



# CS120: Computer Networks

## **Lecture 12. Other Topics in IP Layer**

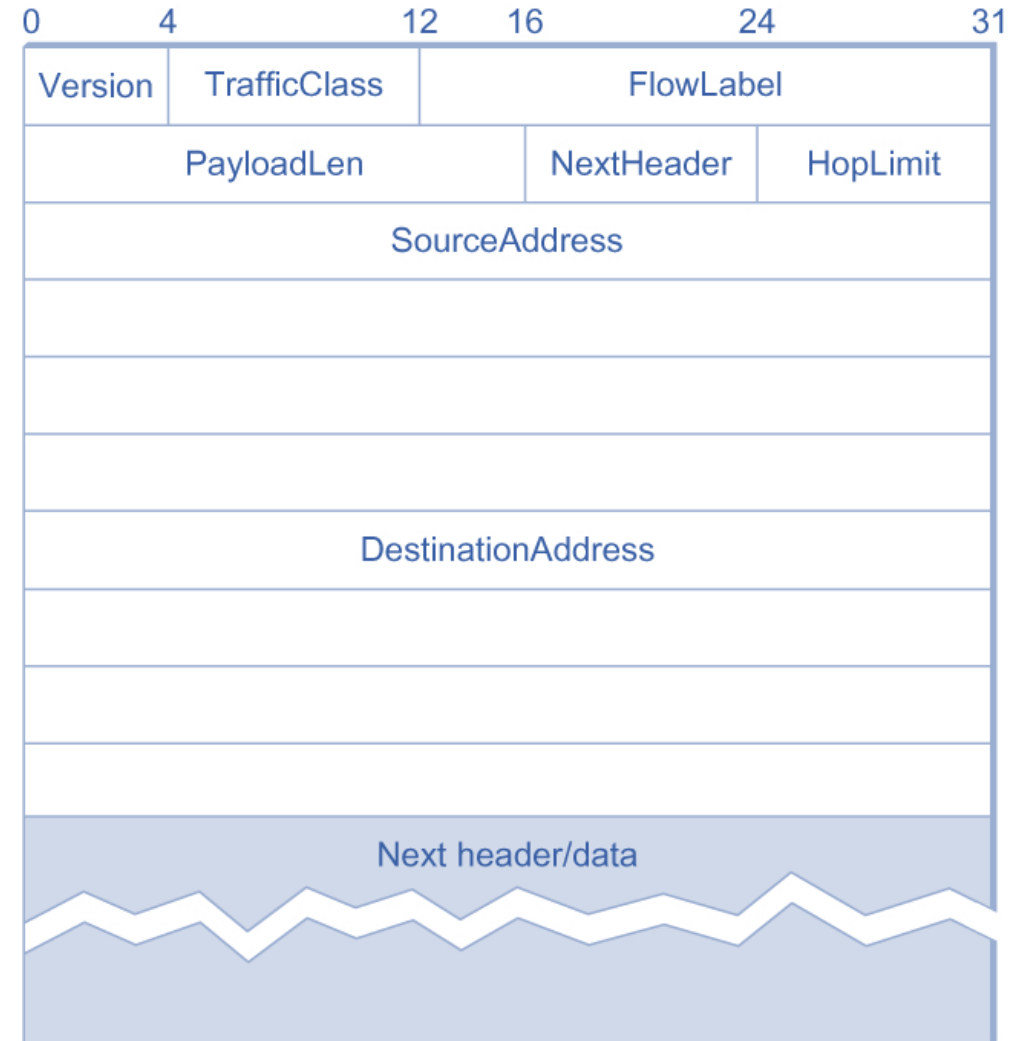
Zhice Yang

# Outline

- IPv6
- NAT
- Router Implementation

# IP Version 6 (IPv6)

- Motivation
  - 32 bits IPv4 Address is not enough
  - Other Features
    - Stateless auto configuration
    - Source routing
- Launched around 2000
- IPv6 “base” Header
  - 40 bytes “base” header
  - 16 bytes addresses
- Extension headers
  - Fragmentation
  - Source routing
  - etc.



# IPv6 Address

- 16 bytes
  - 1500 addresses per square foot (Earth's surface)
- Classless addressing/routing (similar to CIDR)
  - Notation: x:x:x:x:x:x:x/y (x = 16-bit hex number, y = netmask)
  - Contiguous 0s are compressed: 47CD::A456:0124
  - IPv4-mapped IPv6 address: ::FFFF:123.45.67.8
- Address assignment



64bit

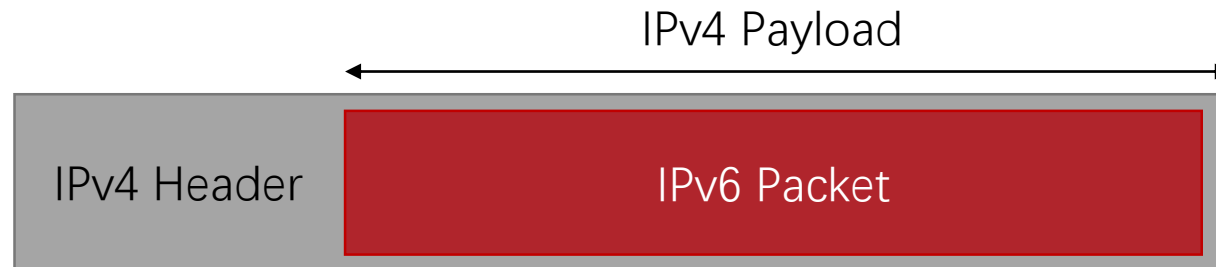
# Transition from IPv4 to IPv6

- IETF began looking at the problem of IPv4 address space in 1991
- Not all routers can be upgraded simultaneously

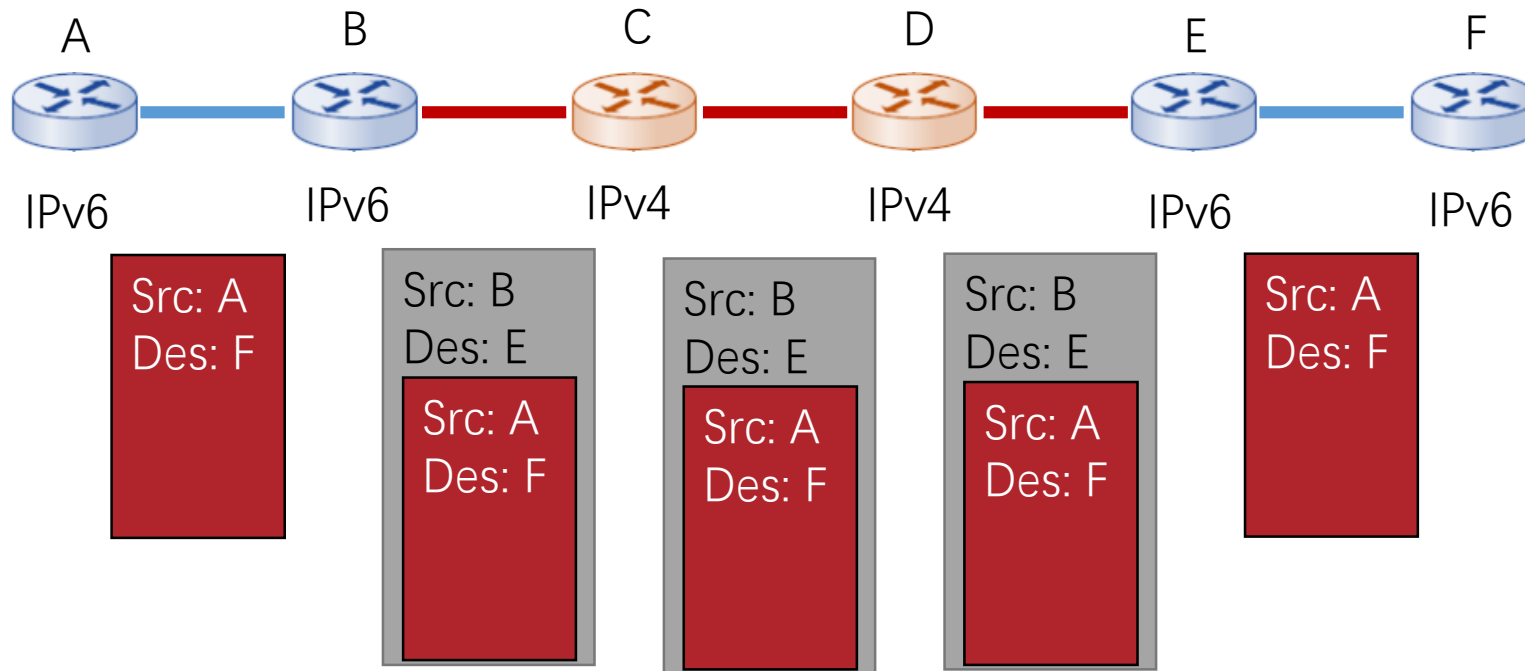
How will network operate with mixed IPv4 and IPv6 routers?

