

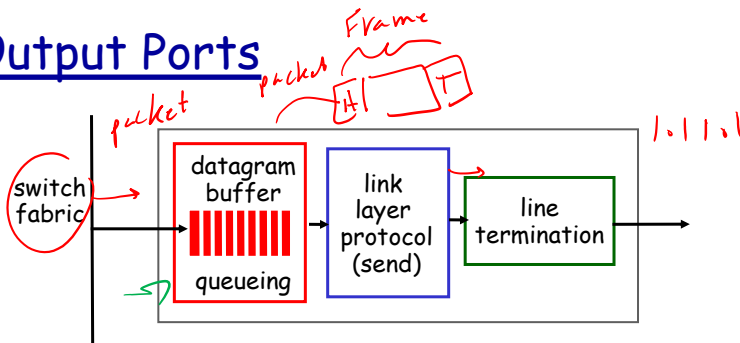
Lecture 20

- ❖ Sections 4.2.3, 4.2.4, 4.2.5, 4.3.1 and 4.3.2
- ❖ Output port processing
- ❖ Input and output port queueing
- ❖ Packet scheduling
- ❖ Internet Protocol (IP) IPv4 IPv6
 - IPv4 packet format
 - IPv4 addressing

Network Layer Data Plane 4-24

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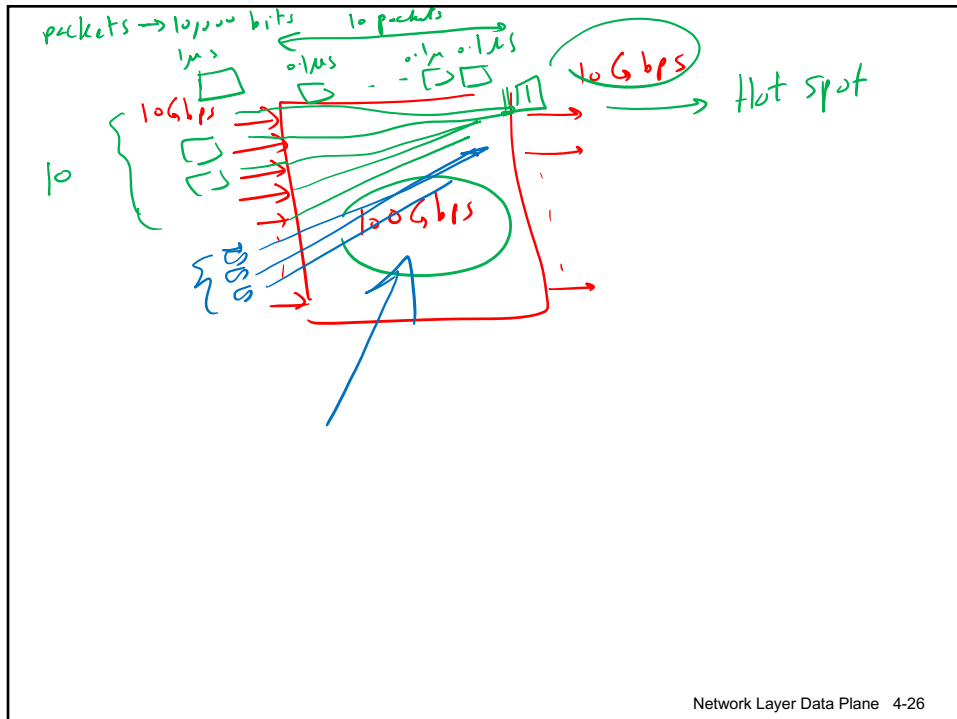
Output Ports



- ❖ buffering required when datagrams arrive from fabric faster than the transmission rate
- ❖ scheduling discipline chooses among queued datagrams for transmission:
 - implements quality of service

