CS120: Computer Networks

Lecture 12. Other Topics in IP (NAT, Router)

Zhice Yang

Outline

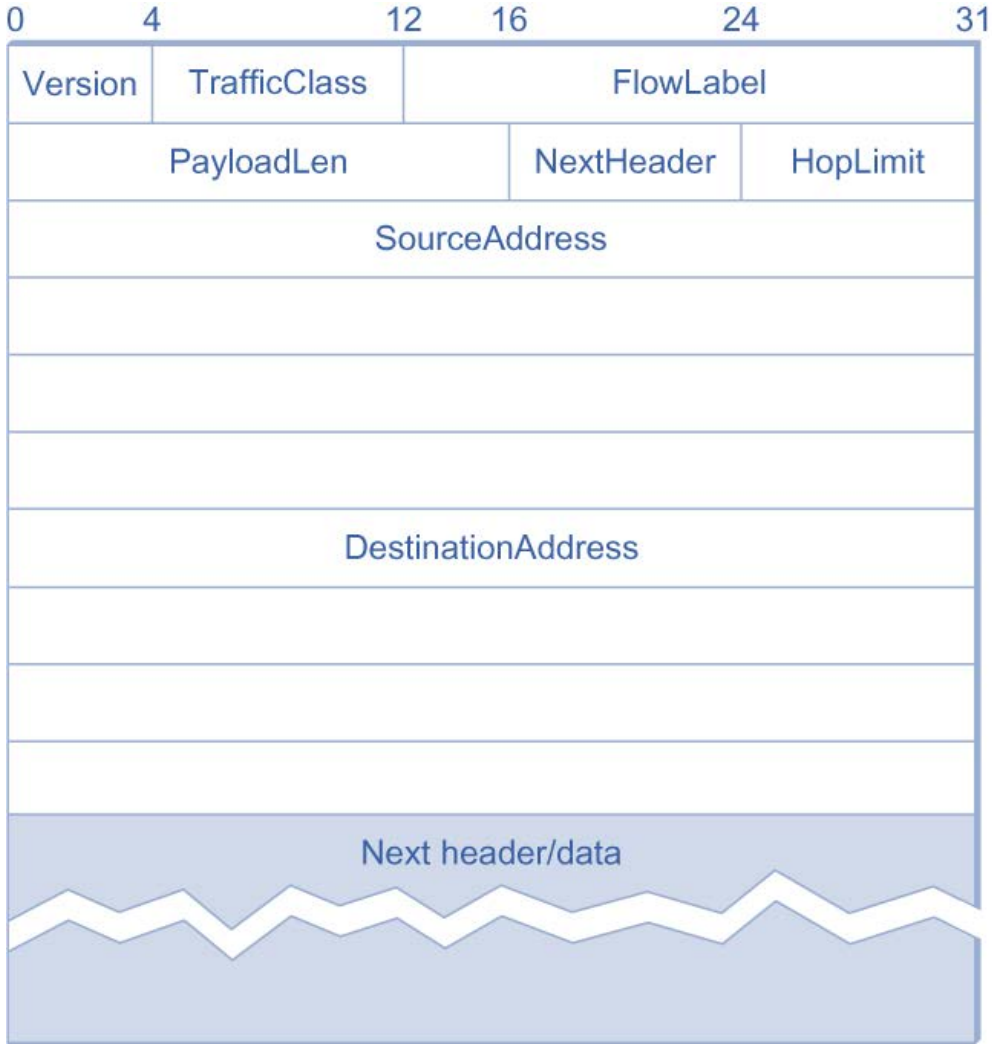
- IPv6
- NAT
- Router Implementation

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:x (x = 16-bit hex number)
  - Contiguous 0s are compressed: 47CD::A456:0124
  - IPv4-mapped IPv6 address: ::FFFF:123.45.67.8
- Address assignment: more hierarchy

IP Version 6 (IPv6)

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



Why haven’t IPv6 replaced IPv4 ?

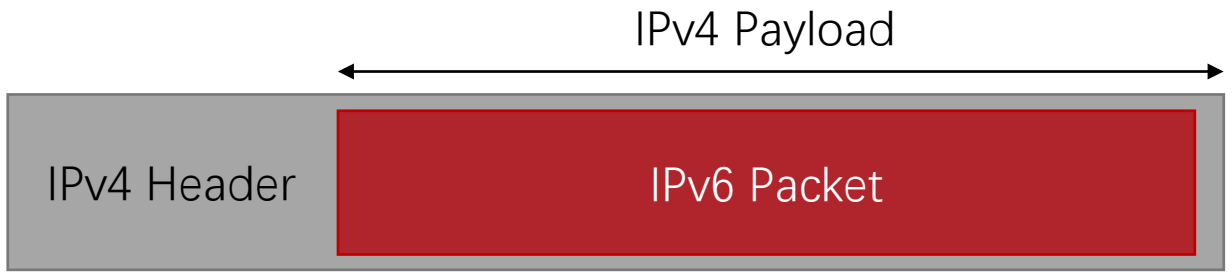
Transition from IPv4 to IPv6

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

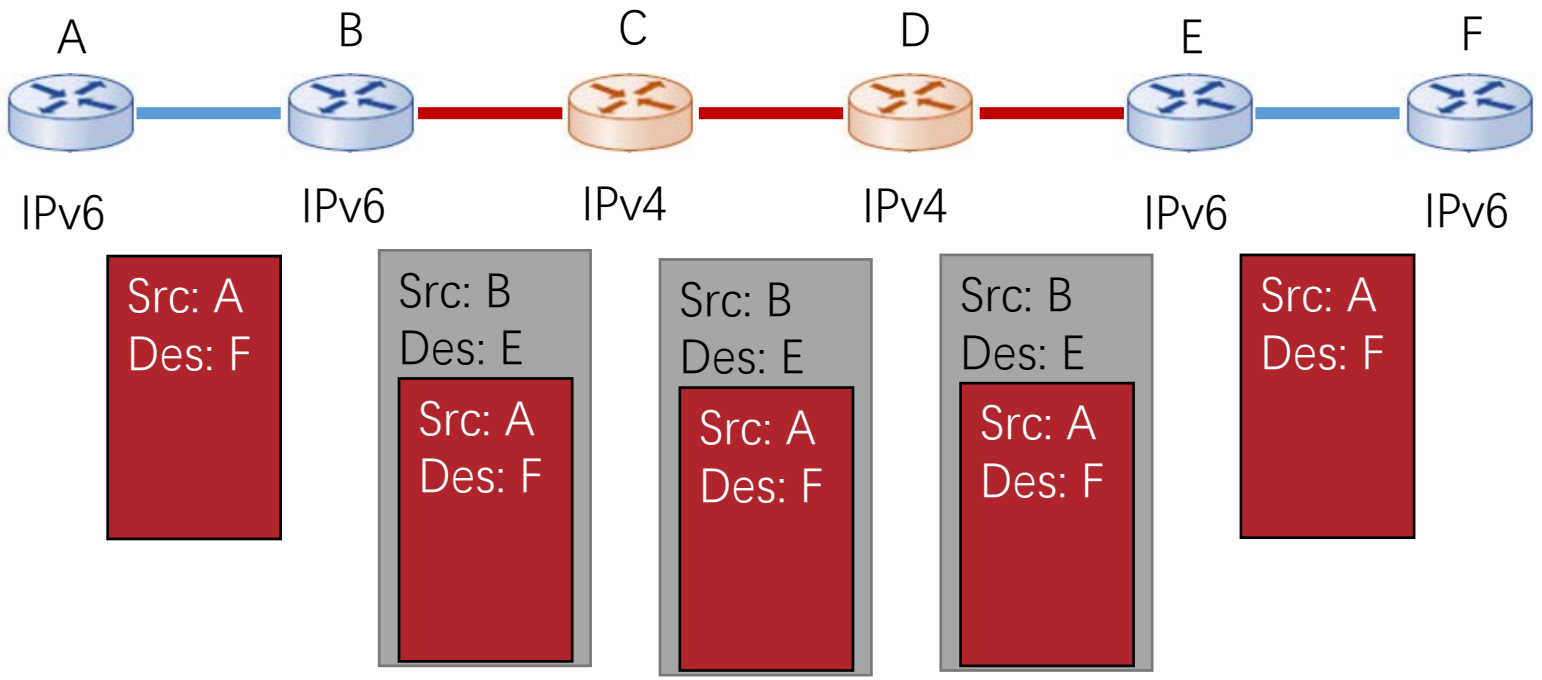
How will network operate with mixed IPv4 and IPv6 routers?