# Transition from IPv4 to IPv6

- Tunneling: IPv6 datagram carried as payload in IPv4 datagram among IPv4 routers



# Transition from IPv4 to IPv6



# Outline

- IPv6
  - NAT
- Router Implementation



# NAT: Network Address Translation

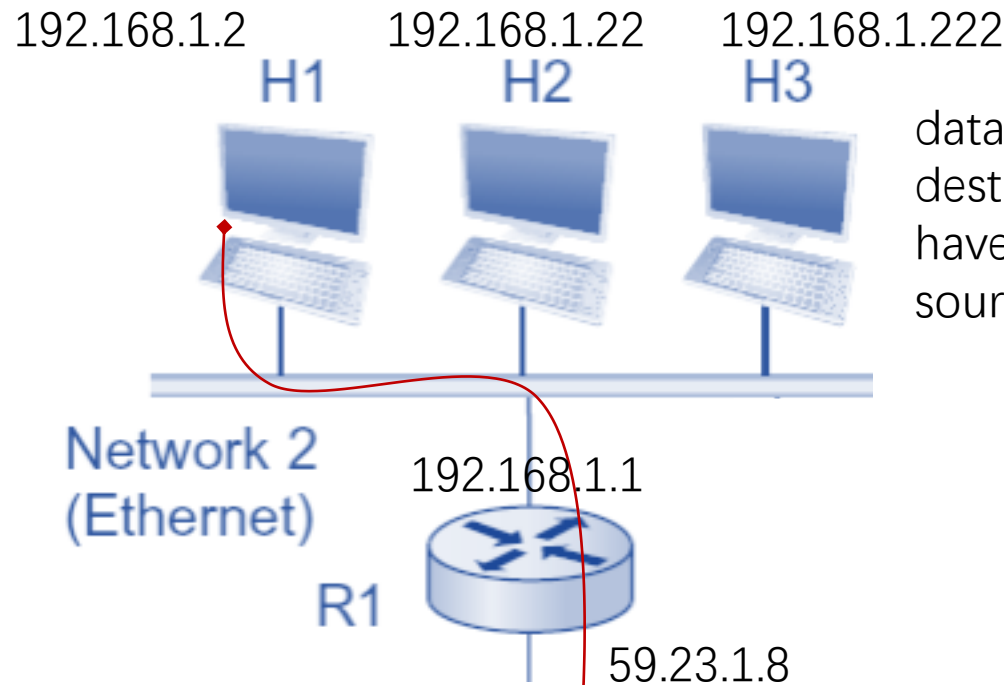
Wireless LAN adapter Wi-Fi:

```

Connection-specific DNS Suffix  . :
Link-local IPv6 Address . . . . . : fe80::d1b5:35be:9832:af6c%9
IPv4 Address. . . . . : 192.168.31.143
Subnet Mask . . . . . : 255.255.255.0
Default Gateway . . . . . : 192.168.31.1
  
```

Address range	Subnet mask	Provides	Addresses per LAN
10.0.0.0 - 10.255.255.255.255	255.0.0.0	1 class A LAN	16,777,216
172.16.0.0 - 172.31.255.255	255.255.0.0	16 class B LANs	65,536
192.168.0.0 - 192.168.255.255	255.255.255.0	256 class C LANs	256

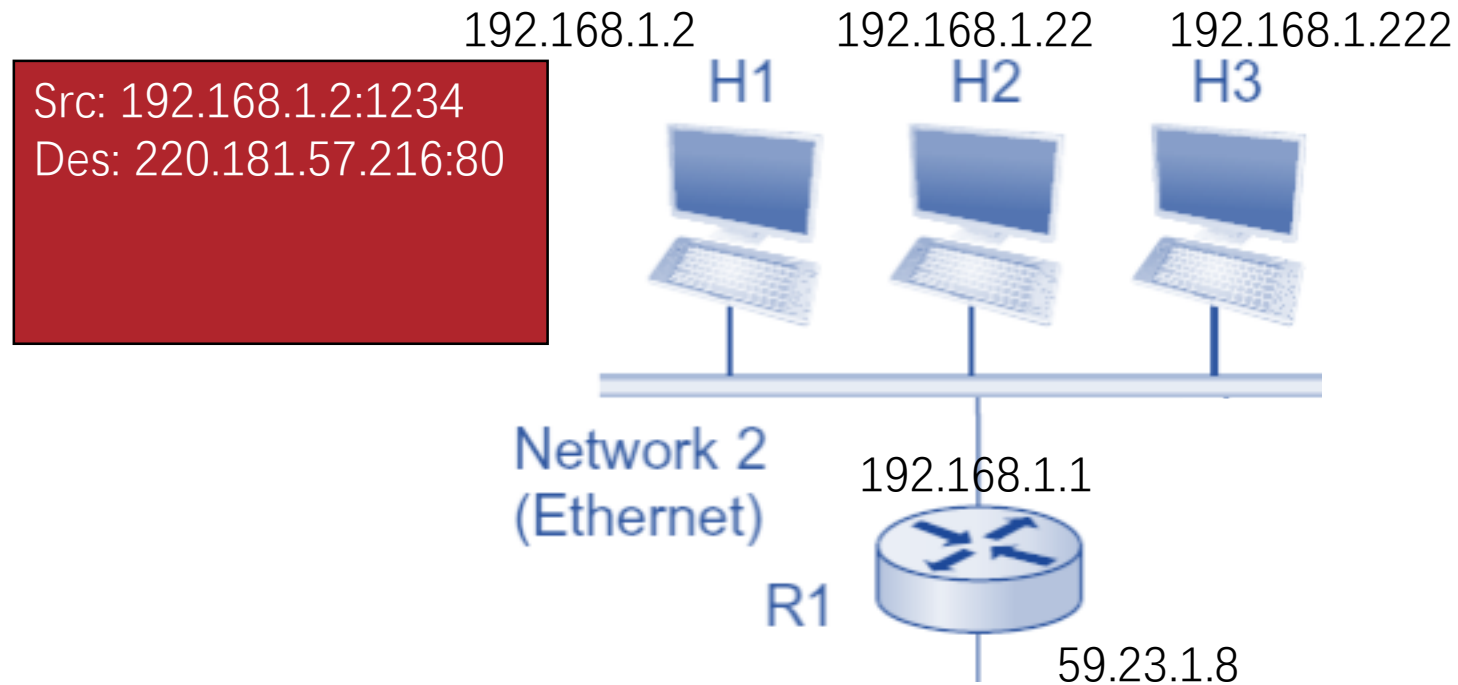
# NAT: Network Address Translation



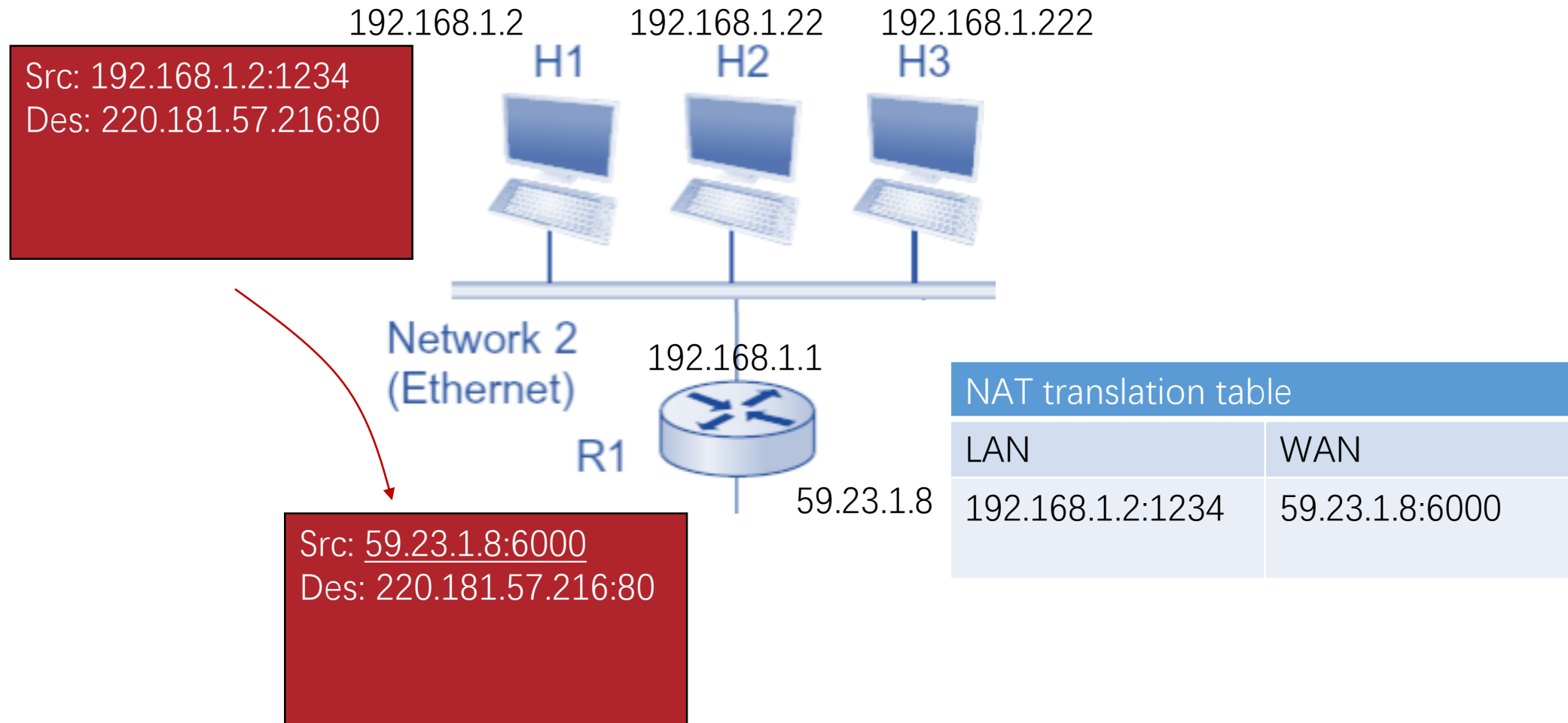
datagrams with source or destination in this network have 192.168.1.0/24 address for source, destination (as usual)