Network Layer 4-25

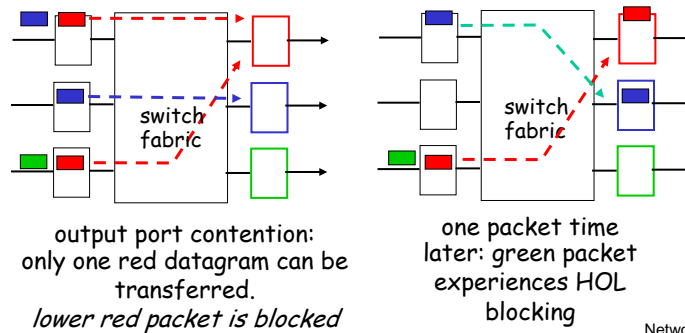
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Input Port Queuing

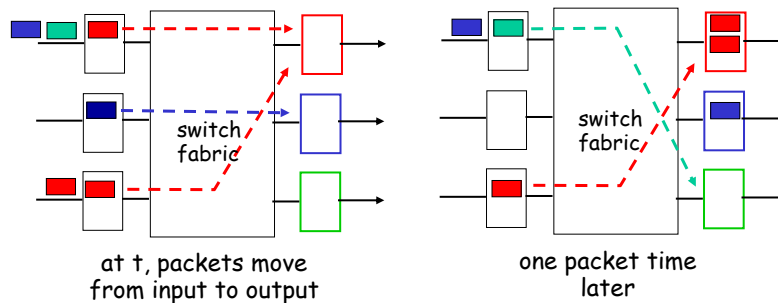
- ❖ fabric slower than input ports combined -> queueing may occur at input queues
 - *queueing delay and loss due to input buffer overflow!*
- ❖ **Head-of-the-Line (HOL) blocking:** queued datagram at front of queue prevents others in queue from moving forward



Network Layer 4-27

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Output port queueing



- ❖ buffering when arrival rate via switch exceeds output line speed
- ❖ *queueing (delay) and loss due to output port buffer overflow!*

Network Layer 4-28

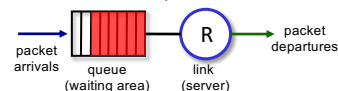
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Packet Scheduling: FCFS

packet scheduling:
deciding which packet to send next on link

- first come, first served
- priority
- round robin
- weighted fair queueing

Abstraction: queue



FCFS: packets transmitted in order of arrival to output port

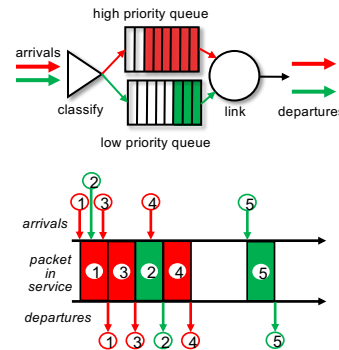
- also known as: First-in-first-out (FIFO)
- real world examples?

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Scheduling policies: priority

Priority scheduling:

- ❖ arriving traffic classified, queued by class
 - any header fields can be used for classification
- send packet from highest priority queue that has buffered packets
 - FCFS within priority class

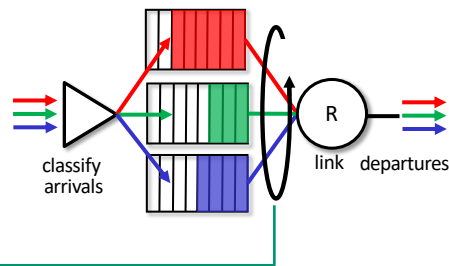


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Scheduling policies: round robin

Round Robin (RR) scheduling:

- ❖ arriving traffic classified, queued by class
 - any header fields can be used for classification
- server cyclically, repeatedly scans class queues, sending one complete packet from each class (if available) in turn



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Scheduling policies: weighted fair queueing

