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## Idea – TRILL-like forwarding

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The following example demonstrates a “Virtual MAC Address Forwarding” principle. The idea is simple – Host 1(h1) wants to ping Host 4(h4). Host 1 sends an ARP request to the Controller, the Controller returns the virtual MAC of the path to Switch 3(S3) – the MAC is 00:00:00:00:00:07. This virtual MAC summarizes all hosts that are directly connected to its ports.

Because of the ARP response, Host 1(h1) puts the 00:00:00:00:00:07 in the Destination MAC Field in the Ethernet header.

Inside the fabric, the forwarding decision is based on that VirtualMAC. Once the packet has reached the switch, where the destination host is directly connected, the switch reads the Dest IP address and puts the corresponding Dest MAC address in the Ethernet header – so that the packet will traverse the OSI layer.

This “Virtual MAC Address Forwarding” principle is suitable for “transparent host migration” - the TopologyMapper application at the controller side will register that a host has moved to another switch. For example, if Host 4 (h4) moves from S3 to S1, the Controller's ARP application will answer with a new VirtualMAC address that points to S1. The Algorithm application will calculate the path based on cost (for example – using Dijkstra's algorithm). The OpenFlow REST application will generate the forwarding rules for that new VirtualMAC address based on the provided path. From now on, when Host1 (h1) tries to ping Host 4 (h4), the controller will give a new ticket (the VirtualMAC) and the established OpenFlow forwarding logic will navigate the packet to S1.

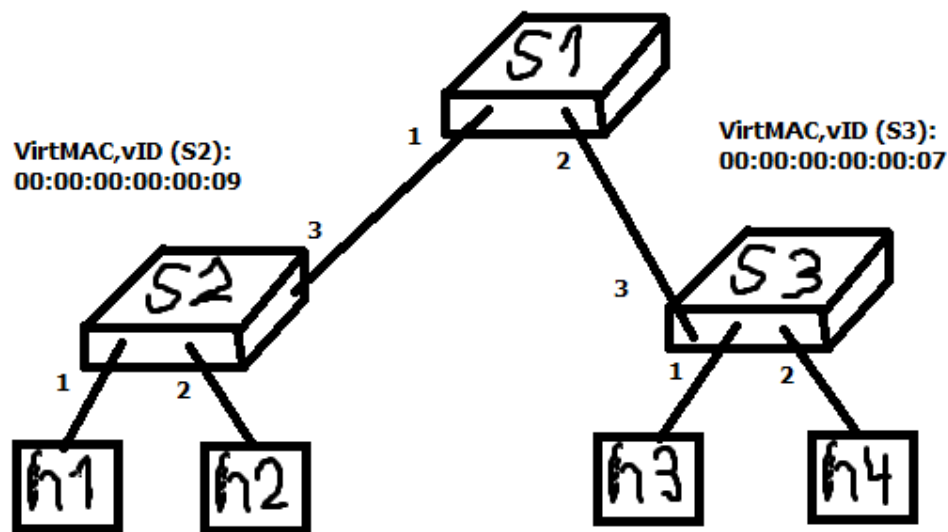
The VirtualMAC address is not a switch identifier – from the point of view of the OpenFlow forwarding logic it is a “ticket” that shows what path the packet should traverse until reaching the edge switch, where the destination host is directly connected. In contrast to standard routing, the Ethernet SourceMAC – DestMAC pair is not changed at each hop transition.

Here is the manual implementation of the described forwarding principle (the “automatic” implementation is currently under development):

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## Topology

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## S2 Config

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```
curl -X POST -d '{
  "dpid": 2,
  "priority": 65,
  "table_id": 0,
  "match": {
    "dl_dst": "00:00:00:00:00:09"
  },
  "actions": [
    {
      "type": "GOTO_TABLE",
      "table_id": 1
    }
  ]
}' http://localhost:8080/stats/flowentry/add
```

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```
curl -X POST -d '{
  "dpid": 2,
  "priority": 65,
  "table_id": 1,
  "match": {
    "nw_dst": "10.0.0.1",
    "dl_type": 2048
  },
  "actions": [
    {
```

```
        "type": "SET_FIELD",
        "field": "eth_dst",
        "value": "00:00:00:00:00:01"
    },
    {
        "type": "OUTPUT",
        "port": 1
    }
]
}' http://localhost:8080/stats/flowentry/add
```

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```
curl -X POST -d '{
    "dpid": 2,
    "priority": 65,
    "table_id": 1,
    "match": {
        "nw_dst": "10.0.0.2",
        "dl_type": 2048
    },
    "actions": [
        {
            "type": "SET_FIELD",
            "field": "eth_dst",
            "value": "00:00:00:00:00:02"
        },
        {
            "type": "OUTPUT",
            "port": 2
        }
    ]
}' http://localhost:8080/stats/flowentry/add
```

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```
curl -X POST -d '{
    "dpid": 2,
    "priority": 65,
    "table_id": 0,
    "match": {
        "dl_dst": "00:00:00:00:00:07"
    },
    "actions": [
        {
            "type": "OUTPUT",
            "port": 3
        }
    ]
}' http://localhost:8080/stats/flowentry/add
```