All datagrams leaving local network have same single source NAT IP address: 59.23.1.8, different source port numbers

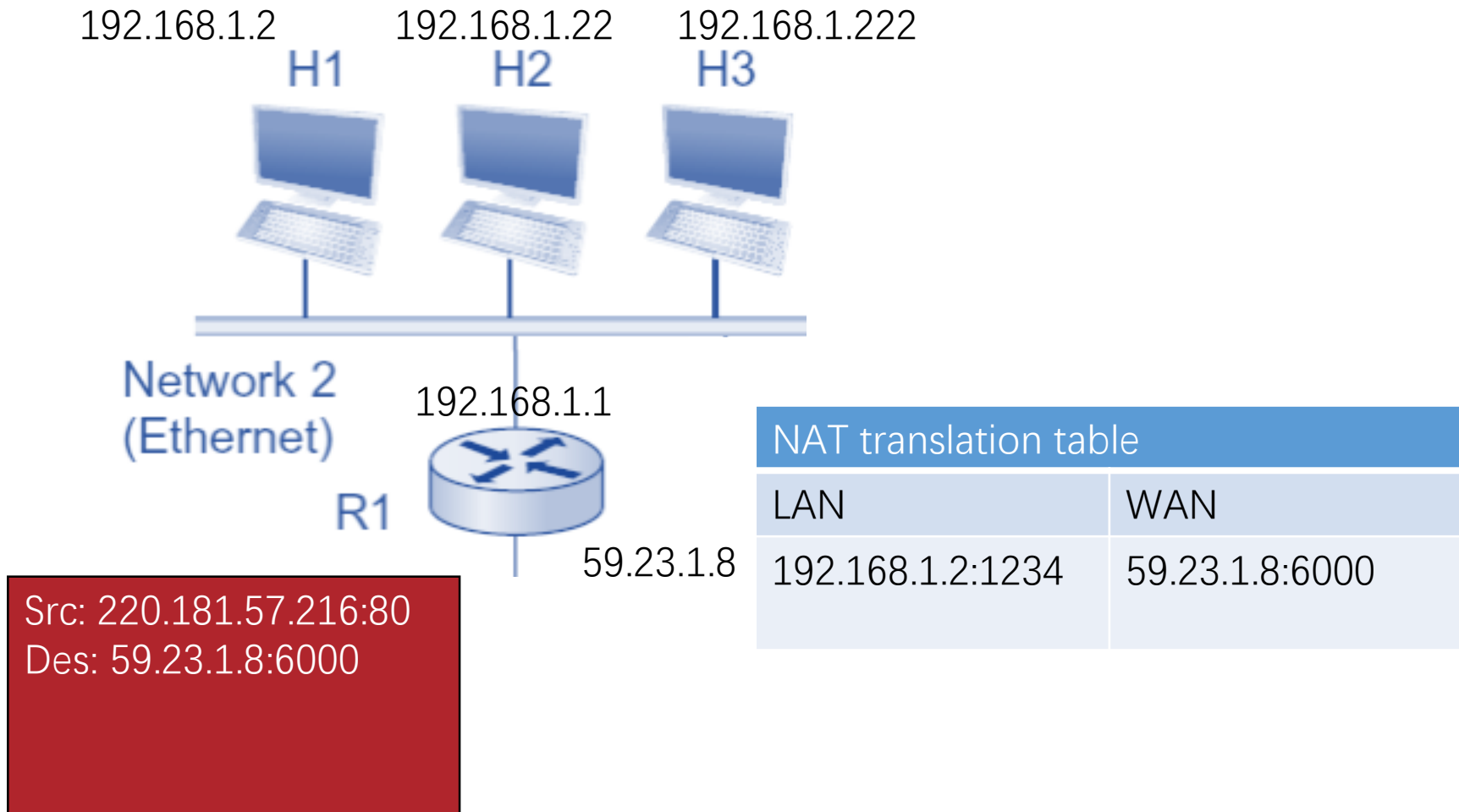
# NAT: Network Address Translation



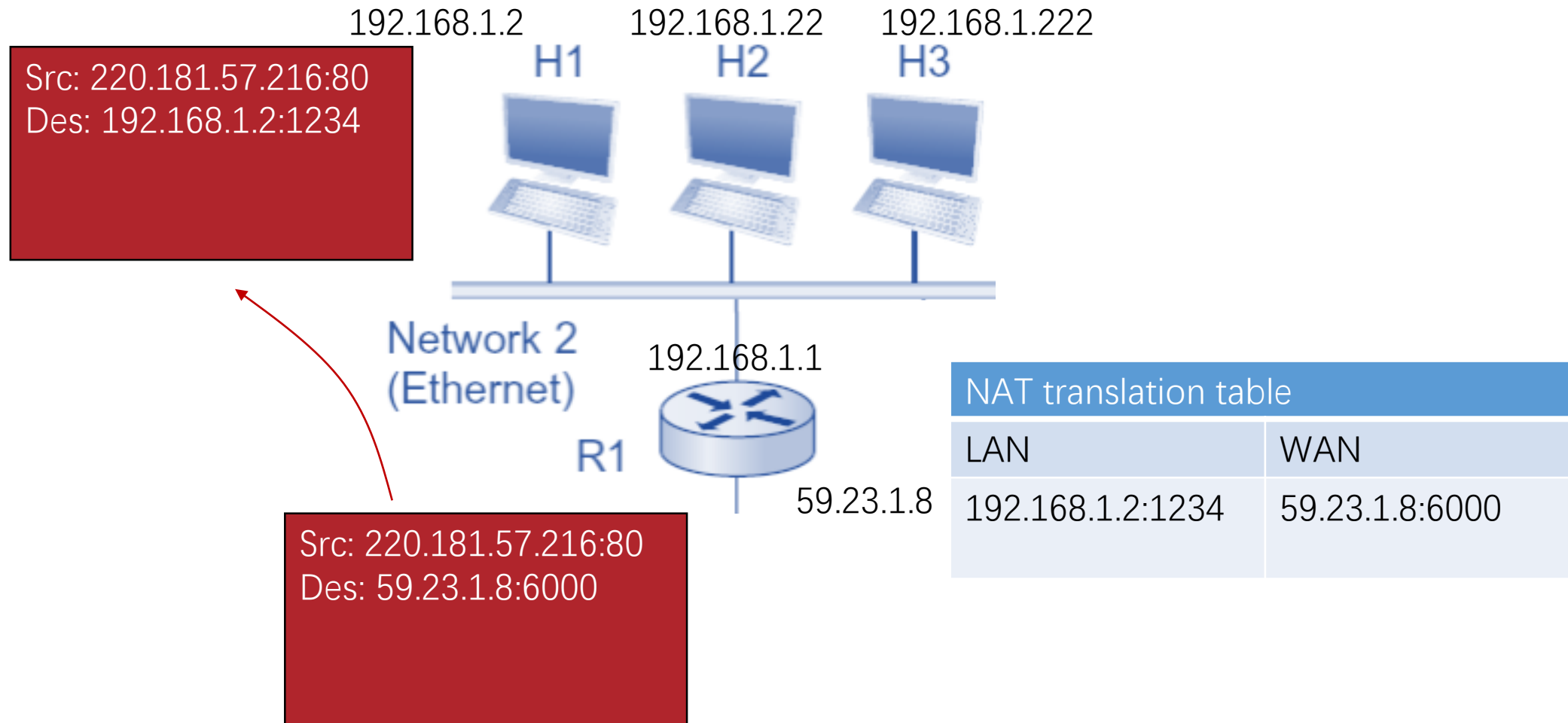
# NAT: Network Address Translation



# NAT: Network Address Translation

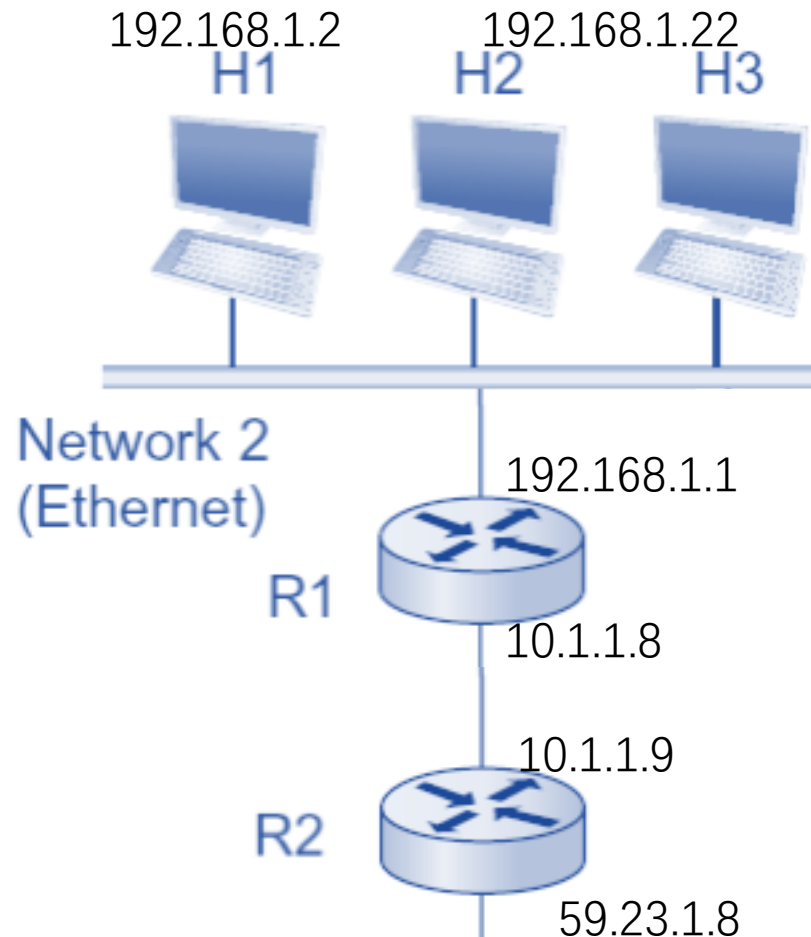


# NAT: Network Address Translation



# NAT: Network Address Translation

- Multi Layer NAT



NAT translation table R1

LAN	WAN
192.168.1.2:1234	10.1.1.8:6321

NAT translation table R2

LAN	WAN
10.1.1.8:6321	59.23.1.8:6000

# NAT: Network Address Translation

- Demo

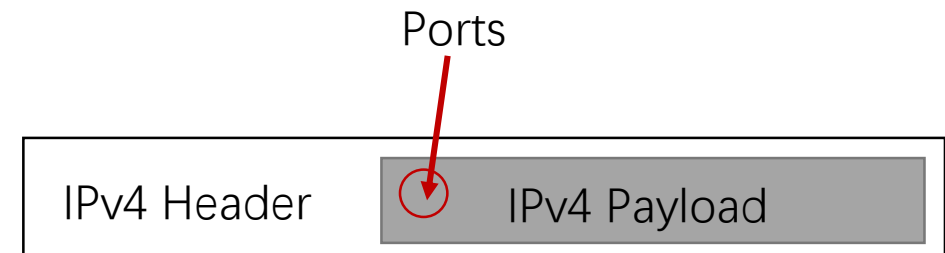
```
Tracing route to baidu.com [111.13.101.208]
over a maximum of 30 hops:

  1      5 ms      2 ms      <1 ms  XiaoQiang [192.168.31.1]
  2      2 ms      2 ms      3 ms   10.19.14.1
  3     11 ms      1 ms      2 ms   10.13.7.25
  4      *         *         *     Request timed out.
```



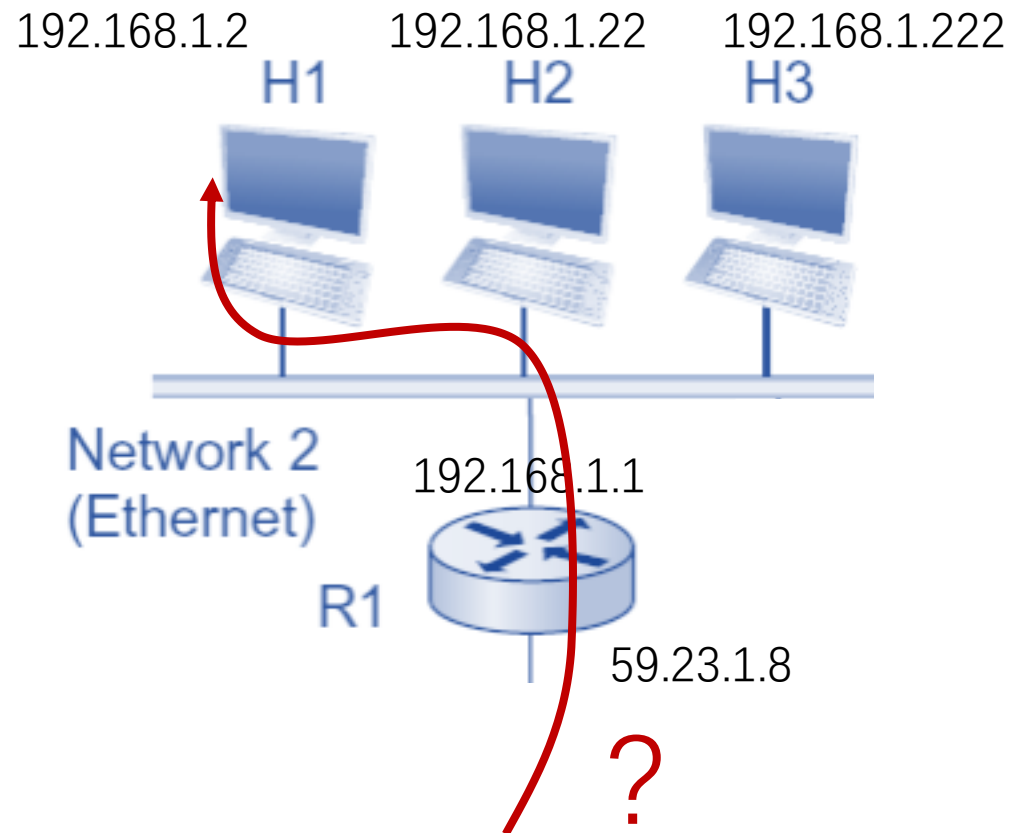
# NAT: Network Address Translation

- 16-bit port-number field (see later lecture)
  - ~60,000 simultaneous connections with a single IPv4 address
  - Hosts uses LAN addresses
    - 192.168.0.0/16
    - 10.0.0.0/8
    - 172.16.0.0/12
    - etc.
- Criticisms
  - NAT is “impure”
    - Routers should not touch higher layers
  - Efficiency
  - Traversal Connections



# NAT Traversal Problem

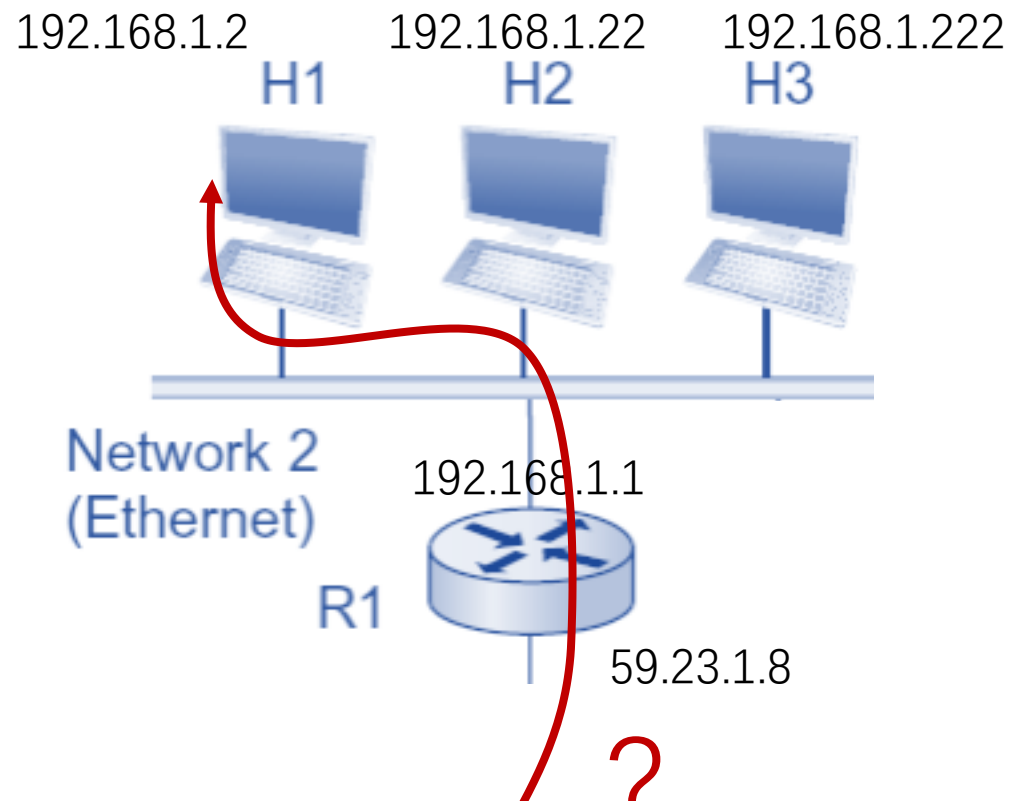
- How to initiate connections to Host 1 from the external network?
  - e.g., VoIP (Voice Call)