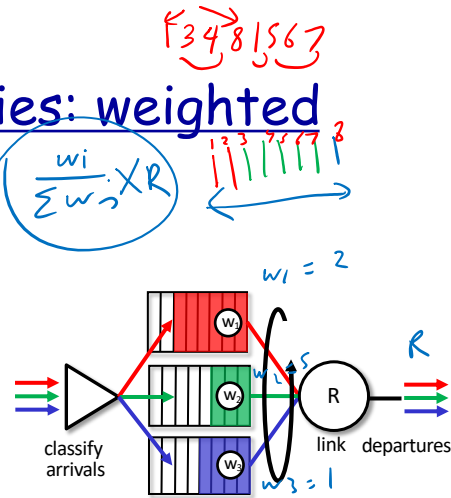
Weighted Fair Queuing (WFQ):

❖ generalized Round Robin

- each class, i , has weight, w_i , and gets weighted amount of service in each cycle:

$$\frac{w_i}{\sum_j w_j}$$

- minimum bandwidth guarantee (per-traffic-class)



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Chapter 4: Network Layer

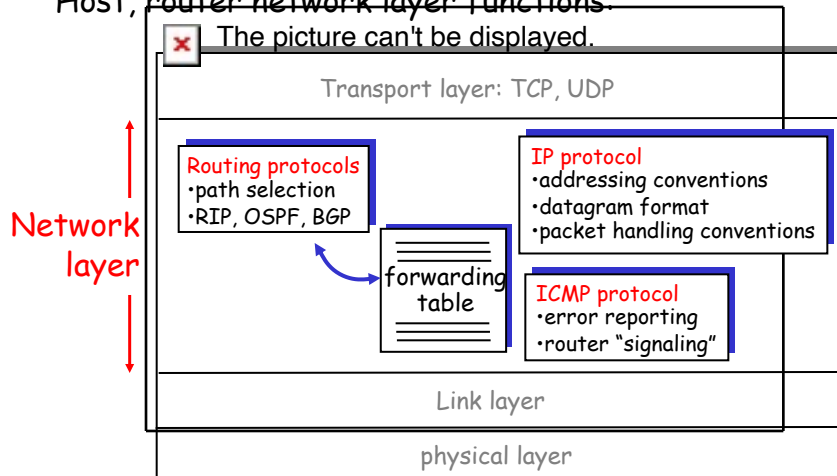
- ❖ 4.1 Introduction
- ❖ 4.2 What's inside a router
- ❖ 4.3 IP: Internet Protocol
 - IPv4 Datagram format

Network Layer 4-33

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The Internet Network layer

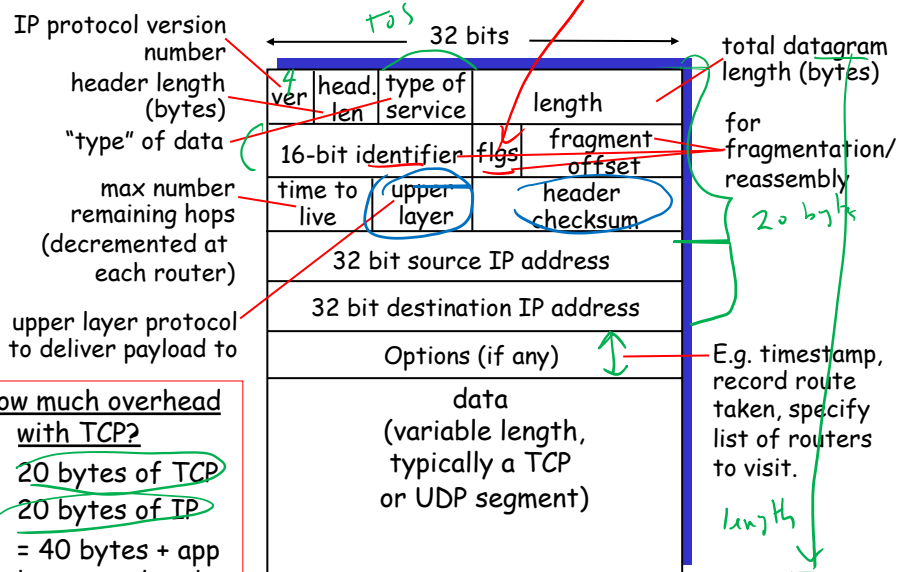
Host, router network layer functions:



Network Layer 4-34

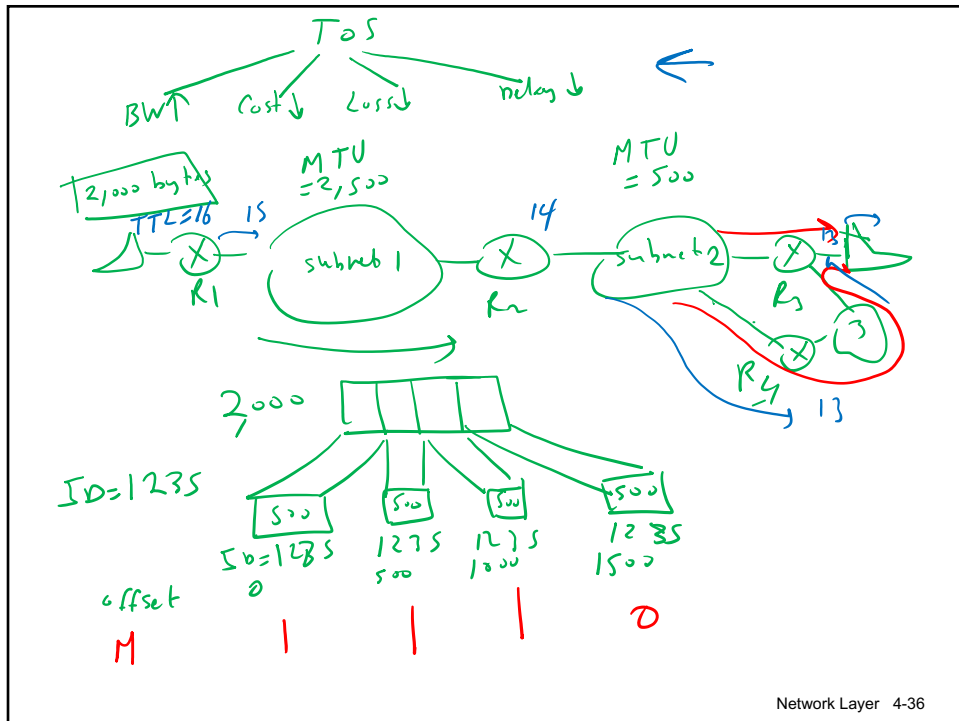
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IP datagram format



Network Layer 4-35

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Chapter 4: Network Layer

4.1 Introduction

4.2 What's inside a router

4.3 IP: Internet Protocol

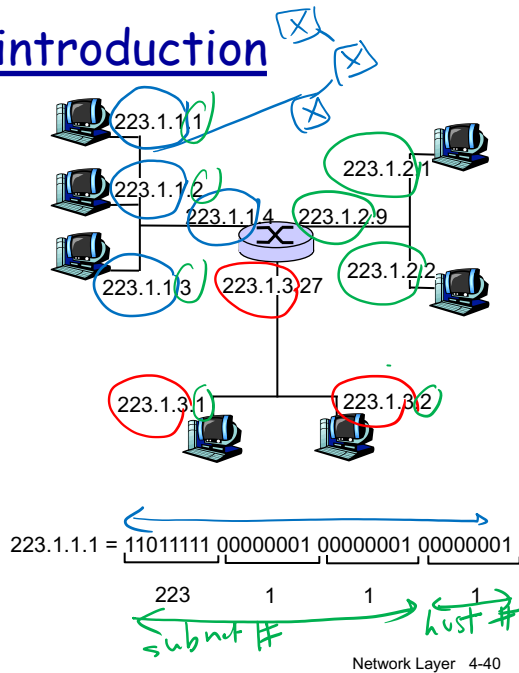
- IPv4 Datagram format
- IPv4 addressing