Transition from IPv4 to IPv6

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



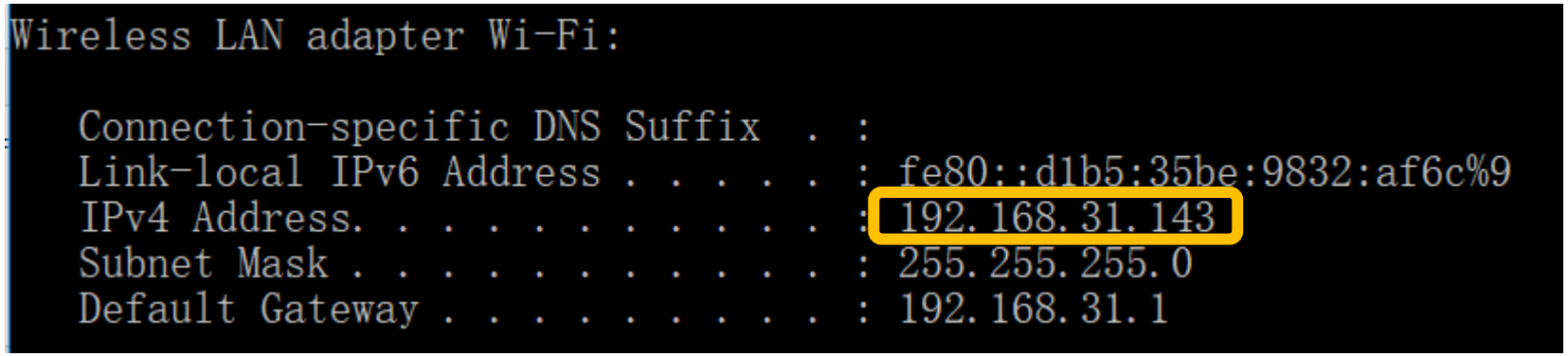
Transition from IPv4 to IPv6



Outline

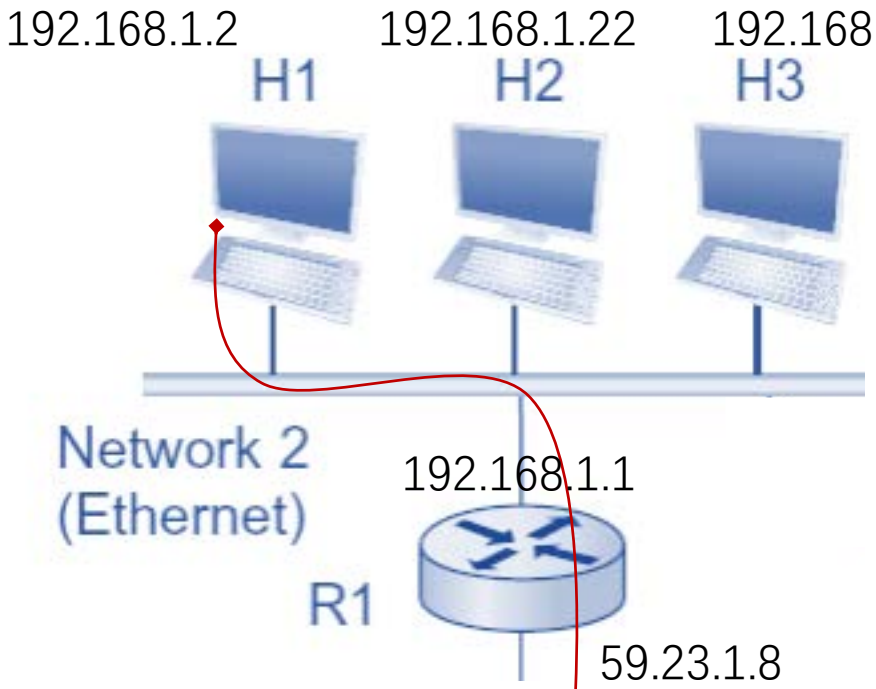
- IPv6
  - NAT
- Router Implementation

NAT: Network Address Translation



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

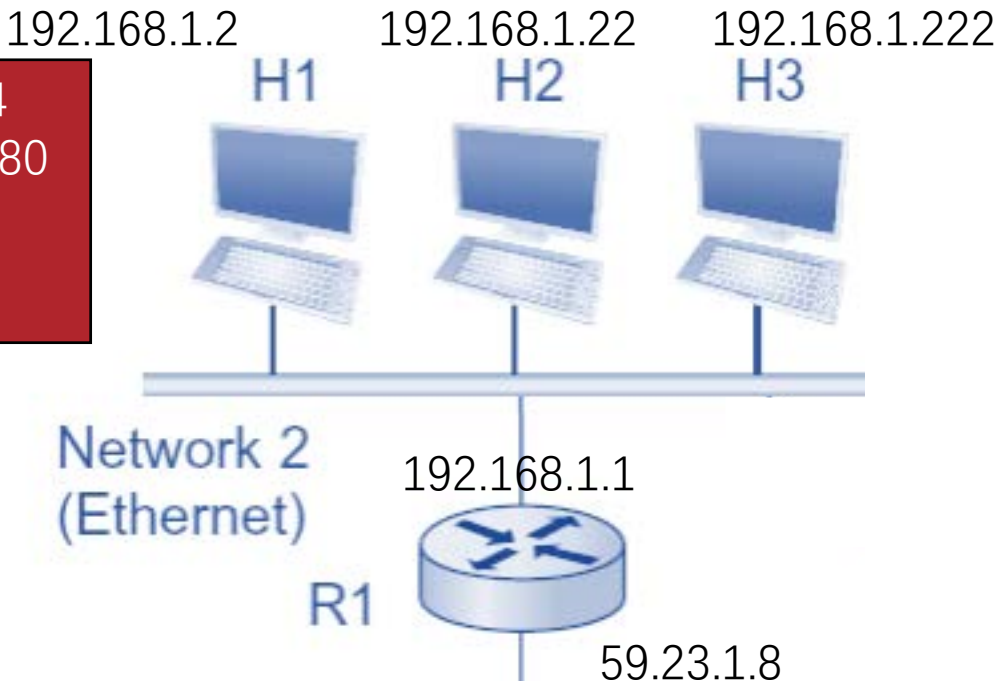


datagrams with source or destination in this network have 192.168.1.0/24 address for source, destination (as usual)

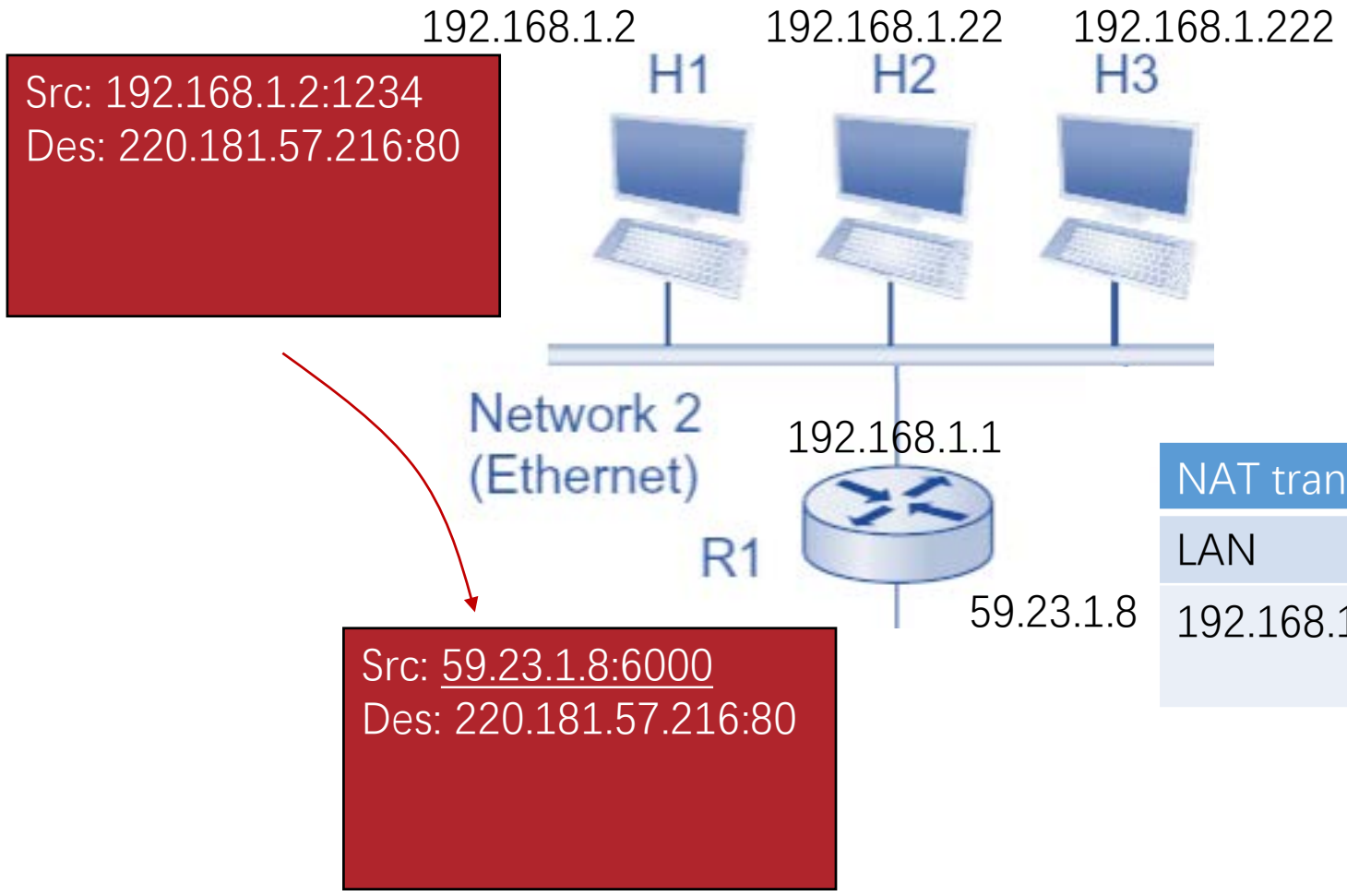
All datagrams leaving local network have same single source NAT IP address: 59.23.1.8, different source port numbers

