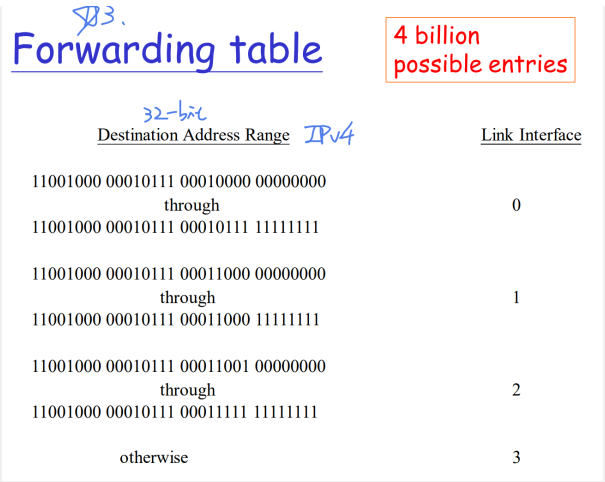
1. What is the major functionalities of Network layer? How do they work?

> - transport segment from sending to receiving host
> - on sending side encapsulates segments into datagrams
> - on receiving side, delivers segments to transport layer
> - network layer protocols in every host, router
> - router examines header fields in all IP datagrams passing through it
> - forwarding: move packets from router's input to appropriate router output
> - routing: determine route taken by packets from source to destination
>   - routing algorithms

2. What are the differences between the functionalities of Network layer and Transport layer?

> The basic difference between network layer and transport layer is that transport layer protocol provides logical communication between processes running on different hosts , whereas network layer protocol provides logical communication between hosts.

3. How does forwarding table work?

> 
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Longest prefix matching

Prefix Match	Link Interface
11001000 00010111 00010	0
11001000 00010111 00011000	1
11001000 00010111 00011	2
otherwise	3

Examples

DA: 11001000 00010111 00010110 10100001 Which interface? 0

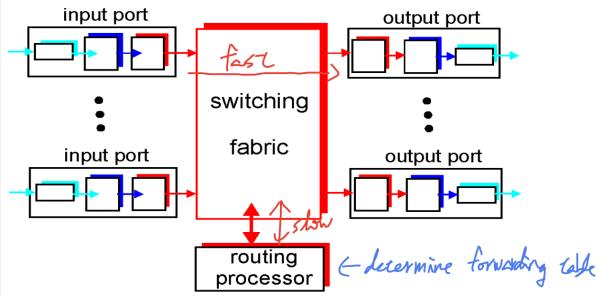
DA: 11001000 00010111 00011000 10101010 Which interface? 1

match 1,2, 1 is longer, so match 1

4. What is the router architecture and its functions? What is the functionality of each component in the router architecture?

Two key router functions:

- run routing algorithms/protocol (RIP, OSPF, BGP)
- forwarding datagrams from incoming to outgoing link



5. What are the three types of router switching fabrics? What are the differences between them?

switching via memory

- traditional computers with switching under direct control of CPU
- packet copied to system's memory
- speed limited by memory bandwidth (2 bus crossings per datagram)

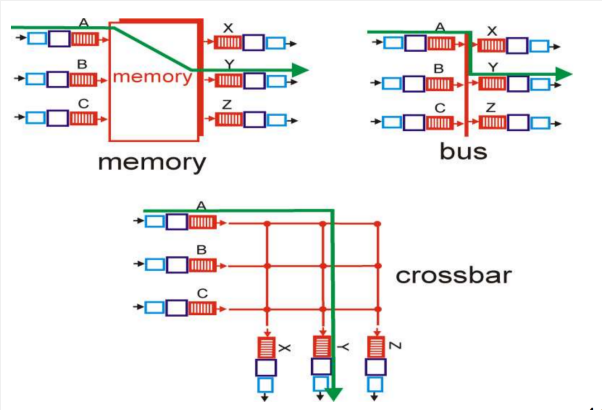
switch via a bus

- datagram from input port memory to output port memory via a shared bus
- bus contention: switching speed limited by bus bandwidth

switching via an interconnection network

- overcome bus bandwidth limitations

- Banyan networks, other interconnection nets initially developed to connect processors in multiprocessor
- advanced design: fragmenting datagram into fixed length cells, switch cells through the fabric

