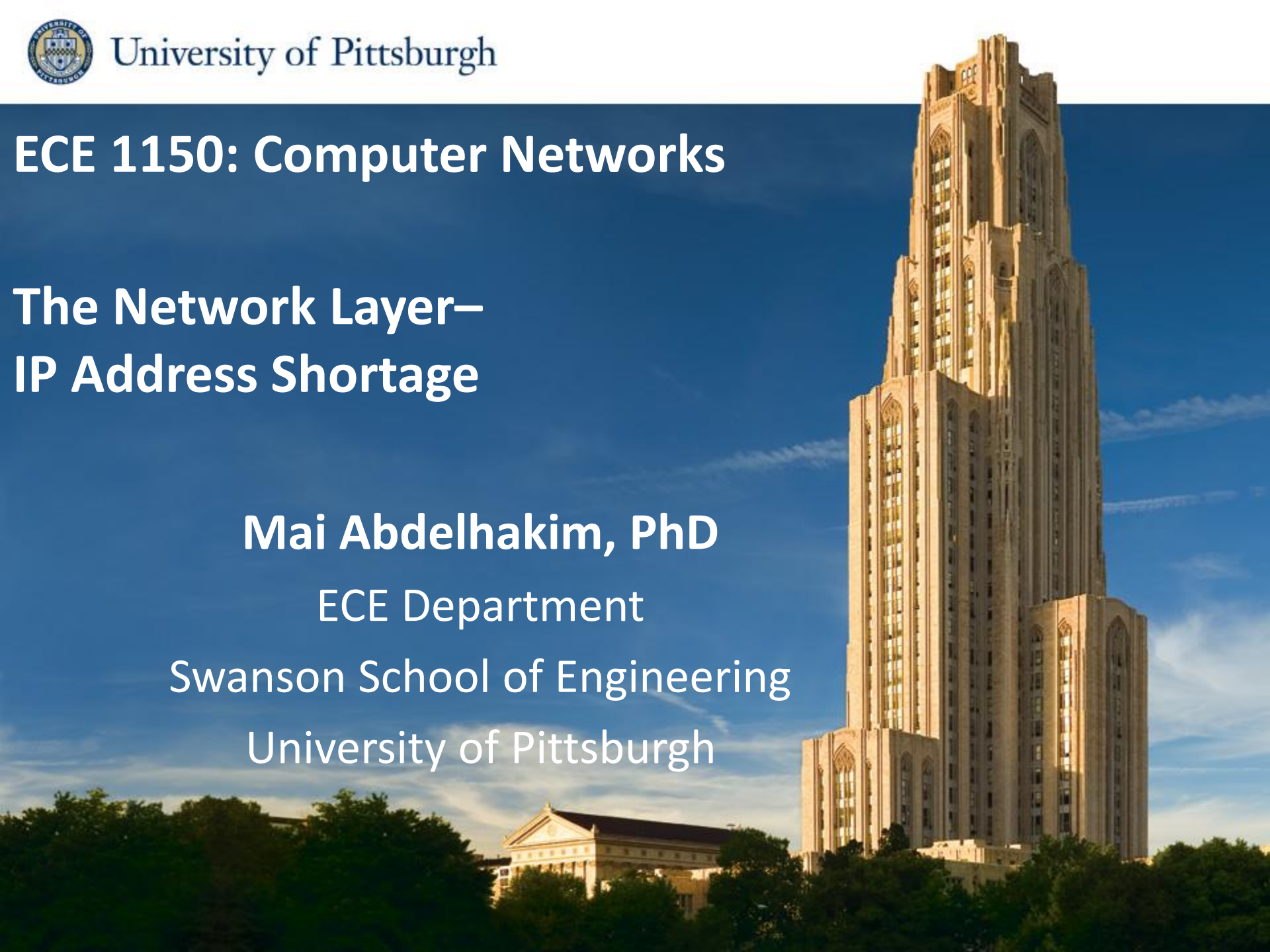

University of Pittsburgh

ECE 1150: Computer Networks

The Network Layer–
IP Address Shortage

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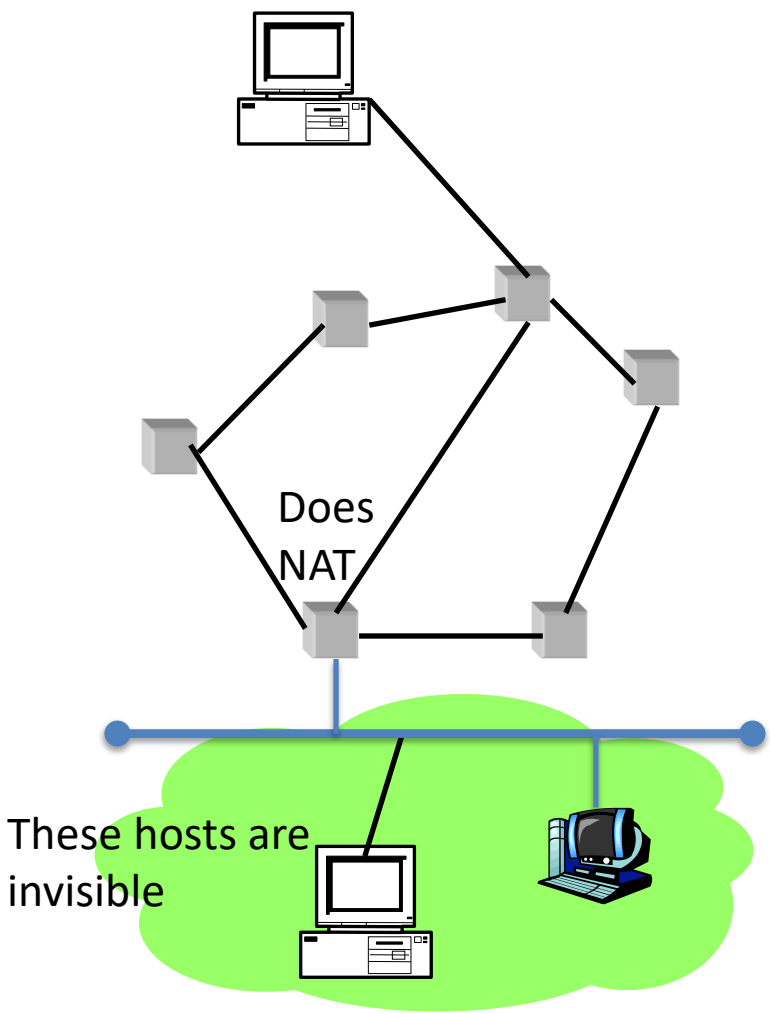
Shortage of IPv4 Addresses

- How To Handle Shortage of IPv4 Addresses?
  - **NAT: Network Address Translation**
    - **Reuse some IP addresses – Called non-routable addresses**
  - **IPv6: IP version 6**

Slide modified from Agrawal

Non-Routable Addresses

- Certain **IP addresses** have been defined to be **reusable** as many times as necessary
- A **small pool of IP addresses** to **serve a large number of computers**
- The **reused** addresses will **NOT** be **globally unique**
  - Hosts using these addresses are invisible to the WAN
  - Routers need to do translation (NAT)