NAT: Network Address Translation

Src: 192.168.1.2:1234
Des: 220.181.57.216:80

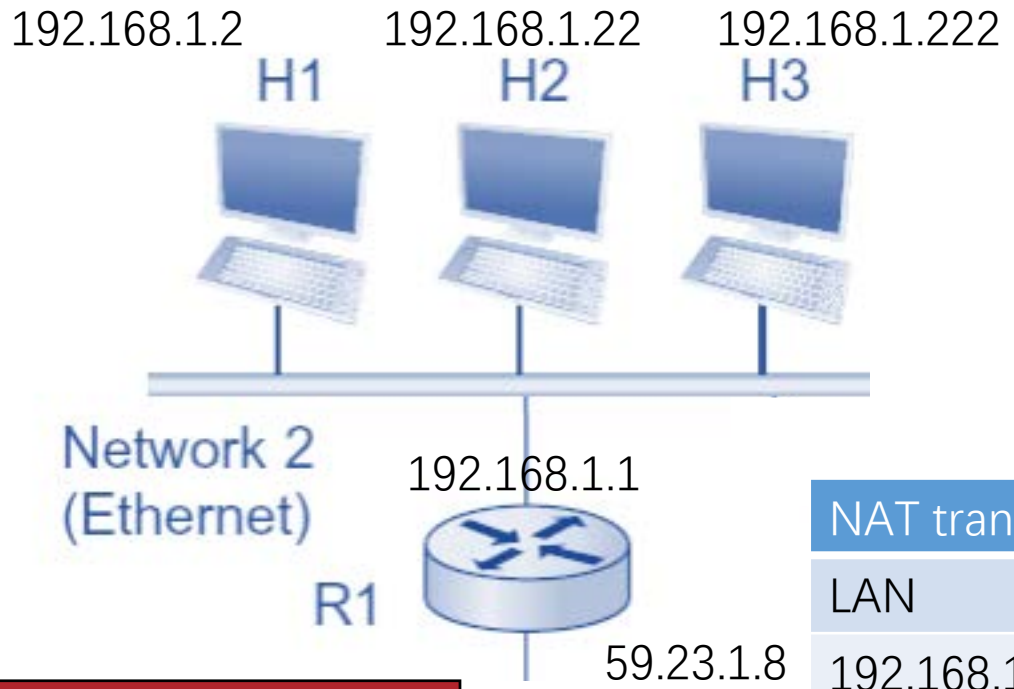


NAT: Network Address Translation



NAT translation table	
LAN	WAN
192.168.1.2:1234	59.23.1.8:6000

NAT: Network Address Translation



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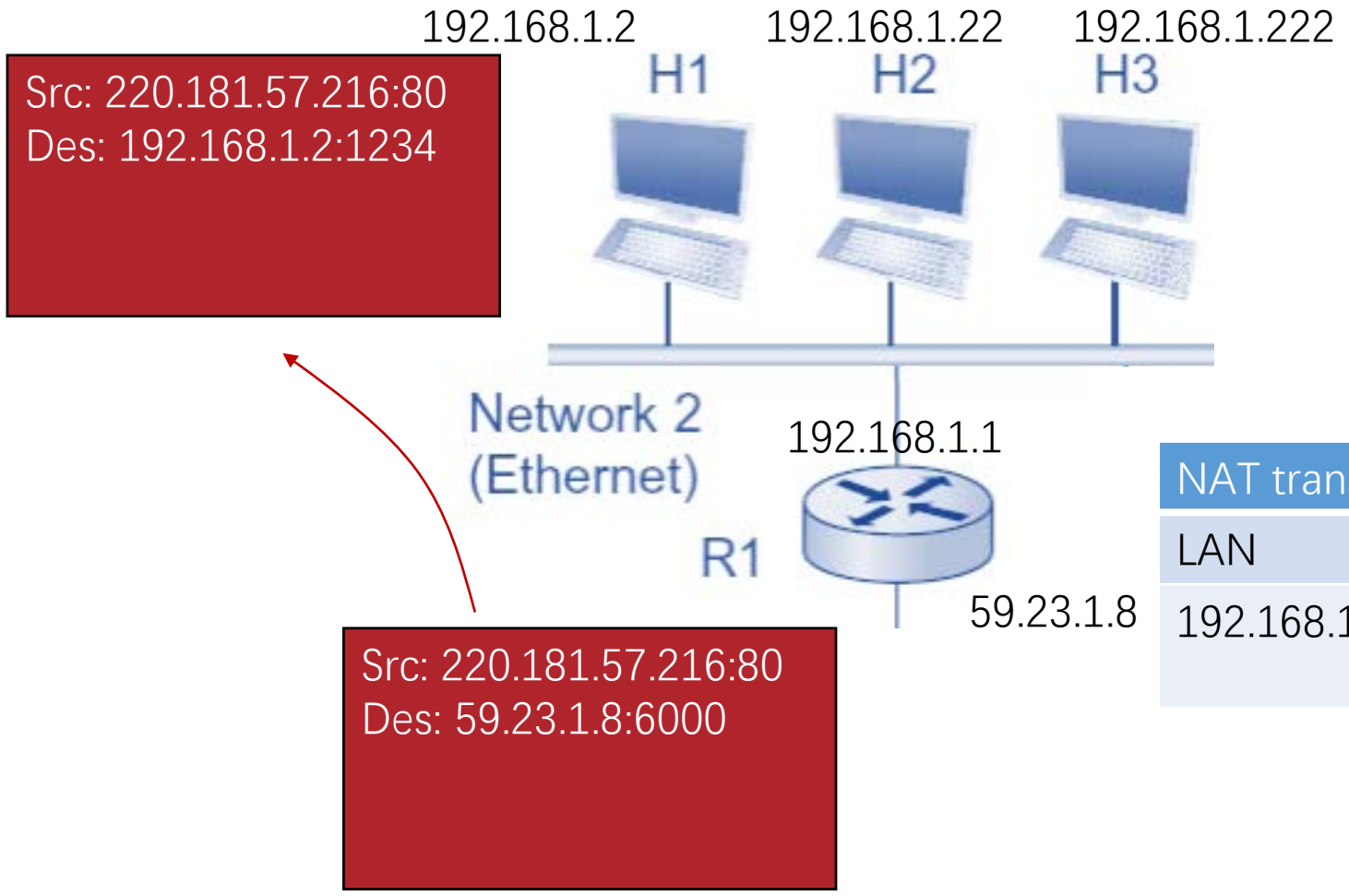
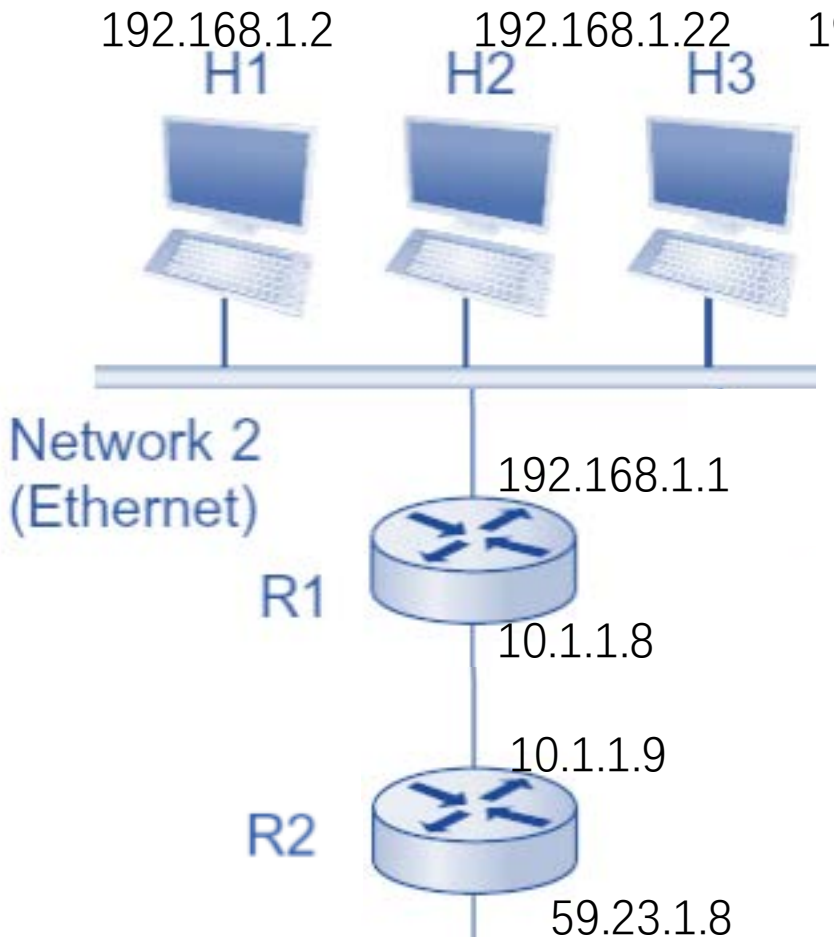