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```
curl -X POST -d '{
  "dpid": 3,
  "priority": 65,
  "table_id": 0,
  "match": {
    "dl_dst": "00:00:00:00:00:07"
  },
  "actions": [
    {
      "type": "GOTO_TABLE",
      "table_id": 1
    }
  ]
}' http://localhost:8080/stats/flowentry/add
```

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```
curl -X POST -d '{
  "dpid": 3,
  "priority": 65,
  "table_id": 1,
  "match": {
    "nw_dst": "10.0.0.3",
    "dl_type": 2048
  },
  "actions": [
    {
      "type": "SET_FIELD",
      "field": "eth_dst",
      "value": "00:00:00:00:00:03"
    },
    {
      "type": "OUTPUT",
      "port": 1
    }
  ]
}' http://localhost:8080/stats/flowentry/add
```

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```
curl -X POST -d '{
  "dpid": 3,
  "priority": 65,
  "table_id": 1,
  "match": {
    "nw_dst": "10.0.0.4",
    "dl_type": 2048
  },
  "actions": [
    {
      "type": "SET_FIELD",
      "field": "eth_dst",
      "value": "00:00:00:00:00:04"
    }
  ]
}' http://localhost:8080/stats/flowentry/add
```

```
        },
        {
            "type": "OUTPUT",
            "port": 2
        }
    ]
}' http://localhost:8080/stats/flowentry/add
```

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```
curl -X POST -d '{
    "dpid": 3,
    "priority": 65,
    "table_id": 0,
    "match": {
        "dl_dst": "00:00:00:00:00:09"
    },
    "actions": [
        {
            "type": "OUTPUT",
            "port": 3
        }
    ]
}' http://localhost:8080/stats/flowentry/add
```

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## S1 Config

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```
curl -X POST -d '{
    "dpid": 1,
    "priority": 65,
    "table_id": 0,
    "match": {
        "dl_dst": "00:00:00:00:00:07"
    },
    "actions": [
        {
            "type": "OUTPUT",
            "port": 2
        }
    ]
}' http://localhost:8080/stats/flowentry/add
```

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```
curl -X POST -d '{
    "dpid": 1,
    "priority": 65,
    "table_id": 0,
    "match": {
        "dl_dst": "00:00:00:00:00:09"
    },
    "actions": [
        {
```

```
        "type": "OUTPUT",
        "port": 1
    }
]
}' http://localhost:8080/stats/flowentry/add
```

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## h1 Config

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```
sudo arp -s 10.0.0.2 00:00:00:00:00:09
sudo arp -s 10.0.0.3 00:00:00:00:00:07
sudo arp -s 10.0.0.4 00:00:00:00:00:07
```

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## h2 Config

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```
sudo arp -s 10.0.0.1 00:00:00:00:00:09
sudo arp -s 10.0.0.3 00:00:00:00:00:07
sudo arp -s 10.0.0.4 00:00:00:00:00:07
```

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## h3 Config

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```
sudo arp -s 10.0.0.1 00:00:00:00:00:09
sudo arp -s 10.0.0.2 00:00:00:00:00:09
sudo arp -s 10.0.0.4 00:00:00:00:00:07
```

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## h4 Config

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```
sudo arp -s 10.0.0.1 00:00:00:00:00:09
sudo arp -s 10.0.0.2 00:00:00:00:00:09
sudo arp -s 10.0.0.3 00:00:00:00:00:07
```

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## Results:

```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4
h2 -> h1 h3 h4
h3 -> h1 h2 h4
h4 -> h1 h2 h3
*** Results: 0% dropped (12/12 received)
```

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Dumped flow table:

mininet> dpctl dump-flows

\*\*\* s1 -----

NXST\_FLOW reply (xid=0x4):

cookie=0x0, duration=12733.595s, table=0, n\_packets=478, n\_bytes=24378, idle\_age=12518,  
priority=65535,dl\_dst=01:80:c2:00:00:0e,dl\_type=0x88cc actions=CONTROLLER:65535  
cookie=0x0, duration=12732.661s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12762,  
priority=65000,arp actions=CONTROLLER:65535  
cookie=0x0, duration=23.559s, table=0, n\_packets=0, n\_bytes=0, idle\_age=23,  
priority=65,dl\_dst=00:00:00:00:00:07 actions=output:2  
cookie=0x0, duration=4.792s, table=0, n\_packets=0, n\_bytes=0, idle\_age=4,  
priority=65,dl\_dst=00:00:00:00:00:09 actions=output:1  
cookie=0x0, duration=12732.663s, table=0, n\_packets=5, n\_bytes=370, idle\_age=12726,  
priority=0 actions=CONTROLLER:65535  
cookie=0x0, duration=12518.355s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12731,  
priority=0,in\_port=2,dl\_src=26:9d:20:7d:59:00 actions=drop  
cookie=0x0, duration=12518.208s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12729,  
priority=0,in\_port=1,dl\_src=0a:eb:f2:78:7c:45 actions=drop