Network Layer 4-39

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IP Addressing: introduction

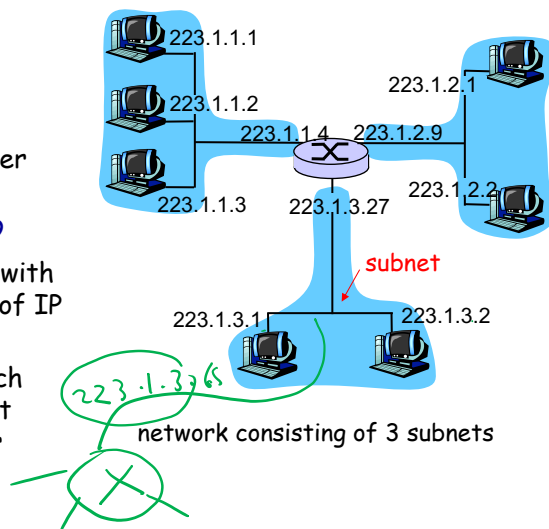
- ❖ **IP address:** 32-bit identifier for host, router *interface*
- ❖ **interface:** connection between host/router and physical link
 - router's typically have multiple interfaces
 - host typically has one interface
 - IP addresses associated with each interface



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Subnets

- ❖ **IP address:**
 - subnet part (high order bits)
 - host part (low order bits)
- ❖ **What's a subnet?**
 - device interfaces with same subnet part of IP address
 - can physically reach each other without intervening router



Network Layer 4-41

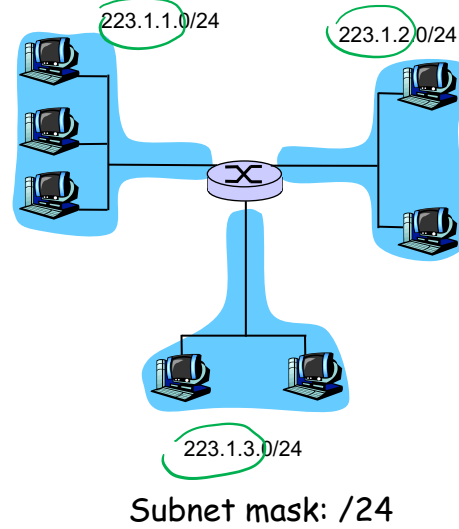
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Subnets

Recipe

- ❖ remove routers, hence creating islands of isolated networks
- ❖ each isolated network is called a **subnet**.
- ❖ each subnet is identified by subnet number, and subnet mask:
 - subnet mask is number of valid bits in subnet number

Example: 223.1.1.0/24

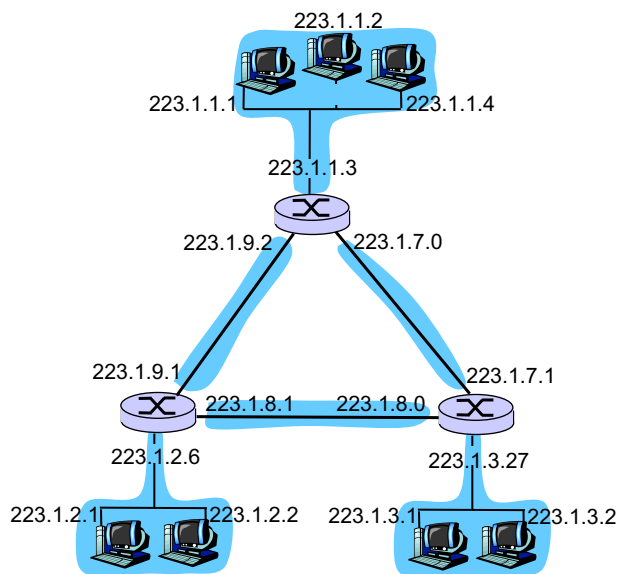


Network Layer 4-42

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Subnets

How many?



Network Layer 4-43

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Supernets

class C:

24 bits for network & 8 bits for host