NAT translation table	
LAN	WAN
192.168.1.2:1234	59.23.1.8:6000

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

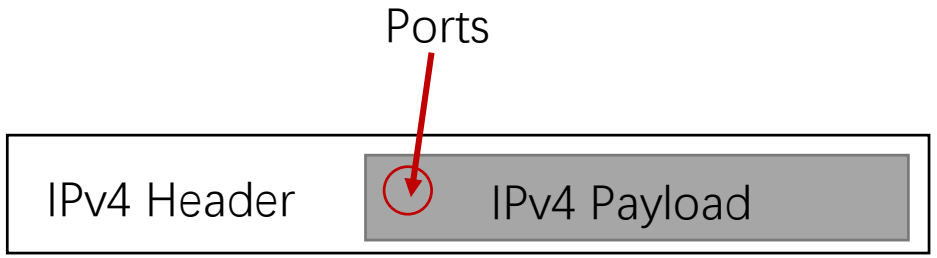
- Demo

```
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.
```

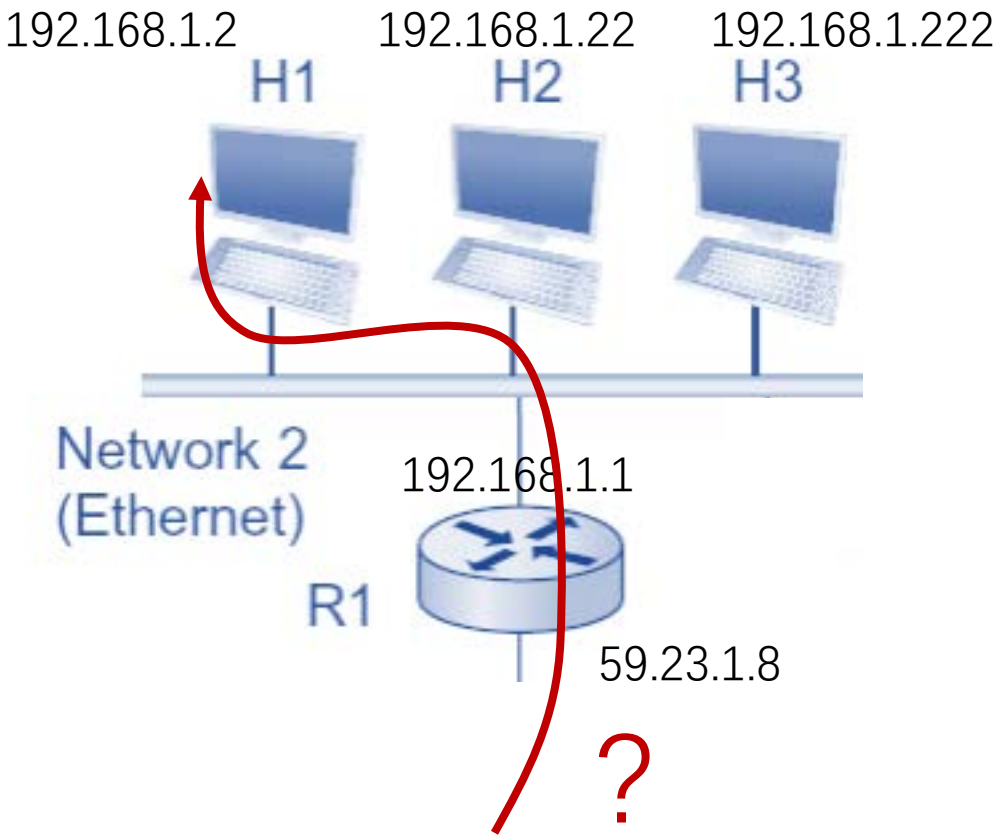
NAT: Network Address Translation

- 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.
- Problems
  - NAT is “impure”
    - Routers should not touch higher layers
  - Efficiency
  - Traversal Connections



NAT Traversal Problem

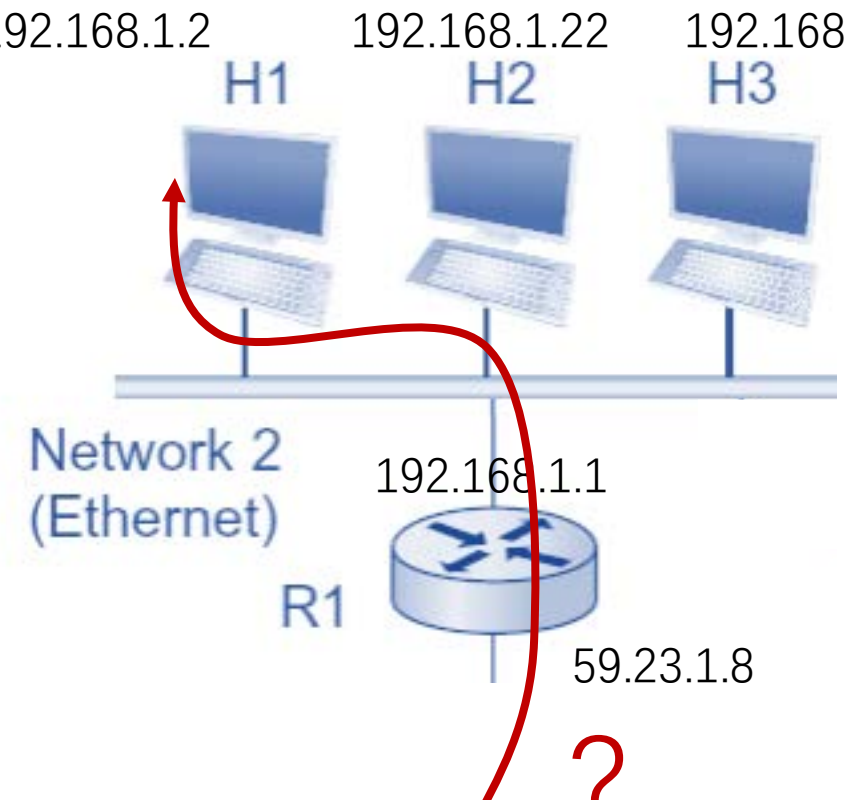
- How to initiate connections to Host 1 from external network ?
  - e.g. IP Phone



NAT Traversal Problem

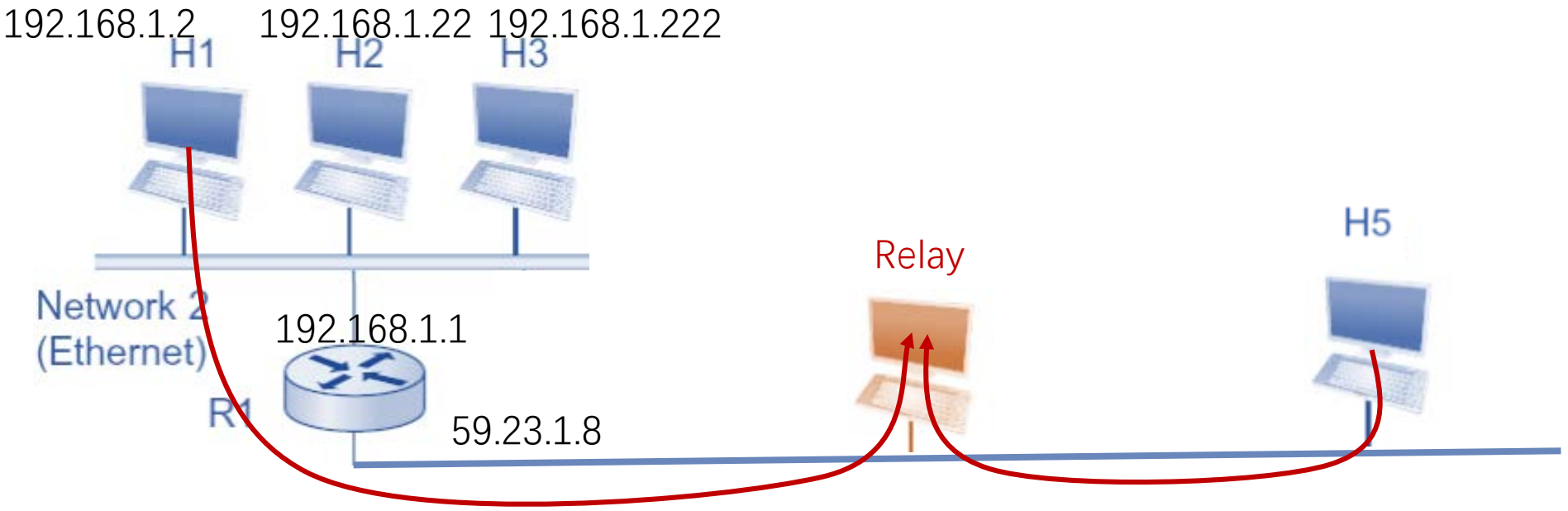
- Solution 1: Static Configure
  - Configure NAT to forward incoming connection requests at given port to the host
  - Need to know the port