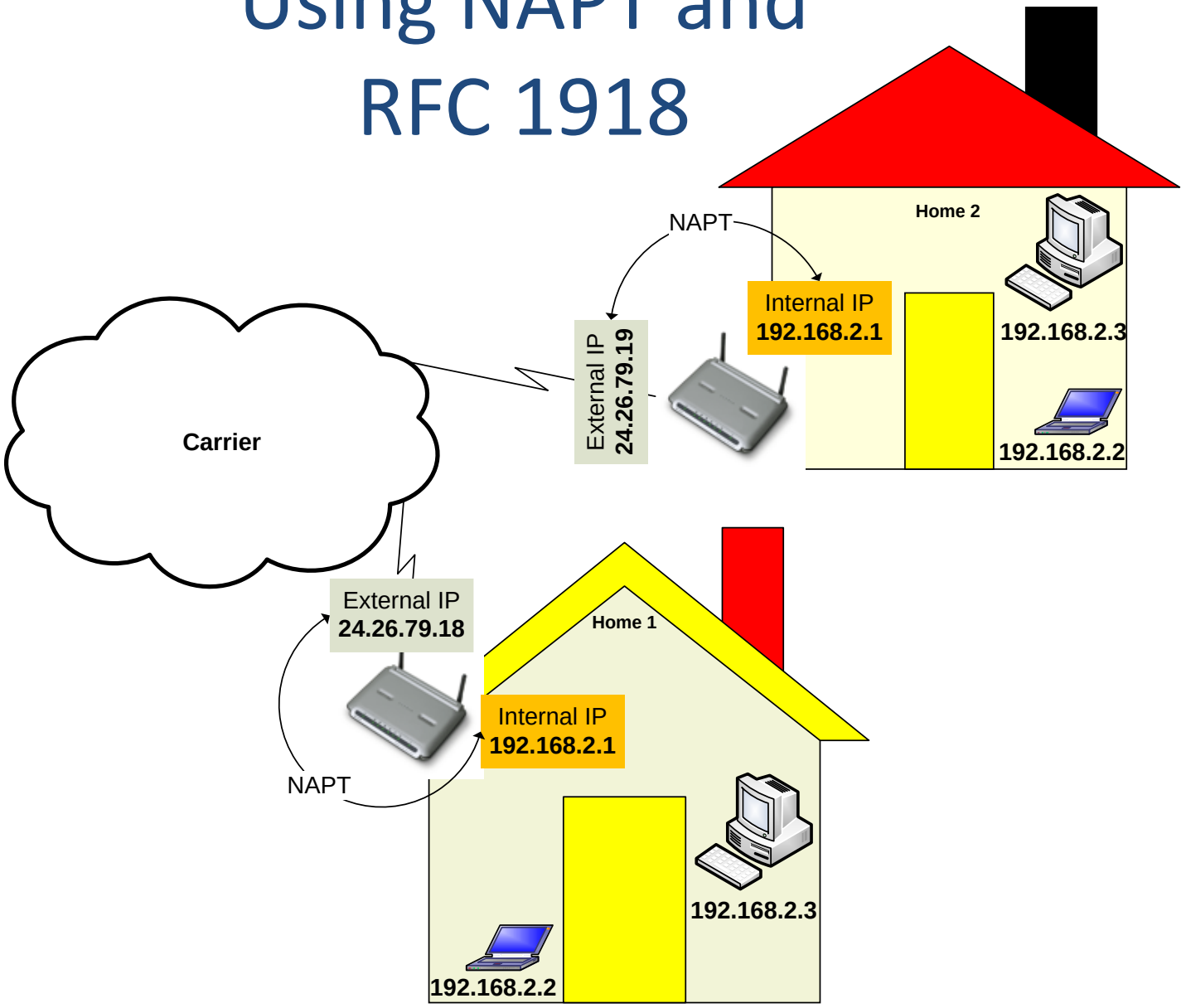
Non-Routable Address Blocks

- One class of **special IP** addresses
- **Three blocks** have been defined in **RFC 1918** to be **reused**