# NAT Traversal Problem

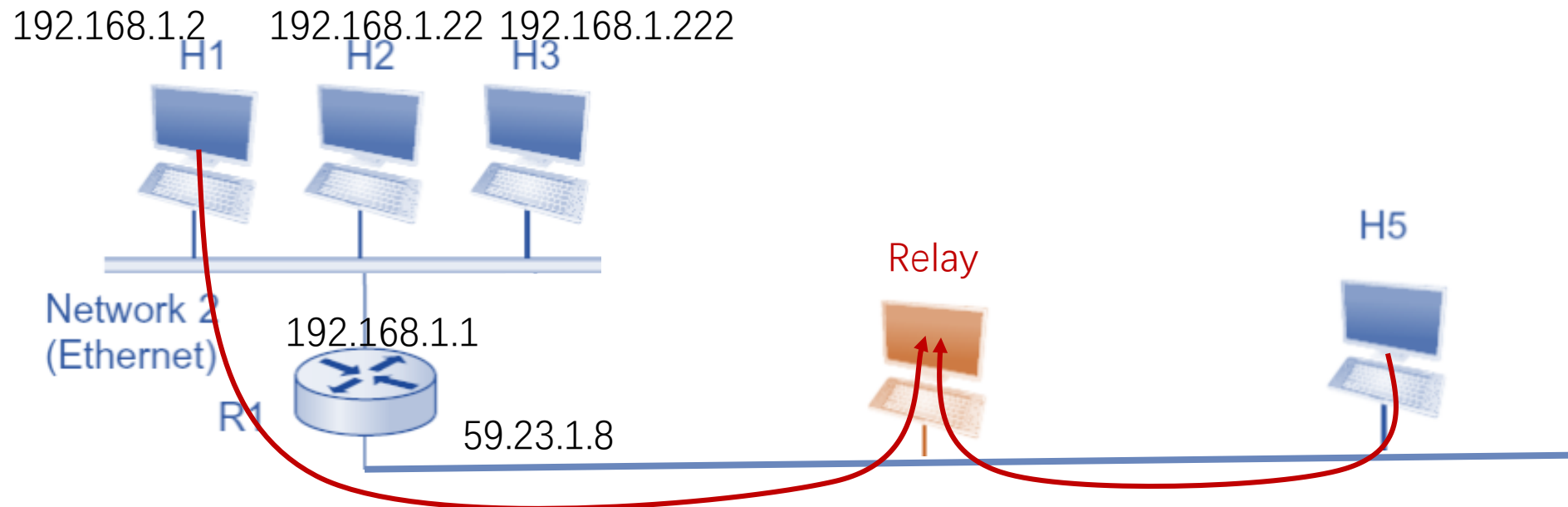
- Solution 1: Static Configure
  - Configure NAT to forward incoming connection requests at given port to the host
  - Need to know the port

NAT translation table	
LAN	WAN
192.168.1.2:80	59.23.1.8: <u>6000</u>



# NAT Traversal Problem

- Solution 2: Relay
  - NATed host establishes connection to relay
  - External host connects to relay
  - Relay bridges packets between two connections



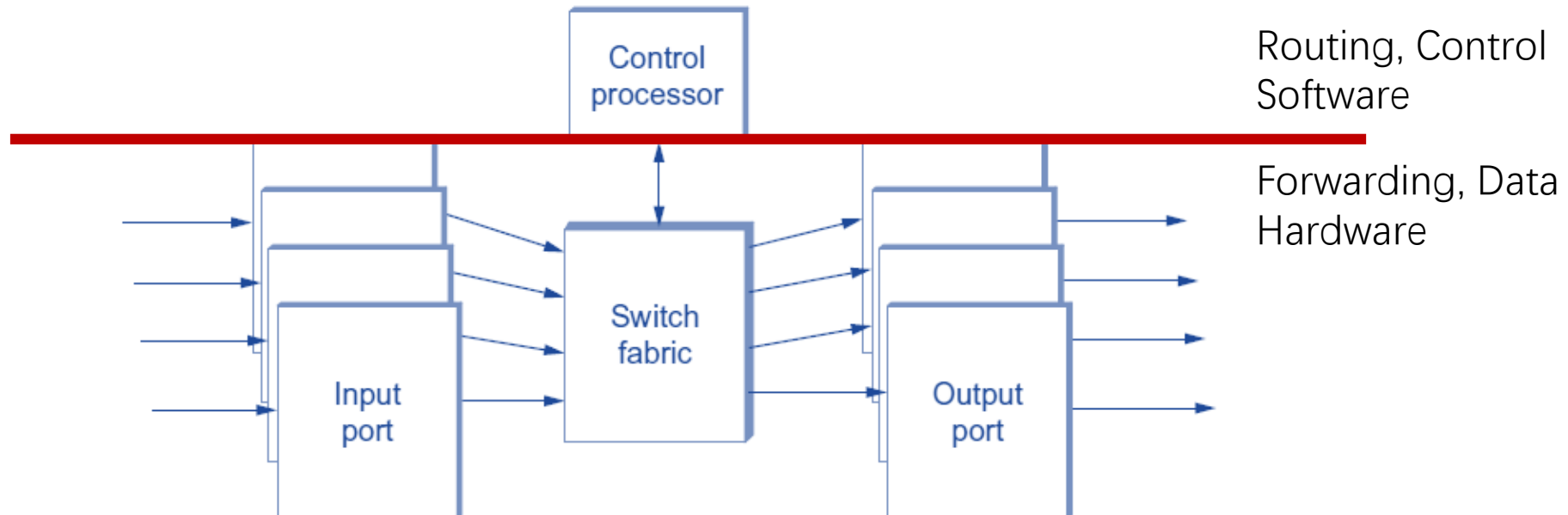
# Outline

- IPv6
- NAT
- Router Implementation

# Router Architecture



- Two Key Functions:
  - Routing protocols (e.g., RIP, OSPF, BGP, etc.)
  - Forwarding packets from input to output ports
- Performance metrics: packet per second (PPS)

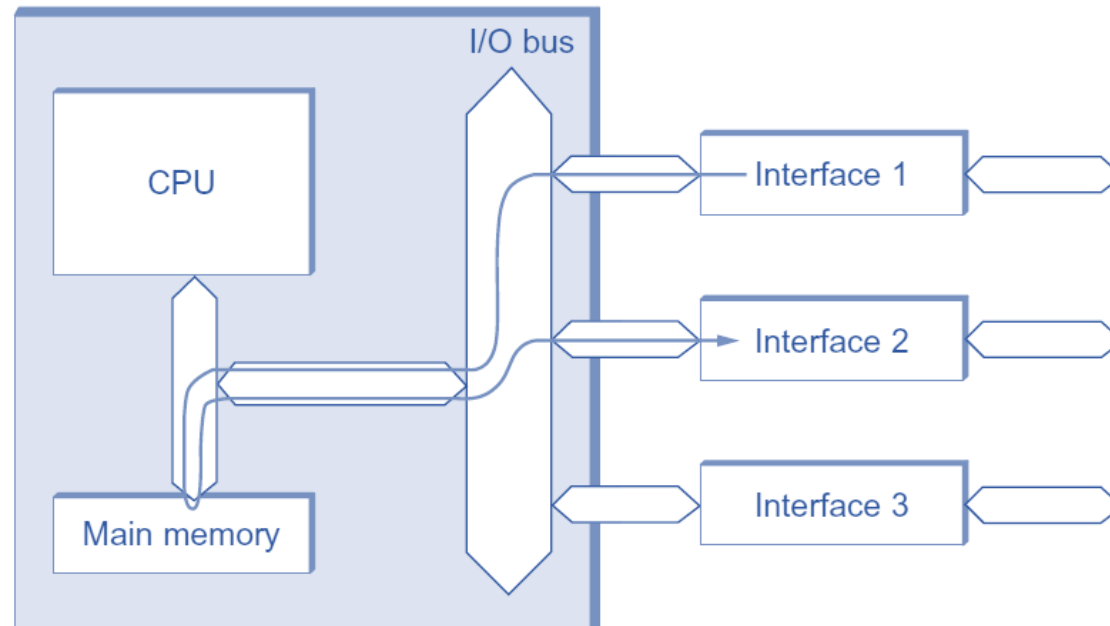


# Key Components

- Control Processor
  - Control and configuration
    - Ports and switch fabrics
  - Calculation
    - Routing Algorithm
    - Push forwarding tables into ports
- Port
  - Handle PHY and MAC Protocols
  - Output Port Looking Up
  - Deliver Packet to Switch Fabric
  - Buffer
- Switching Fabrics
  - Transfer packets from input buffer to appropriate output buffer
  - Types
    - Shared Bus/memory
    - Crossbar
    - Self-routing