NAT translation table	
LAN	WAN
192.168.1.2	59.23.1.8:6000



NAT Traversal Problem

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

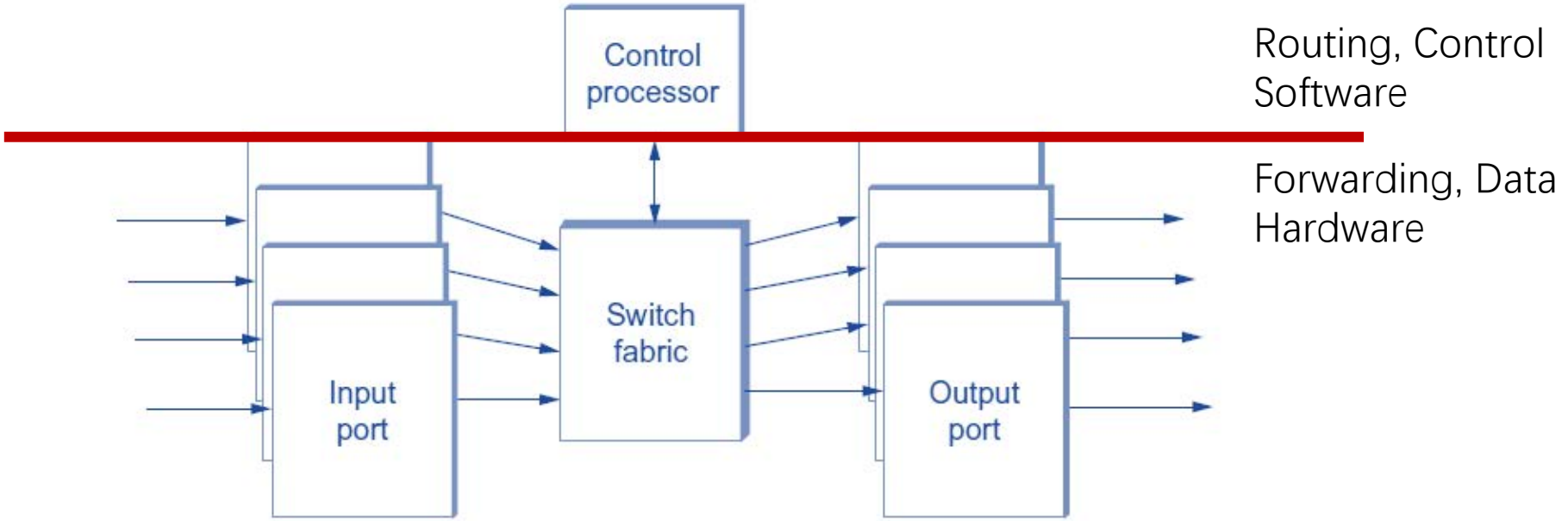


Outline

- IPv6
- NAT
- ➢Router Implementation

Router Architecture

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



Control Processor

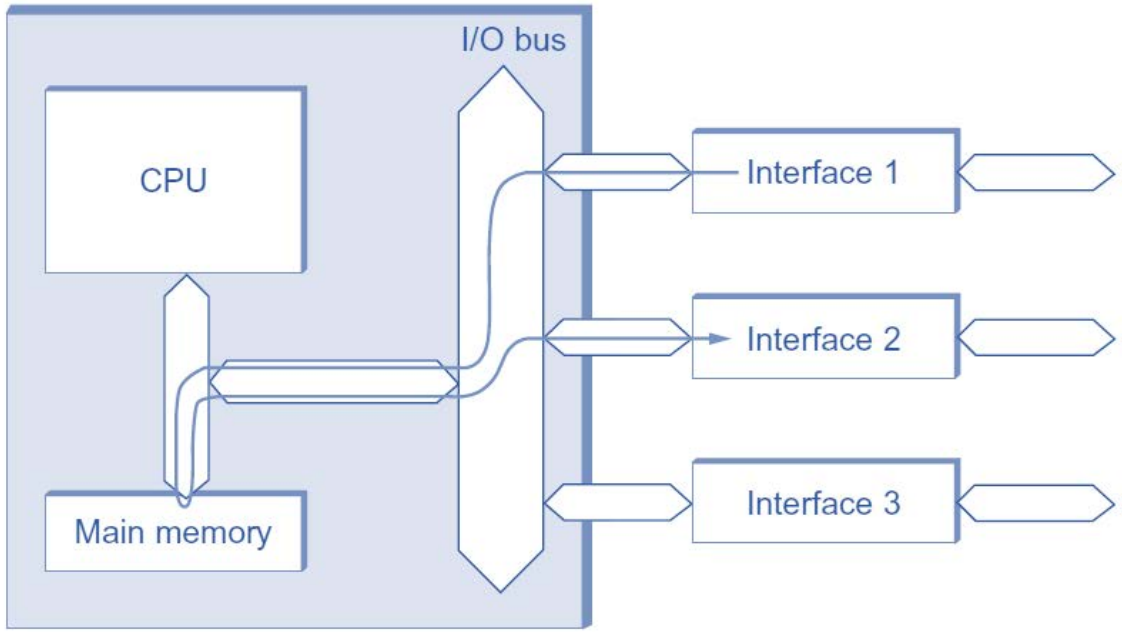
- Function
  - Control and configuration
    - Ports and switch fabrics
  - Calculation
    - Routing Algorithm (Router)
      - Push forwarding tables into ports
    - Ports and switch fabric do not run routing algorithms

Switching Fabrics

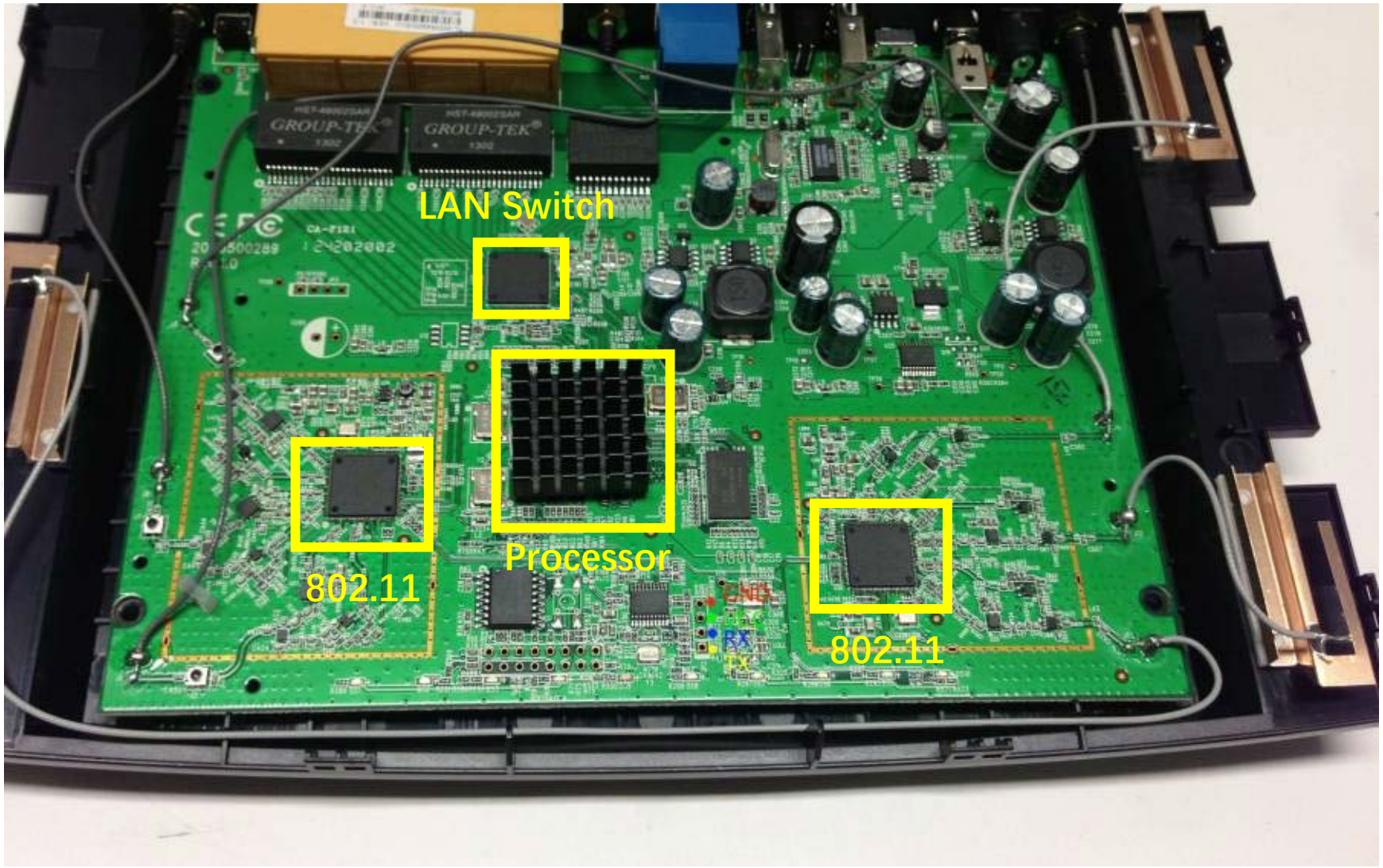
- Transfer packets from input buffer to appropriate output buffer
- Switching Throughput
  - Rate at which packets can be transfer from inputs to outputs
  - N inputs: switching throughput N times line rate desirable
- Four Types
  - Shared Bus
  - Shared Memory
  - Crossbar
  - Self-routing