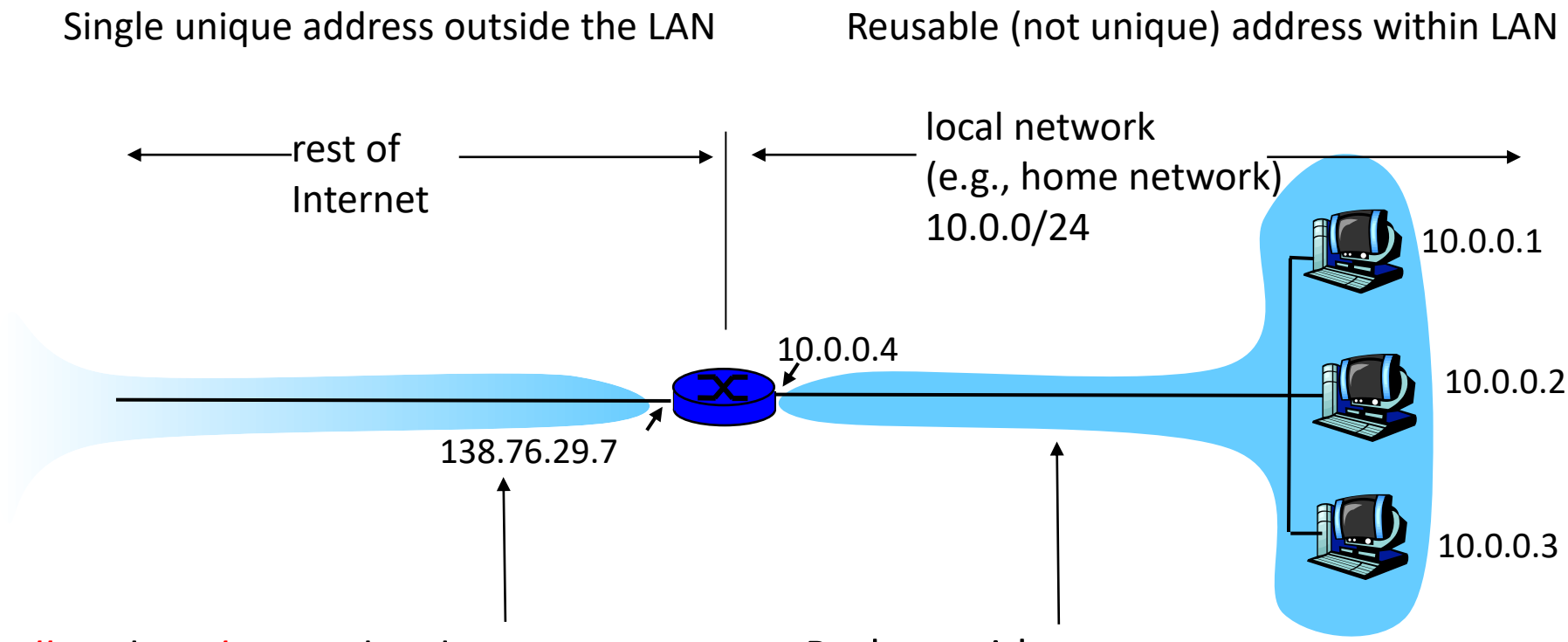
  prefix=number of bits in Net ID

  – 10.0.0.0- 10.255.255.255 (10/8 prefix)
  – 172.16.0.0 - 172.31.255.255 (172.16/12 prefix)
  – 192.168.0.0- 192.168.255.255 (192.168/16 prefix)
- May be used **internally without any co-ordination with any Internet registry**
- Routinely used in **small offices** and **home networks**

Using NAPT and RFC 1918



NAT Example



All packets *leaving* local network have same single source NAT IP address: 138.76.29.7, different source port numbers

Packets with source or destination in this network have 10.0.0/24 address for source, destination (as usual)