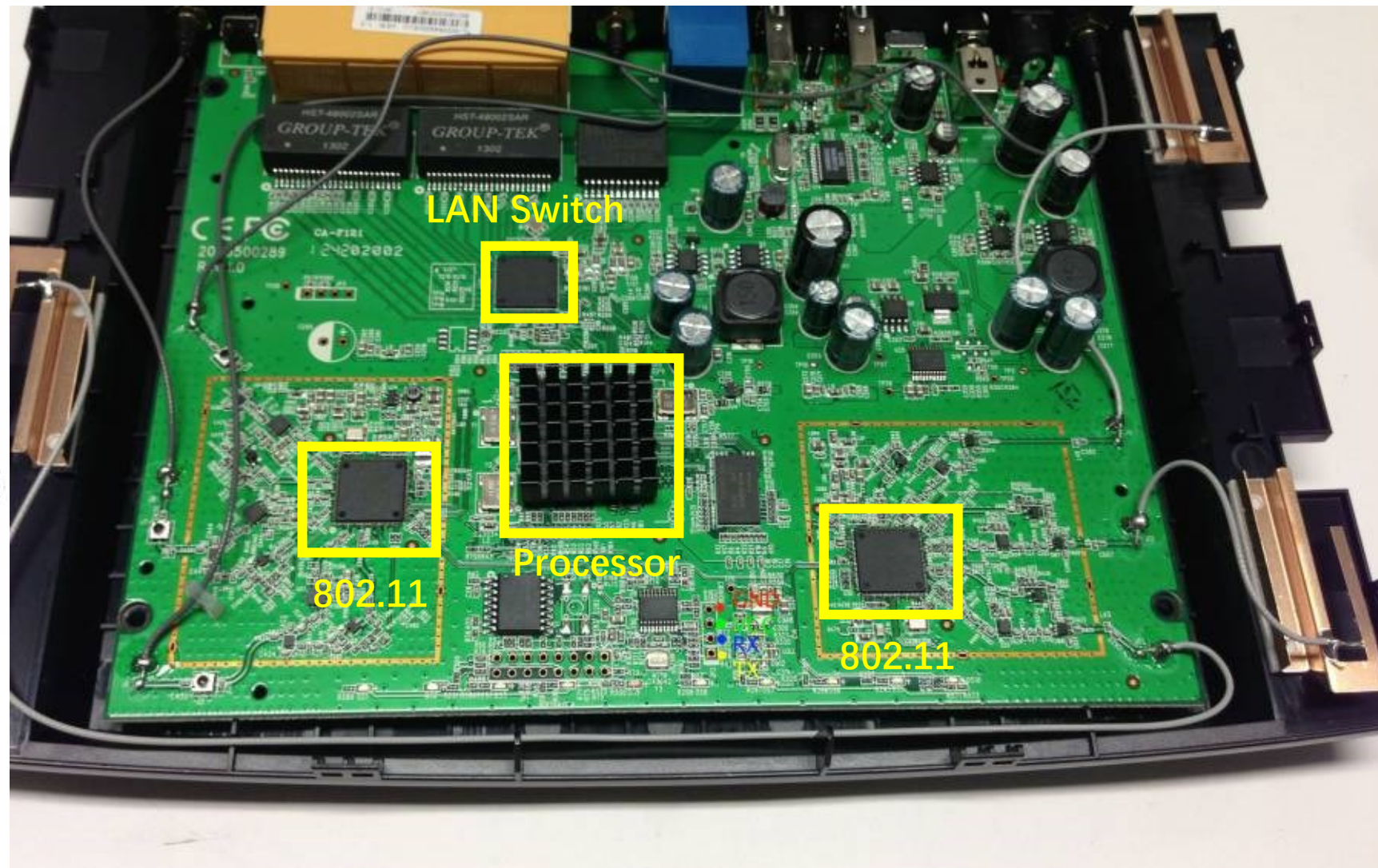
# Shared Bus/Memory

- Datagram from input port to output port via a shared bus
  - 2 bus crossings per datagram
  - Bus and memory bandwidth determines switch throughput



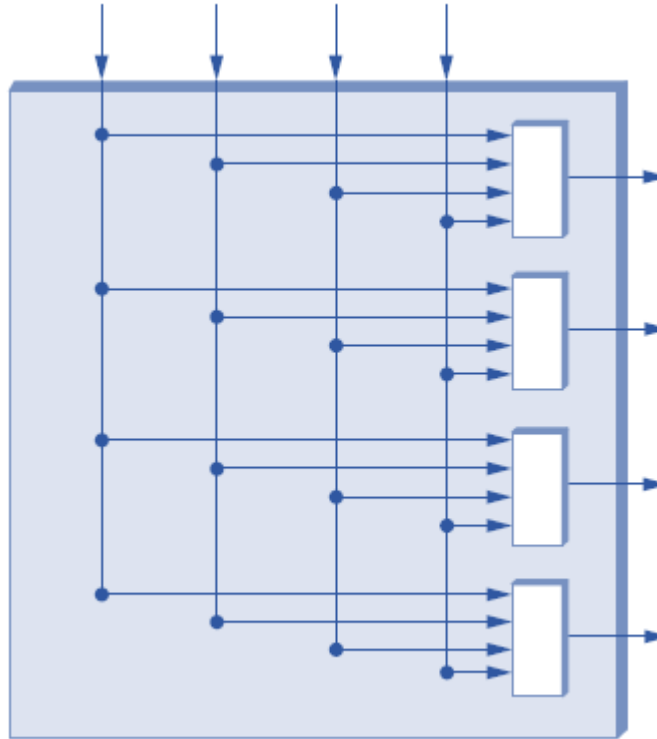


# Inside Wireless Routers



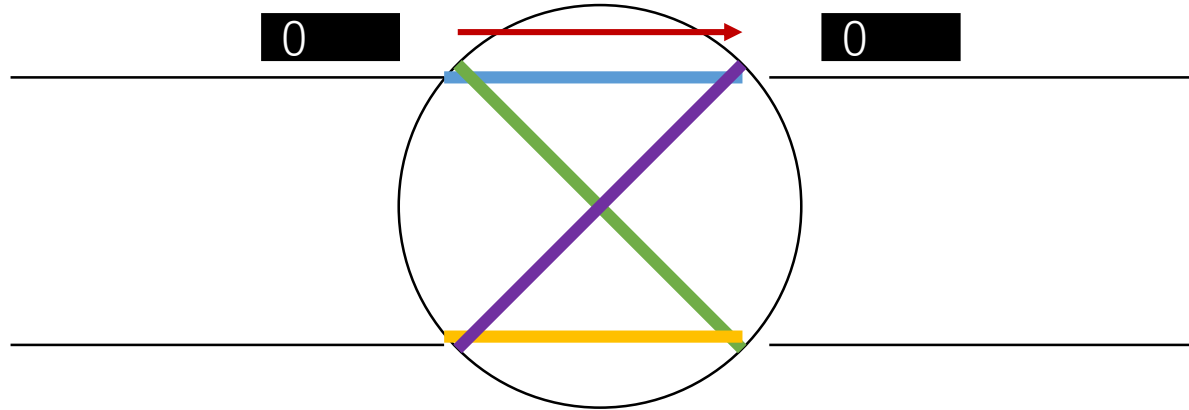
# Crossbar

- A crossbar switch is a matrix of pathways that can be configured to connect any input port to any output port