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

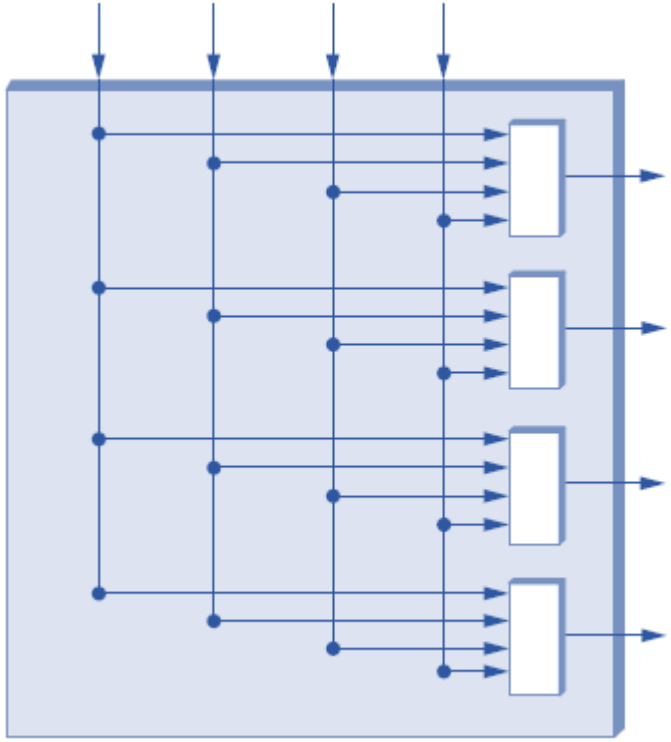


Inside Wireless Routers



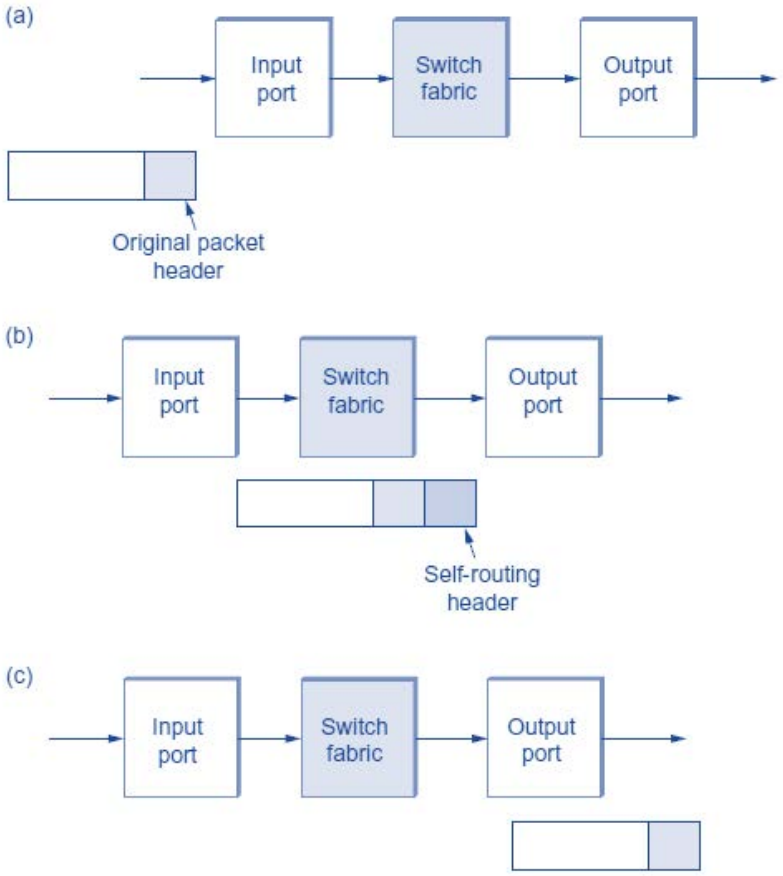
Crossbar

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



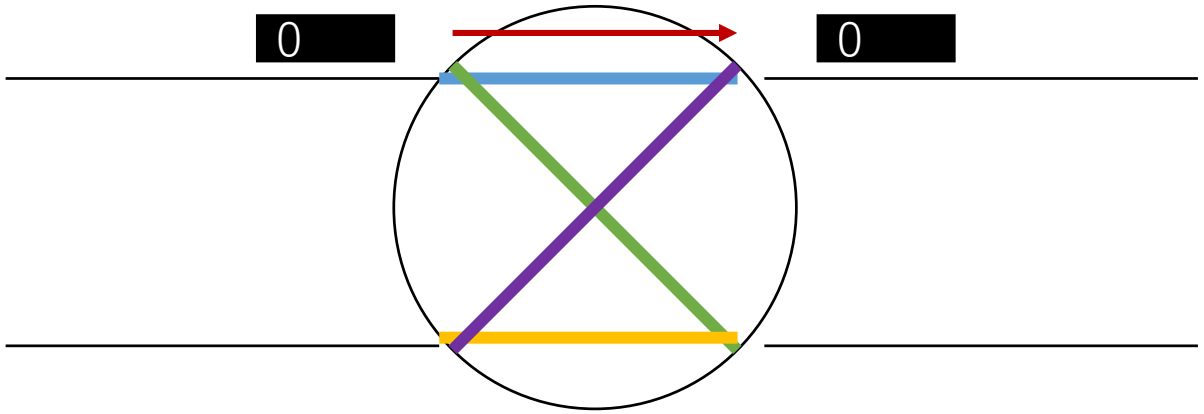
Self-routing

- Routing Header



Self-routing

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



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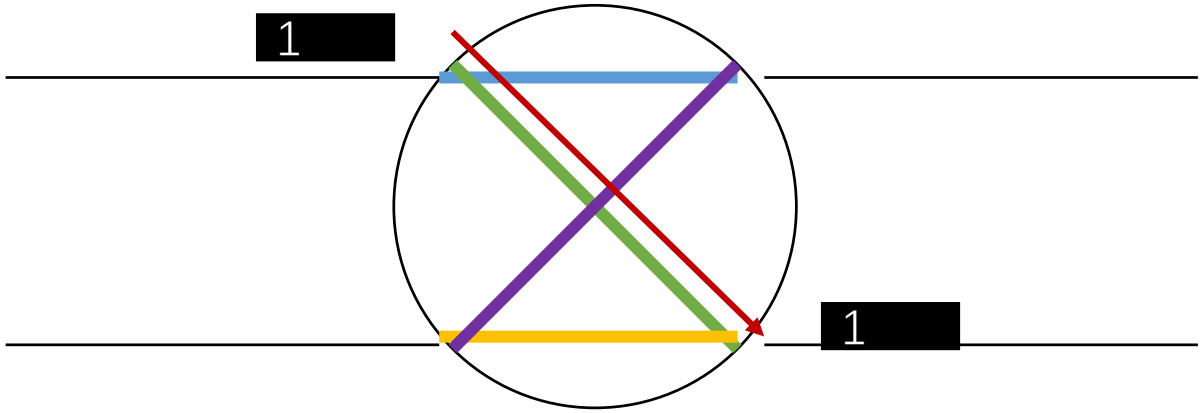