Ref. Kurose, computer networking

NAT Implementation in Router

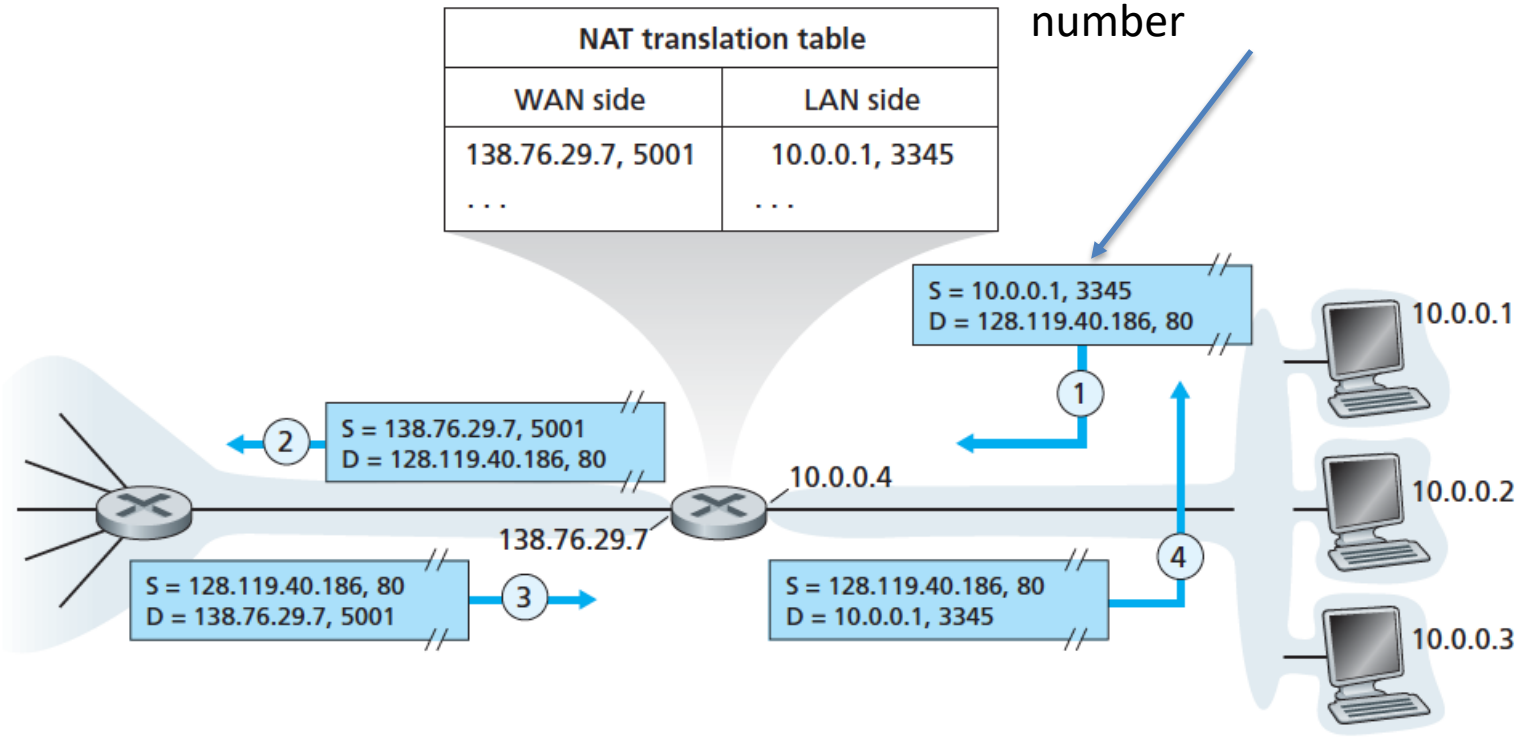
- Outgoing datagrams: replace (source IP address, port #) of every outgoing datagram to (NAT IP address, new port #)
  - Source address is not globally unique
  - NAT IP address is unique
- **NAT translation table**: has (source IP address, port #) to (NAT IP address, new port #) translation pair
- Incoming datagrams: replace (NAT IP address, new port #) in destination fields of every incoming datagram with corresponding (source IP address, port #) stored in NAT table

Example

Going outside LAN: Router records (IP address, port number) of source, and its translated (IP address, port number) to the WAN side

Coming to LAN: When router receives a message, it looks at the (destination IP, port number), and from the translation table it gets the original source on the LAN side

Source: IP address, port number
Destination (final): IP address, port number



Question - tophat

Q_Reusable IP addresses

Reusable IP addresses can be used outside LANs to provide a global addressing over the Internet