\*\*\* s2 -----

NXST\_FLOW reply (xid=0x4):

cookie=0x0, duration=12733.604s, table=0, n\_packets=238, n\_bytes=12138, idle\_age=12518,  
priority=65535,dl\_dst=01:80:c2:00:00:0e,dl\_type=0x88cc actions=CONTROLLER:65535  
cookie=0x0, duration=12732.683s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12732,  
priority=65000,arp actions=CONTROLLER:65535  
cookie=0x0, duration=108.129s, table=0, n\_packets=0, n\_bytes=0, idle\_age=108,  
priority=65,dl\_dst=00:00:00:00:00:09 actions=resubmit(1)  
cookie=0x0, duration=57.637s, table=0, n\_packets=0, n\_bytes=0, idle\_age=57,  
priority=65,dl\_dst=00:00:00:00:00:07 actions=output:3  
cookie=0x0, duration=12732.692s, table=0, n\_packets=8, n\_bytes=616, idle\_age=10735,  
priority=0 actions=CONTROLLER:65535  
cookie=0x0, duration=12518.446s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12728,  
priority=0,in\_port=3,dl\_src=b2:35:7e:b0:e2:04 actions=drop  
cookie=0x0, duration=12725.229s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12727,  
priority=0,in\_port=2,dl\_src=00:00:00:00:00:02 actions=drop  
cookie=0x0, duration=12725.117s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12727,  
priority=0,in\_port=1,dl\_src=00:00:00:00:00:01 actions=drop  
cookie=0x0, duration=10755.499s, table=0, n\_packets=0, n\_bytes=0, idle\_age=10755,  
priority=0,in\_port=3,dl\_src=00:00:00:00:00:03 actions=drop  
cookie=0x0, duration=10735.414s, table=0, n\_packets=0, n\_bytes=0, idle\_age=10735,  
priority=0,in\_port=3,dl\_src=00:00:00:00:00:04 actions=drop  
cookie=0x0, duration=90.361s, table=1, n\_packets=0, n\_bytes=0, idle\_age=90,  
priority=65,ip,nw\_dst=10.0.0.1 actions=mod\_dl\_dst:00:00:00:00:00:01,output:1  
cookie=0x0, duration=71.786s, table=1, n\_packets=0, n\_bytes=0, idle\_age=71,  
priority=65,ip,nw\_dst=10.0.0.2 actions=mod\_dl\_dst:00:00:00:00:00:02,output:2

\*\*\* s3 -----

NXST\_FLOW reply (xid=0x4):

cookie=0x0, duration=12733.677s, table=0, n\_packets=239, n\_bytes=12189, idle\_age=12518,  
priority=65535,dl\_dst=01:80:c2:00:00:0e,dl\_type=0x88cc actions=CONTROLLER:65535  
cookie=0x0, duration=12732.742s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12732,  
priority=65000,arp actions=CONTROLLER:65535  
cookie=0x0, duration=11646.098s, table=0, n\_packets=8, n\_bytes=784, idle\_age=525,  
priority=65,dl\_dst=00:00:00:00:00:07 actions=resubmit(1)  
cookie=0x0, duration=11565.397s, table=0, n\_packets=4, n\_bytes=392, idle\_age=10725,  
priority=65,dl\_dst=00:00:00:00:00:09 actions=output:3  
cookie=0x0, duration=12732.744s, table=0, n\_packets=8, n\_bytes=600, idle\_age=12725,  
priority=0 actions=CONTROLLER:65535  
cookie=0x0, duration=12518.546s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12730,  
priority=0,in\_port=3,dl\_src=6a:45:54:01:0b:ad actions=drop  
cookie=0x0, duration=12725.003s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12727,  
priority=0,in\_port=2,dl\_src=00:00:00:00:00:04 actions=drop  
cookie=0x0, duration=12725.034s, table=0, n\_packets=0, n\_bytes=0, idle\_age=12727,  
priority=0,in\_port=1,dl\_src=00:00:00:00:00:03 actions=drop  
cookie=0x0, duration=11620.689s, table=1, n\_packets=4, n\_bytes=392, idle\_age=525,  
priority=65,ip,nw\_dst=10.0.0.3 actions=mod\_dl\_dst:00:00:00:00:00:03,output:1  
cookie=0x0, duration=11593.530s, table=1, n\_packets=4, n\_bytes=392, idle\_age=525,  
priority=65,ip,nw\_dst=10.0.0.4 actions=mod\_dl\_dst:00:00:00:00:00:04,output:2