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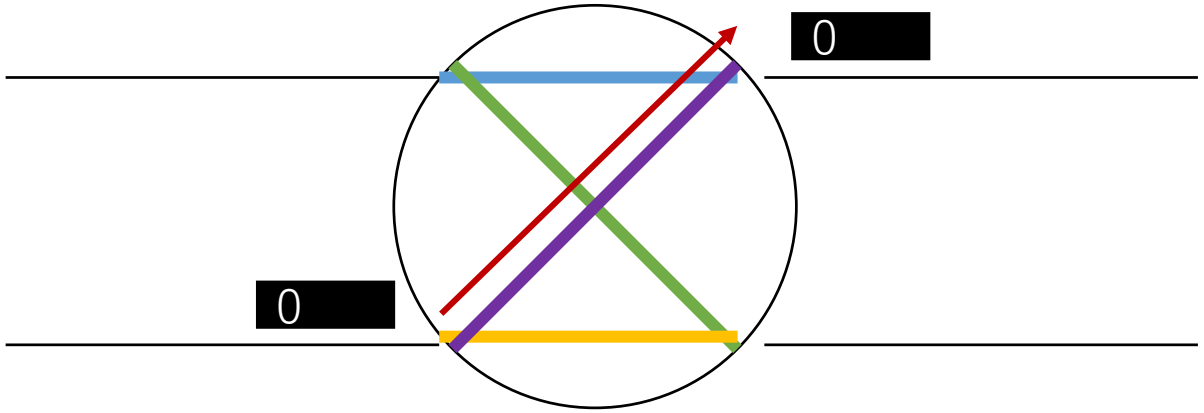

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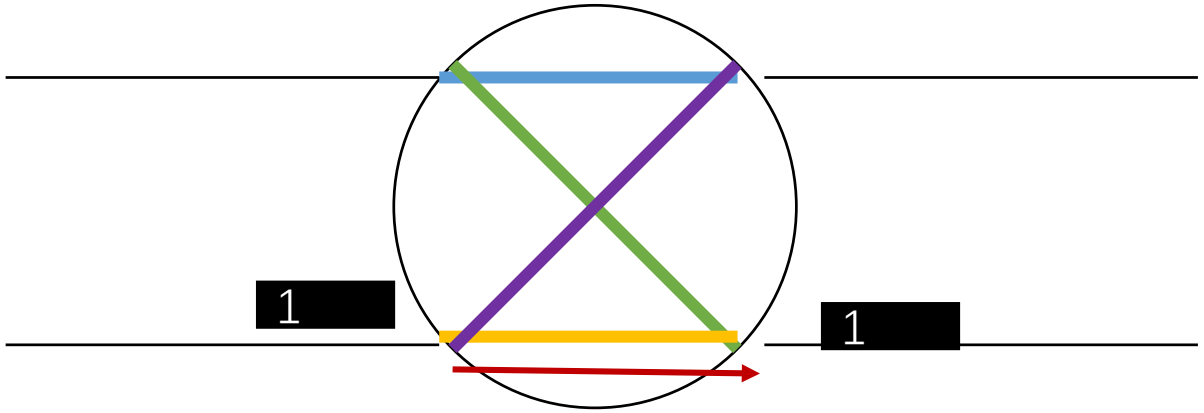
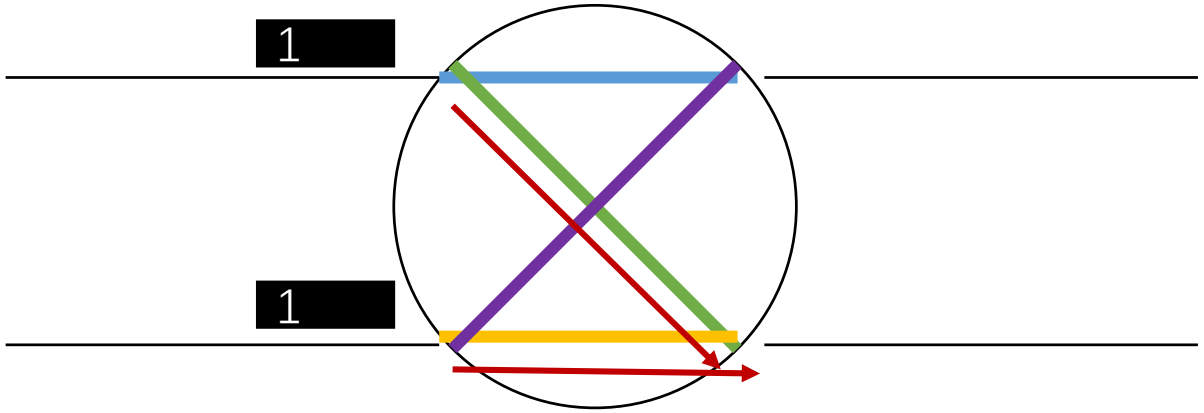


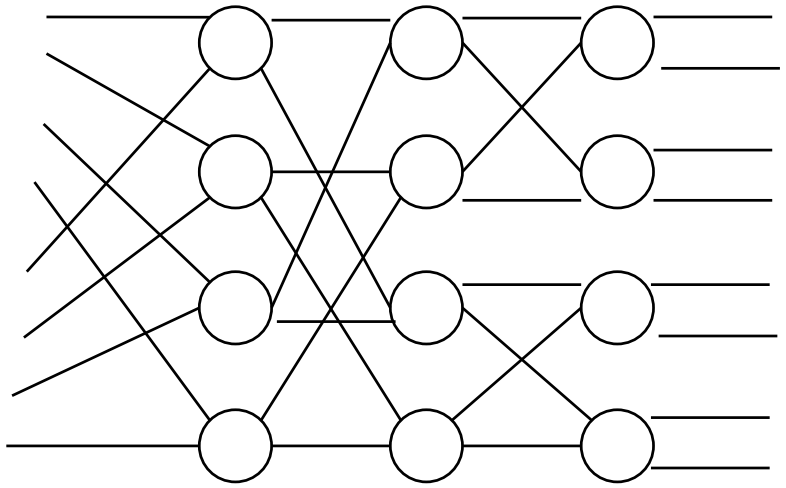
Self-routing

- 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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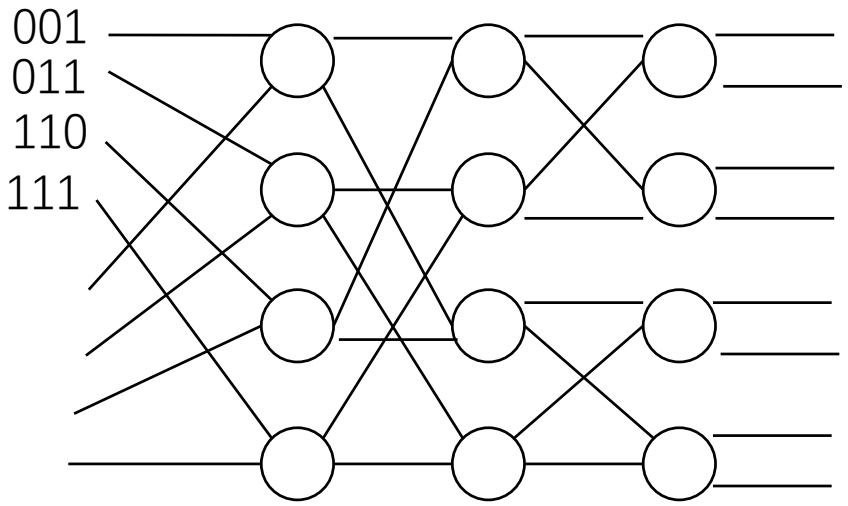

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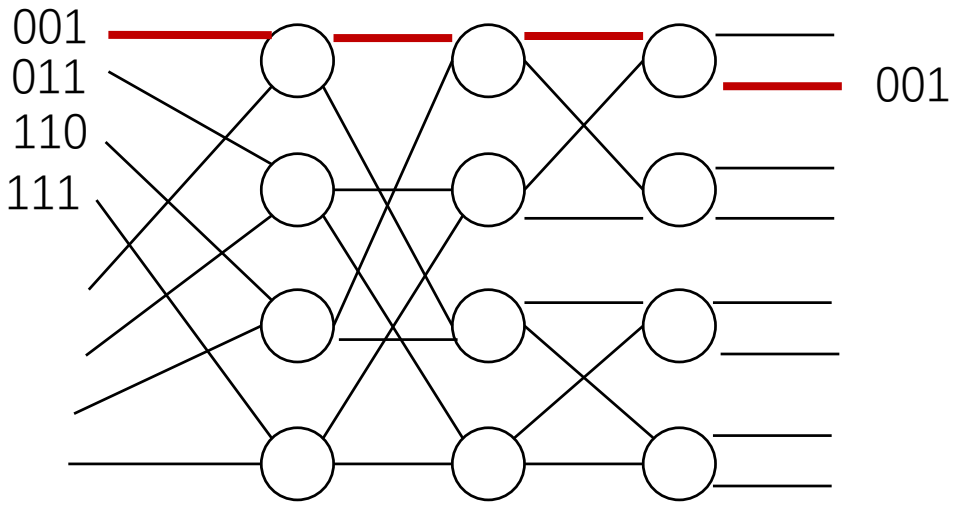