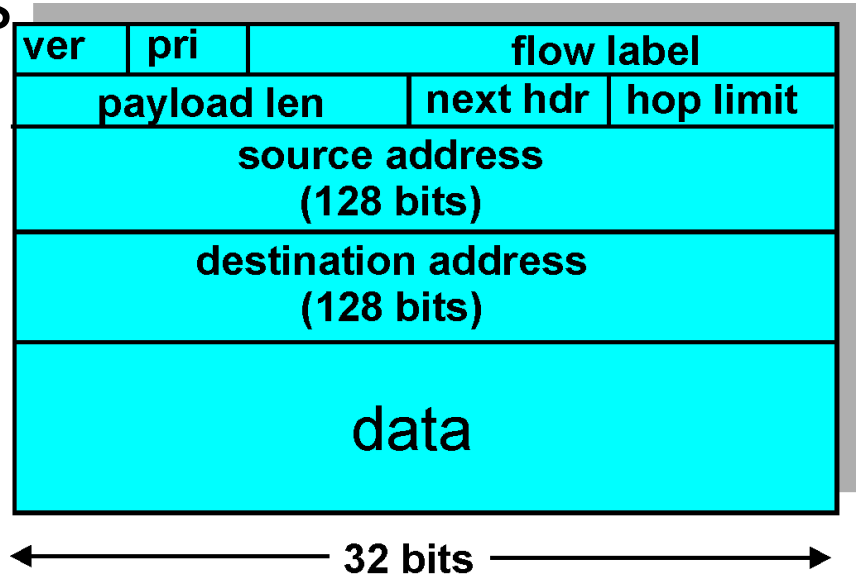
A	True
B	False

Note

- Until IPv6 is universally deployed, NAT and RFC 1918 expands the availability of IP addresses
- Many experts hate NAT because it does not preserve IP addresses end-to-end
  - Hundreds of thousands of devices could have the same IP address.
  - But NAT has a huge commercial success

IP Version 6

- IPv6 defined in RFC 2460
- Primarily expands source and destination address fields from 32 bits to 128 bits



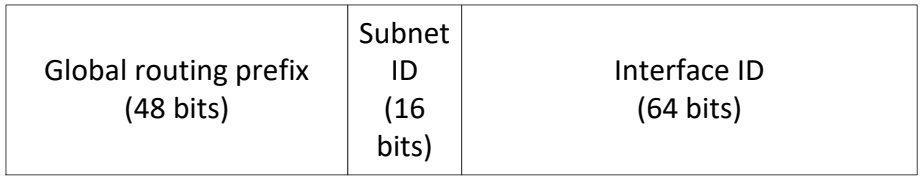
- Eliminates header checksum: Modern networks assumed to be fairly robust

IP Version 6 Address Pool

- IP version 6 is mainly intended to eliminate shortage of IP addresses
  - Total address pool = 2^{128} addresses =
    - 340,282,366,920,938,463,463,374,607,431,768,211,456 addresses (340×10^{36})
- Surface area of earth = 510,007,200,000,000 m^2 (510×10^{12} m^2)
  - 600 billion trillion IP addresses **per square meter** of the Earth's surface (including oceans, deserts etc.)

Subnetting in IPv6

- RFC 3587
  - Standard lengths for network and subnet parts of unicast IPv6 addresses
    - Global routing prefix (network part)
      - 48 bits
    - Subnet ID
      - 16 bits
    - Interface ID (host part)
      - 64 bits
  - Simplifies packet processing & routing



Questions

- There are protocols in the application layer that supports the following functions:
  - How does a **device get its own IP address** & subnet Information
    - DHCP: Dynamic Host Configuration Protocol
  - How does a **device get the destination IP address**
    - DNS: Domain Name Service

Summary: Address Shortage

- Solutions to shortage of IPv4 address
  - NAT: non-routable addresses and network address translation
    - Allows reuse of predefined IP address blocks
    - NAT router makes translation from globally assigned address to internal address though maintaining NAT forwarding table.
  - IPv6 expands the IP address space from 32 bits to 128 bits.