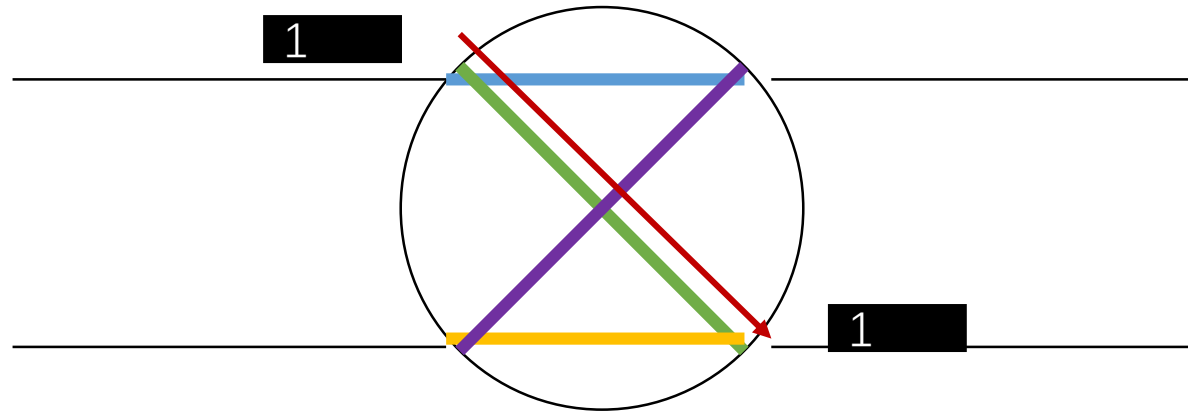
# Self-routing

- Switching Element
  - 0=> up
  - 1=> down



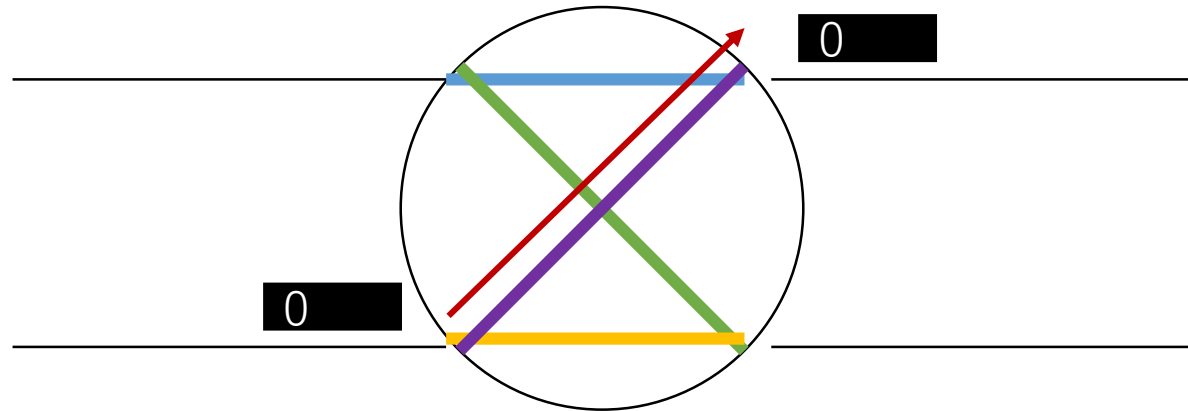
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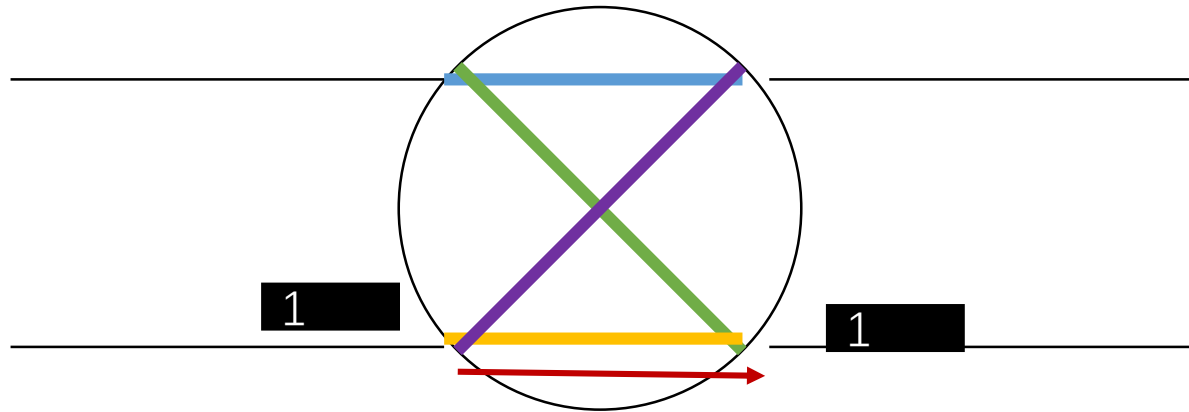
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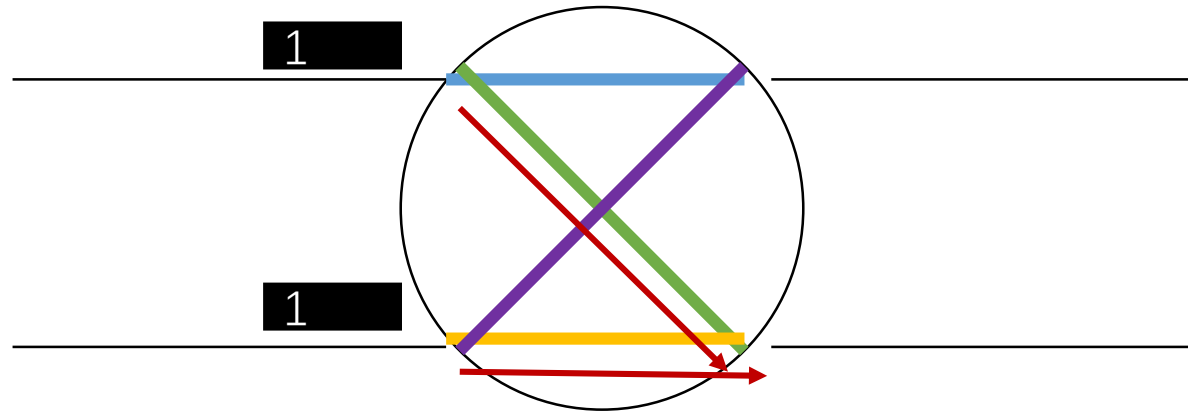
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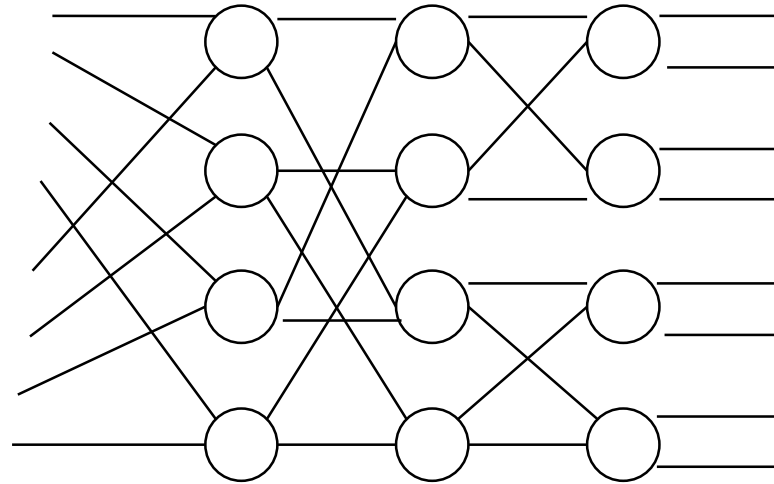
# Self-routing

- Switching Element
  - Collision: Two packets with same output ports



# Self-routing

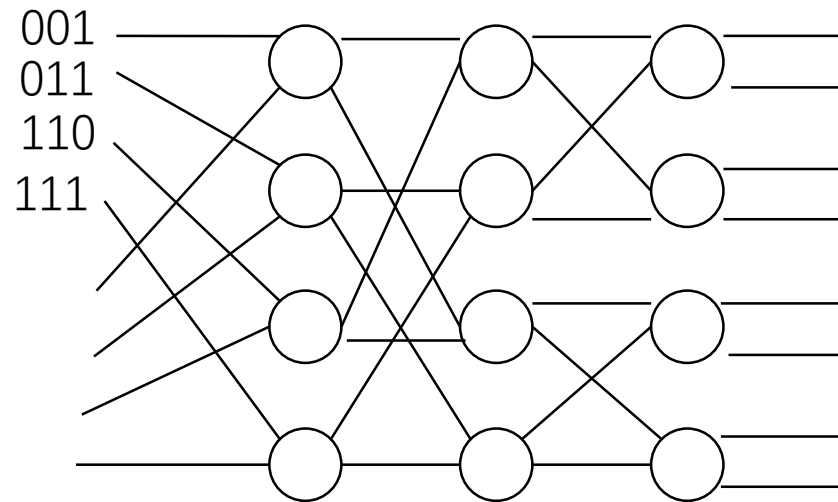
- Banyan Network
  - Collision Free
    - Input Packets are sorted according to routing header