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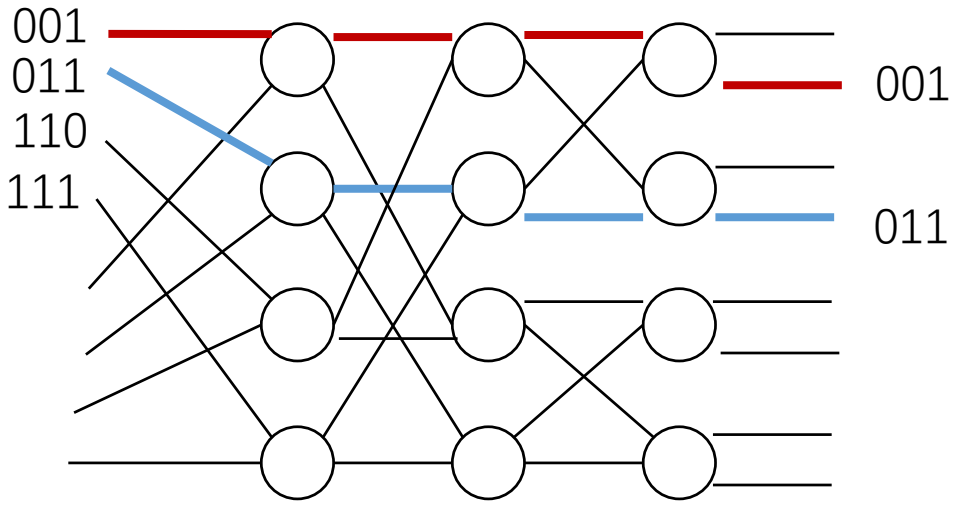

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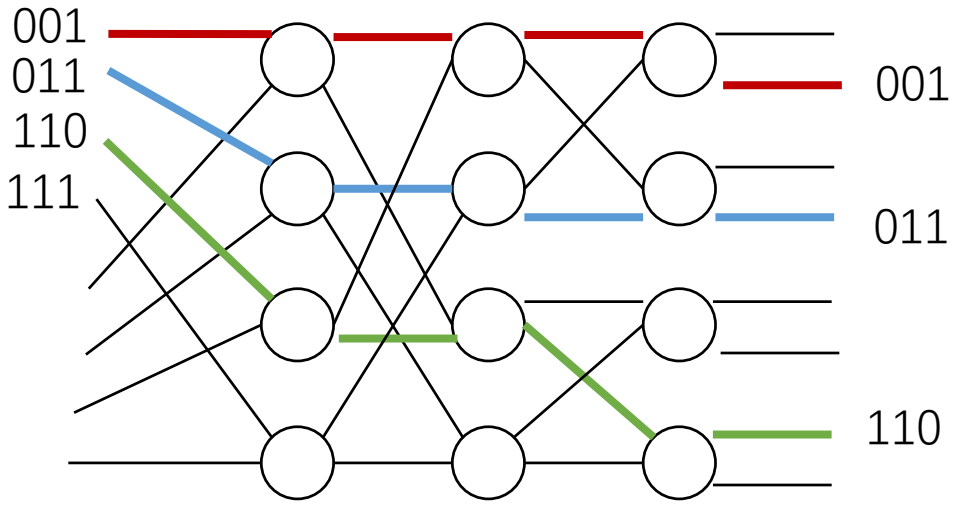

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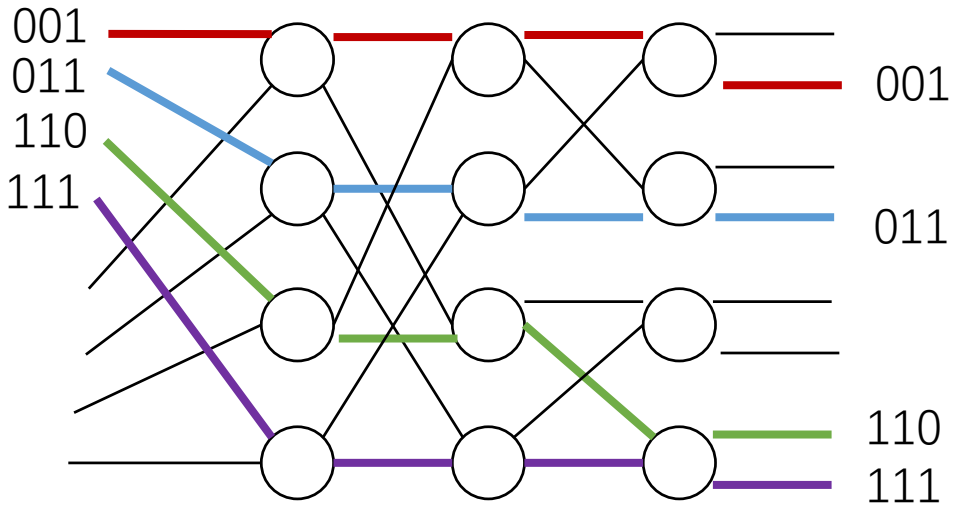
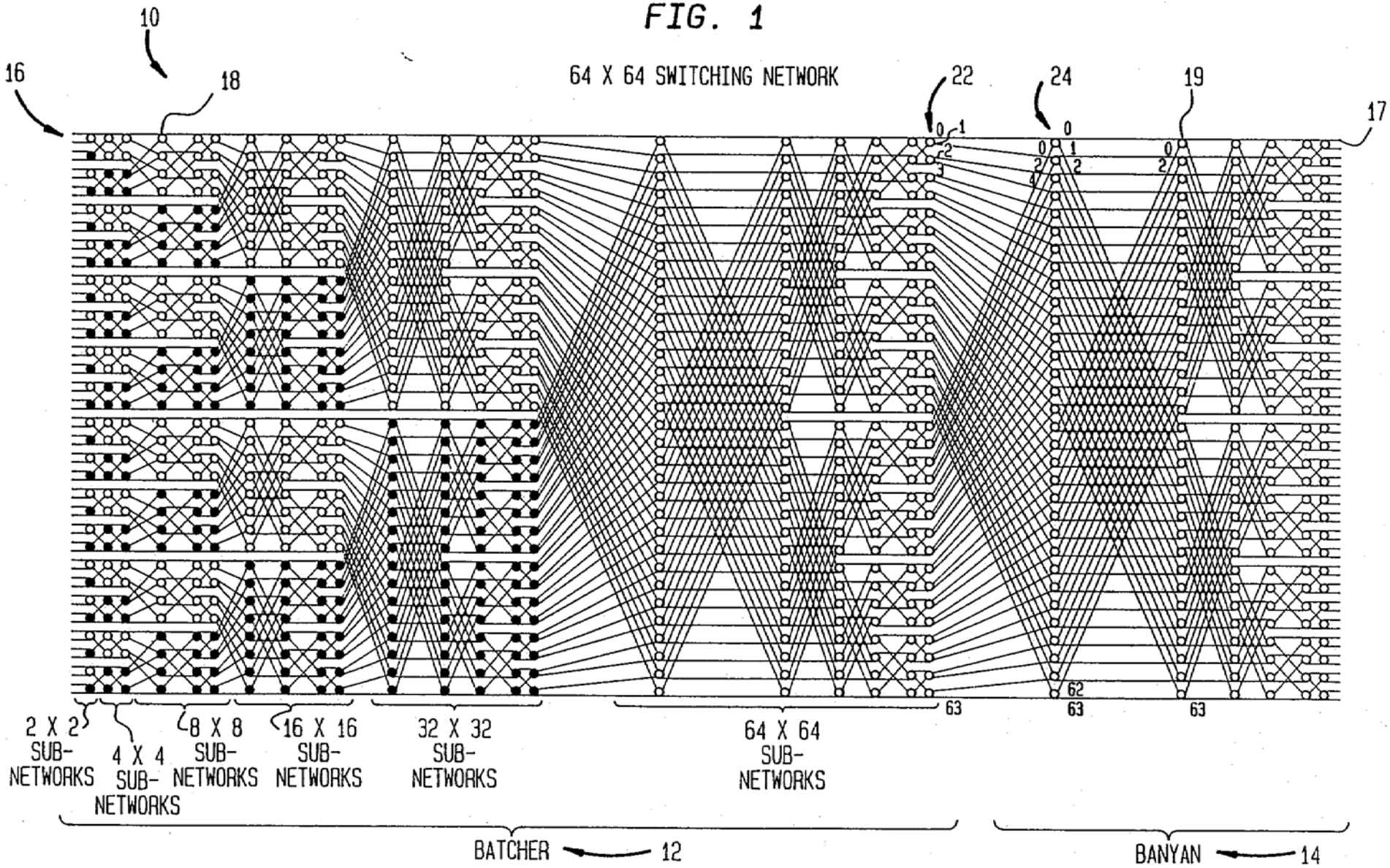


FIG. 1


10
16
18
64 X 64 SWITCHING NETWORK
22
24
19
17
0 1 2 3
0 1 2 4
0 2
0
62 63
63
63
2 X 2 SUB-NETWORKS
4 X 4 SUB-NETWORKS
8 X 8 SUB-NETWORKS
16 X 16 SUB-NETWORKS
32 X 32 SUB-NETWORKS
64 X 64 SUB-NETWORKS
BATCHER 12
BANYAN 14

Reference

- Textbook 4.1
- Textbook 4.3
- Textbook 3.4