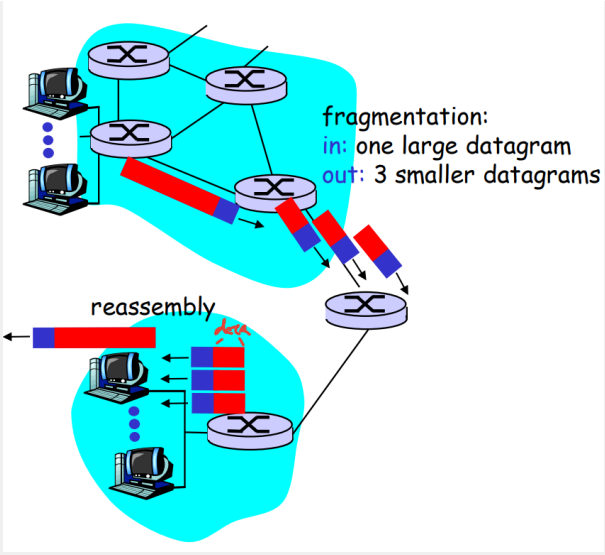


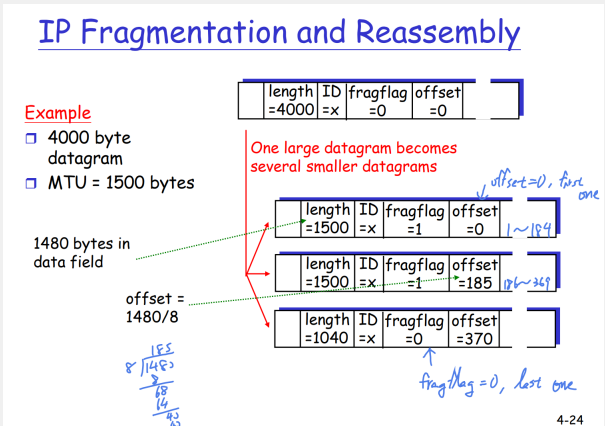
6. What are the major component of the Internet network layer? What is the functionality of each component?

1. The internet Protocol, or more commonly, the IP Protocol, which defines network-layer addressing, the fields in the datagram, and the actions taken by routers and end systems on a datagram based on the values in these fields. Has two versions: IPv4 and IPv6
2. The path determination component, which determines the route a datagram follows from source to destination
3. The Internet's network-layer error and information reporting protocol, **ICMP**, is a facility to report errors in datagrams and respond to requests for certain network-layer information
4. Forwarding table, which is responsible for storing the next hop of each network and identifying the frame type

7. How does IP fragmentation work? Show the details of dividing and reassembling a datagram.

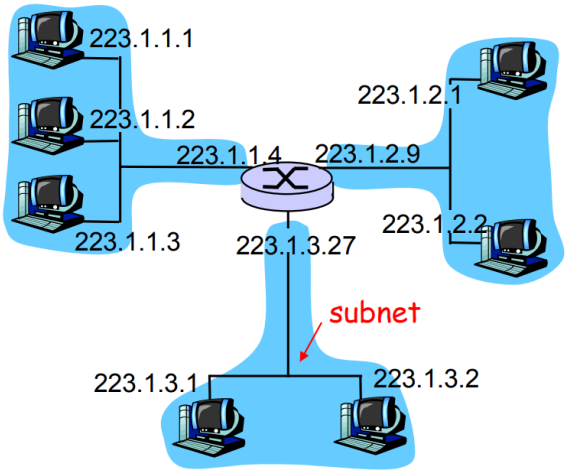
- network links have MTU (max transfer size) - largest possible link-level frame
  - different link types, different MTUs
- large IP datagram divided ("fragmented") within net
  - one datagram becomes several datagrams
  - "reassembled" only at final destination
  - IP header bits used to identify, order related fragments





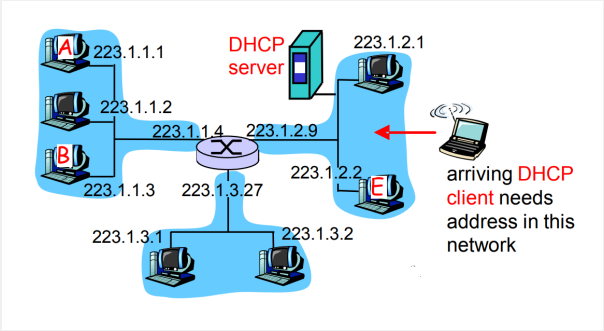
8. What is a subnet in IPv4? What is the format of a subnet address?