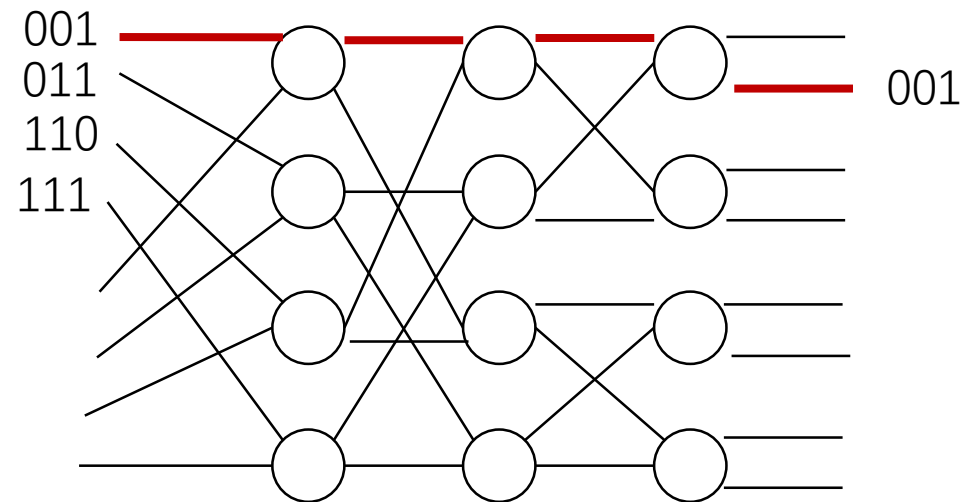
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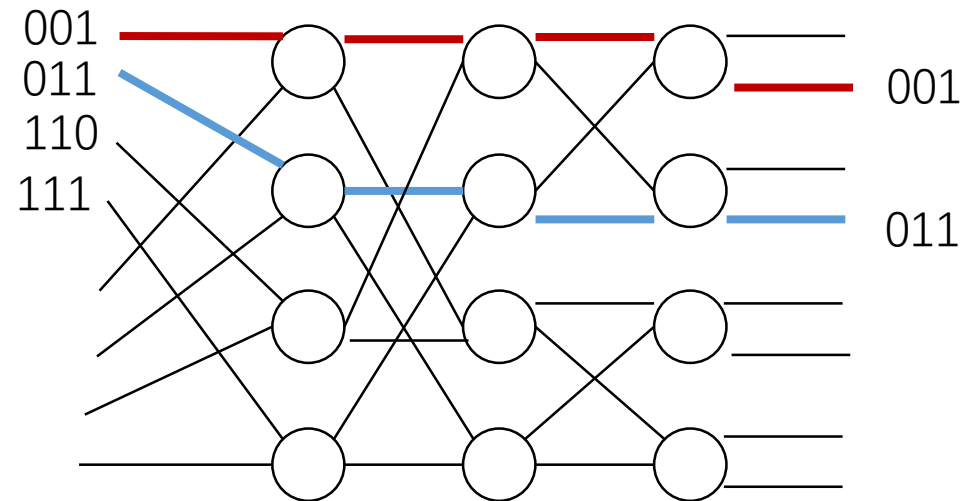
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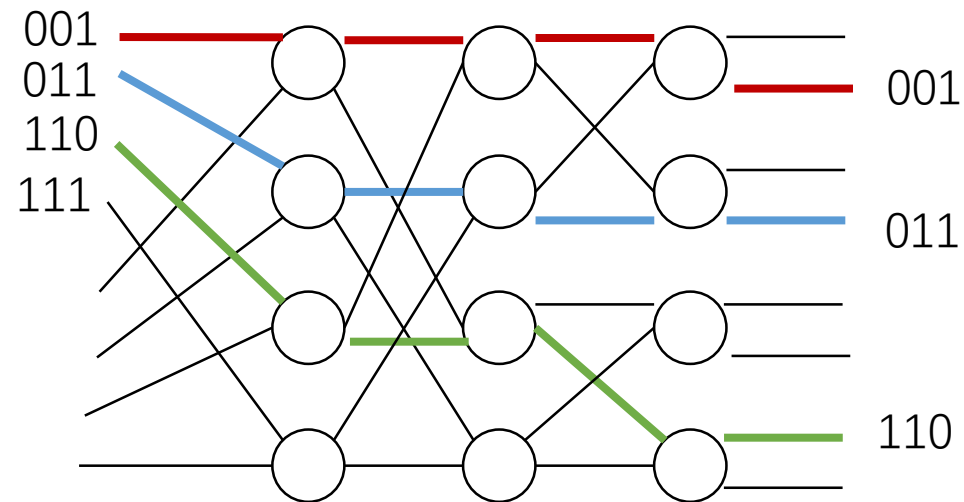
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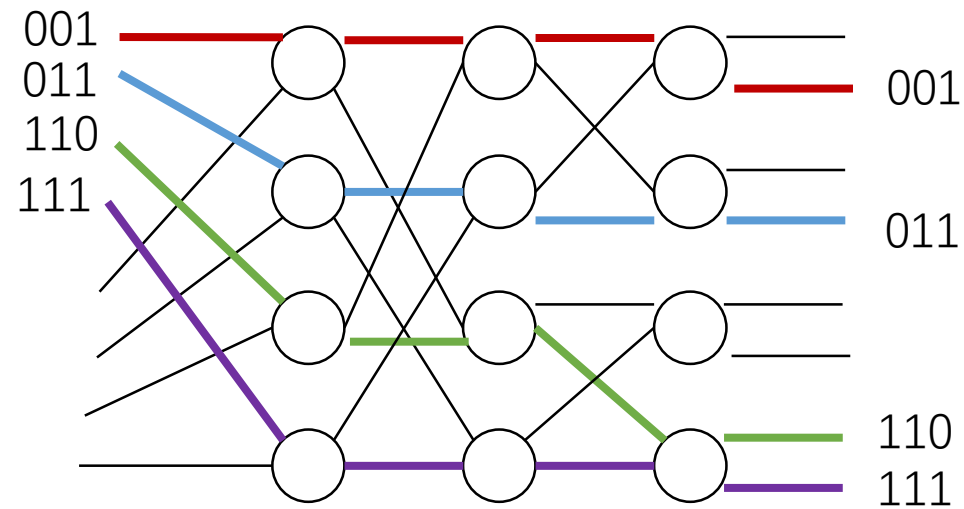
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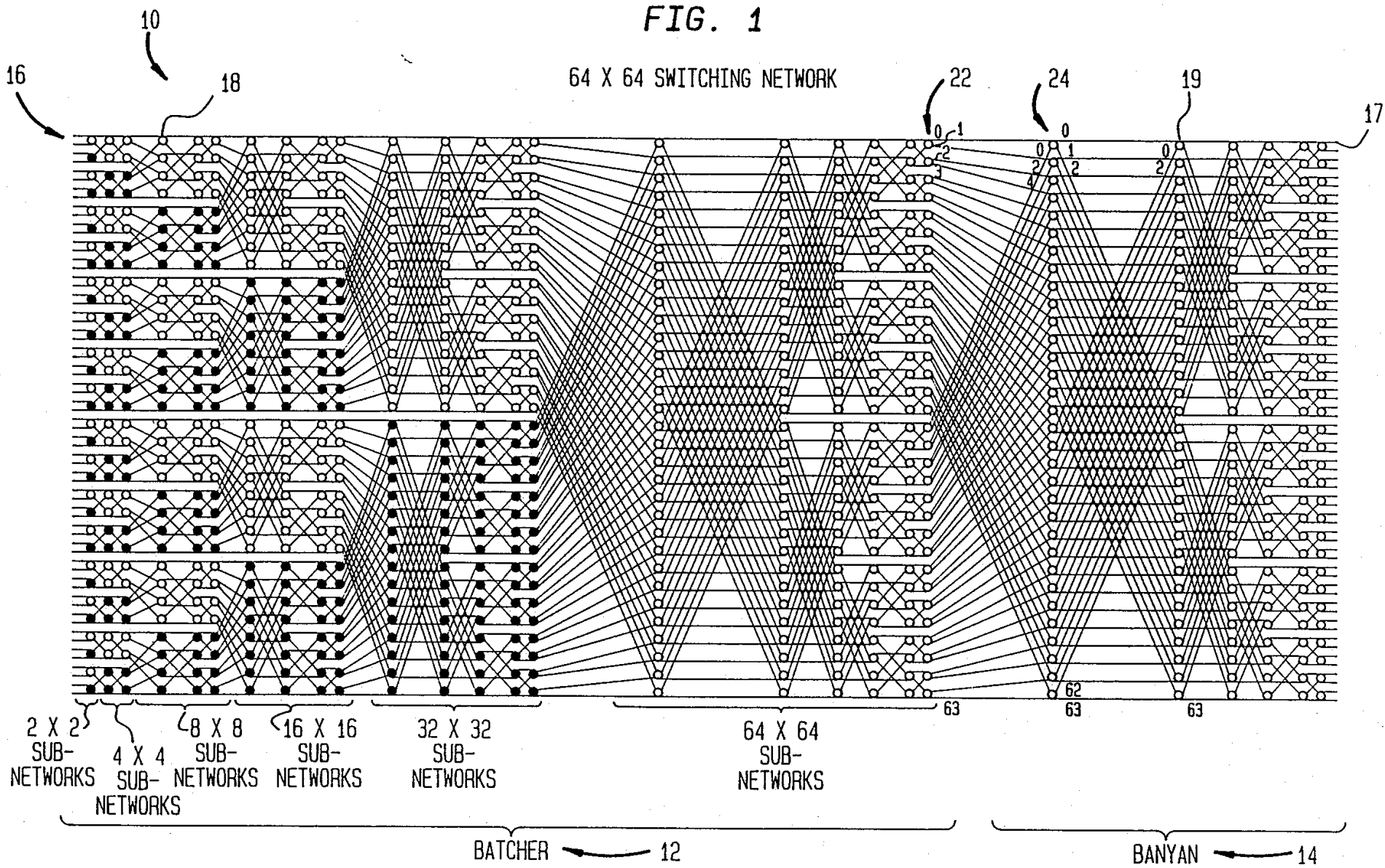
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# Self-routing

- Banyan Network
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# Reference

- Textbook 4.1
- Textbook 4.3
- Textbook 3.4