICMP echo reply, id 9, seq 1, length 64
2022-04-02 10:16:24.737169 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 9, seq 2, length 64
2022-04-02 10:16:24.738435 08:00:27:99:cf:ce > 08:00:27:3b:8d:be, ethertype IPv4 (0x0800), length 98: 10.10.3.5 > 10.10.2.7: ICMP echo reply, id 9, seq 2, length 64
```

## ● 虚拟机 C 断开网线

```
ip link set dev enp0s3 down
```

```
-- 网络接口
```

```
enp0s3: <BROADCAST,MULTICAST> mtu 1500 qdisc fq_codel state DOWN group default qlen 1000
    link/ether 08:00:27:99:cf:ce brd ff:ff:ff:ff:ff:ff
```

```
-- 路由表
```

```
default via 10.10.3.1 dev enp0s9 proto dhcp metric 102
10.10.3.0/24 dev enp0s9 proto kernel scope link src 10.10.3.5 metric 102
```

```
-- 邻近表
```

```
192.168.56.100 dev enp0s8 lladdr 08:00:27:7d:10:6e STALE
10.10.3.4 dev enp0s9 lladdr 08:00:27:13:df:b6 STALE
192.168.56.1 dev enp0s8 lladdr 0a:00:27:00:00:00 REACHABLE
10.10.3.1 dev enp0s9 lladdr 52:54:00:12:35:00 REACHABLE
10.10.3.3 dev enp0s9 lladdr 08:00:27:66:3d:a8 STALE
```

## 虚拟机 C 的抓包信息

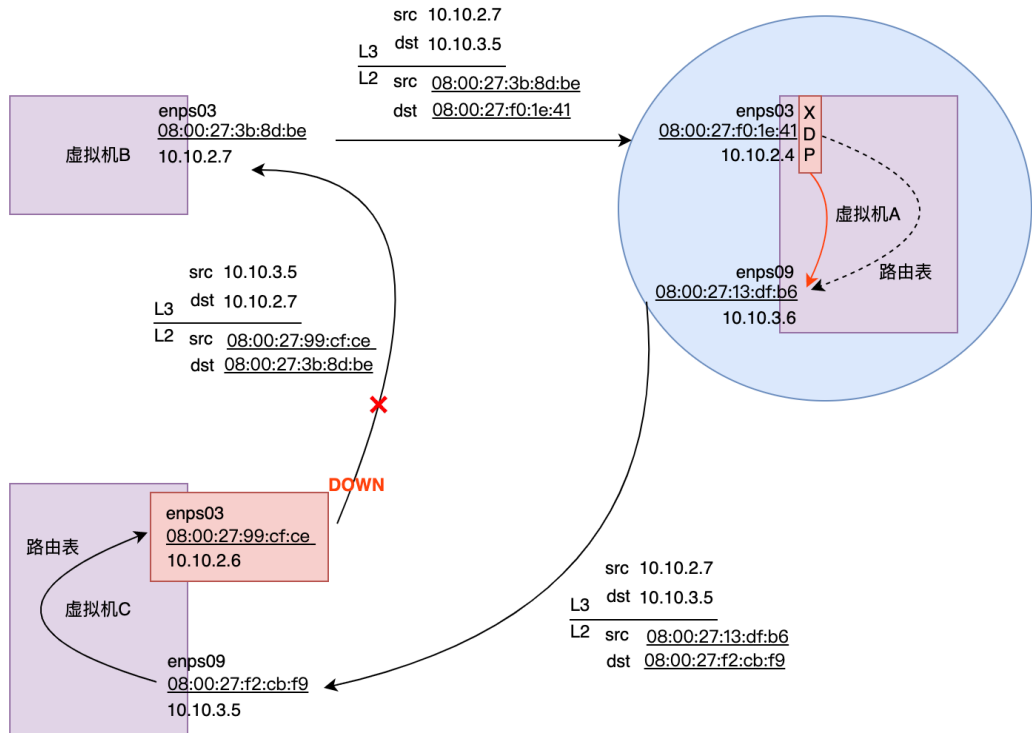
```
18:26:15.443735 08:00:27:13:df:b6 > 08:00:27:f2:cb:f9, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 10, seq 432, length 64
18:26:15.443799 08:00:27:f2:cb:f9 > 52:54:00:12:35:00, ethertype IPv4 (0x0800), length 98: 10.10.3.5 > 10.10.2.7: ICMP echo reply, id 10, seq 432, length 64
18:26:16.467785 08:00:27:13:df:b6 > 08:00:27:f2:cb:f9, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 10, seq 433, length 64
18:26:16.467849 08:00:27:f2:cb:f9 > 52:54:00:12:35:00, ethertype IPv4 (0x0800), length 98: 10.10.3.5 > 10.10.2.7: ICMP echo reply, id 10, seq 433, length 64
```

由于虚拟机 C enp0s3 网卡失效，所以虚拟机 C 接收到请求报文后进行响应报文，但是不知 10.10.2.7 的 mac 地址，所以将其送到 10.10.3.1 网关。

08:00:27:13:df:b6 虚拟机 B enp0s3 mac 地址

08:00:27:f2:cb:f9 虚拟机 C enp0s9 mac 地址

52:54:00:12:35:00 网关 10.10.3.1 mac 地址



## ● 修改下一跳

```
ip netns replace dev enps09 10.10.3.1 lladdr 08:00:27:13:df:b6
```

```
10.10.3.1 dev enps09 lladdr 08:00:27:13:df:b6 PERMANENT
```

## 虚拟机 B enps03 抓包结果

```
2022-04-02 10:58:47.809215 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 16, seq 1, length 64
2022-04-02 10:58:47.810481 08:00:27:f0:1e:41 > 08:00:27:3b:8d:be, ethertype IPv4 (0x0800), length 98: 10.10.3.5 > 10.10.2.7: ICMP echo reply, id 16, seq 1, length 64
2022-04-02 10:58:48.810920 08:00:27:3b:8d:be > 08:00:27:f0:1e:41, ethertype IPv4 (0x0800), length 98: 10.10.2.7 > 10.10.3.5: ICMP echo request, id 16, seq 2, length 64
2022-04-02 10:58:48.812717 08:00:27:f0:1e:41 > 08:00:27:3b:8d:be, ethertype IPv4 (0x0800), length 98: 10.10.3.5 > 10.10.2.7: ICMP echo reply, id 16, seq 2, length 64
```

## 虚拟机 A XDP Trace 结果

```
cat /sys/kernel/debug/tracing/trace_pipe

<idle>-0 [000] d.s. 11786.002732: bpf_trace_printk: fast fwd dstIp=5030a0a (5030a0a = 10.10.3.5)
<idle>-0 [000] d.s. 11786.003337: bpf_trace_printk: fast fwd dstIp=7020a0a (7020a0a = 10.10.2.7)
<idle>-0 [000] d.s. 11787.004502: bpf_trace_printk: fast fwd dstIp=5030a0a
<idle>-0 [000] d.s. 11787.004904: bpf_trace_printk: fast fwd dstIp=7020a0a
```

## 虚拟机 A enps03 enps09 抓包均未有数据，由于 XDP 转发

```
tcpdump -i enps03 -ennn -tttt -c 3 icmp
tcpdump -i enps09 -ennn -tttt -c 3 icmp
```