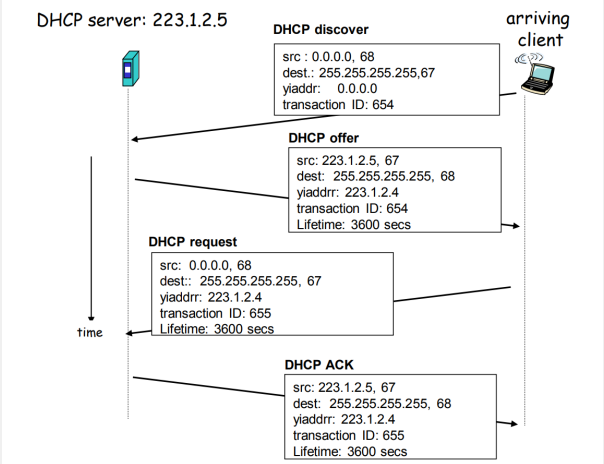
- device interfaces with same subnet part of IP address
- can physically reach each other without intervening router
- to determine the subnets, detach each interface from its host or router, creating islands of isolated networks. Each isolated network is called a subnet
- IP address: (前三組數字相同，最後一組數字不同)
  - subnet part (high order bits)
  - host part (low order bits)



9. How does DHCP work?

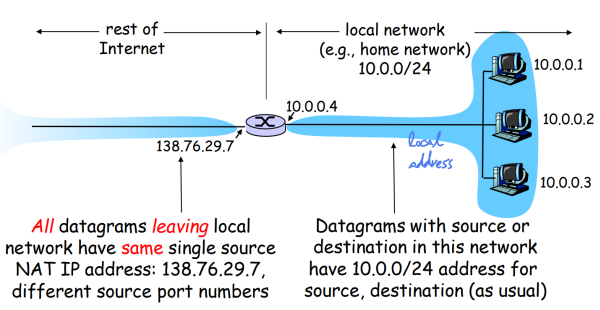
- Goal: allow host to dynamically obtain its IP address from network server when it joins network
  - Can renew its lease on address in use
  - Allows reuse of address (only hold address while connected an "on")
  - Support for mobile users who want to join network (more shortly)
- DHCP (Dynamic Host Configuration Protocol) overview:
  - host broadcasts "DHCP discover" message
  - DHCP server responds with "DHCP offer" message
  - host requests IP address: "DHCP request" message
  - DHCP server sends address: "DHCP ack" message



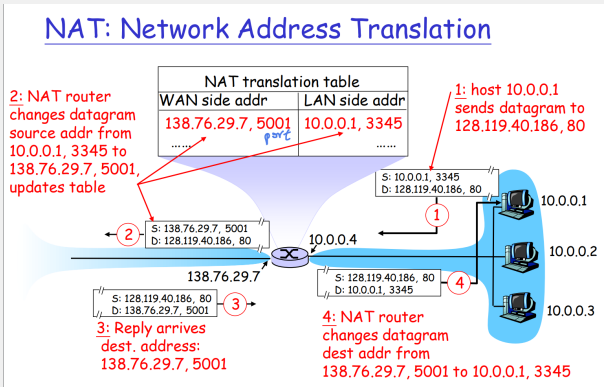


10. How does NAT work? How does host connect the server behind NAT?

- Motivation: local network uses just one IP address as far as outside world is concerned
  - range of addresses not needed from ISP: just one IP address for all devices
  - can change addresses of devices in local network without notifying outside world
  - can change ISP without changing addresses of devices in local network
  - devices inside local net not explicitly addressable, visible by outside world (a security plus)



- outgoing datagrams: replace (source IP address, port #) of every outgoing datagram to (NAT IP address, new port #) as destination address
- remember (in NAT translation table) every (source IP address, port #) to (NAT IP address, new port #) translation pair
- incoming datagrams: replace (NAT IP address, new port #) in destination fields of every incoming datagram with corresponding (source IP address, port #) stored in NAT table



11. What are two functionalities of CIDR ?

- CIDR: Classless InterDomain Routing
  - subnet portion of address of arbitrary length
  - address format: a.b.c.d/x, where x is # bits in subnet portion of address

12. How does traceroute work using ICMP?

- Source sends series of UDP segments to destination
  - first has TTL=1

    - second has TTL=2, etc
    - unlikely port number
- When n-th datagram arrives to n-th router:
    - router discards datagram
    - and sends to source an ICMP message (type 11, code 0)
    - message includes name of router & IP address
- When ICMP message arrives, source calculates RTT
- Traceroute does this 3 times

Stopping criterion

- UDP segment eventaully arrives at destination host
- Destination returns ICMP "host unreachable" packet (type 3, code 3)
- When source gets this ICMP, stops