Computer Networks COL 334/672

Data Plane

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Slides adapted from KR
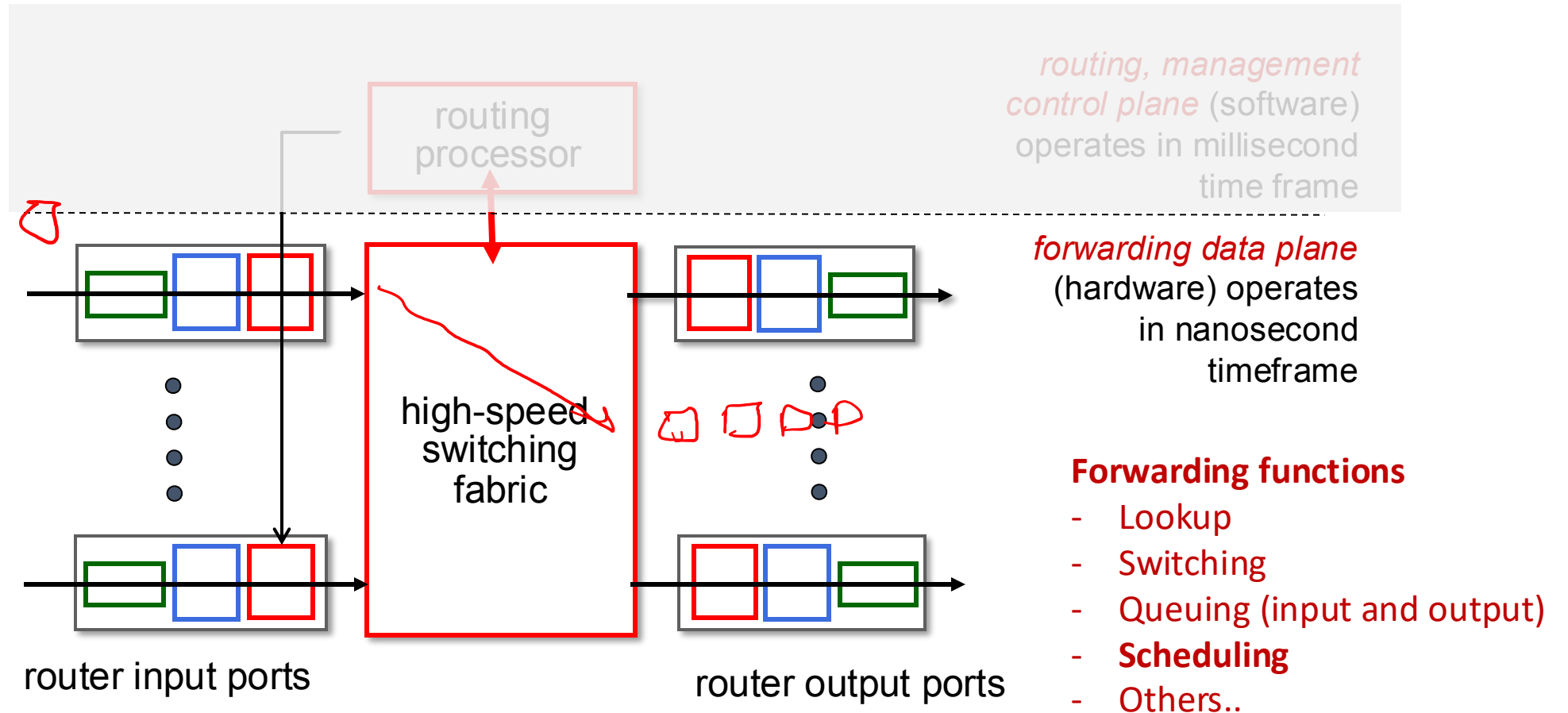
Sem 1, 2024-25

Quiz

baubles

Recap

Network Layer: Data Plane

router input ports

high-speed switching fabric

router output ports

routing processor

*routing, management
control plane* (software)
operates in millisecond
time frame

forwarding data plane
(hardware) operates
in nanosecond
timeframe

Forwarding functions
- Lookup
- Switching
- Queuing (input and output)
- **Scheduling**
- Others..

Data Plane Functions

- Prefix lookup
- Switching
- Queuing
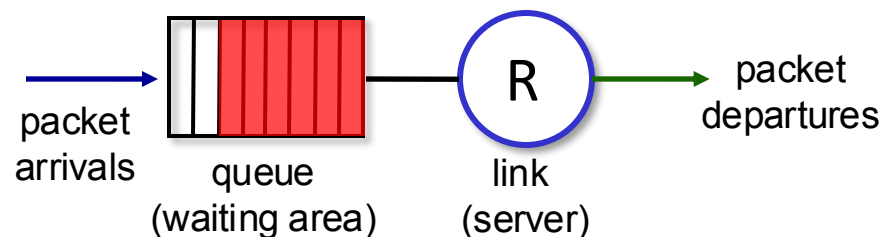- Scheduling

Packet Scheduling: FCFS

packet scheduling: deciding which packet to send next on link

Can you think of some queuing policies?

FCFS: packets transmitted in order of arrival to output port

- also known as: First-in-first-out (FIFO)

Abstraction: queue

packet arrivals → queue (waiting area) → link (server) R → packet departures

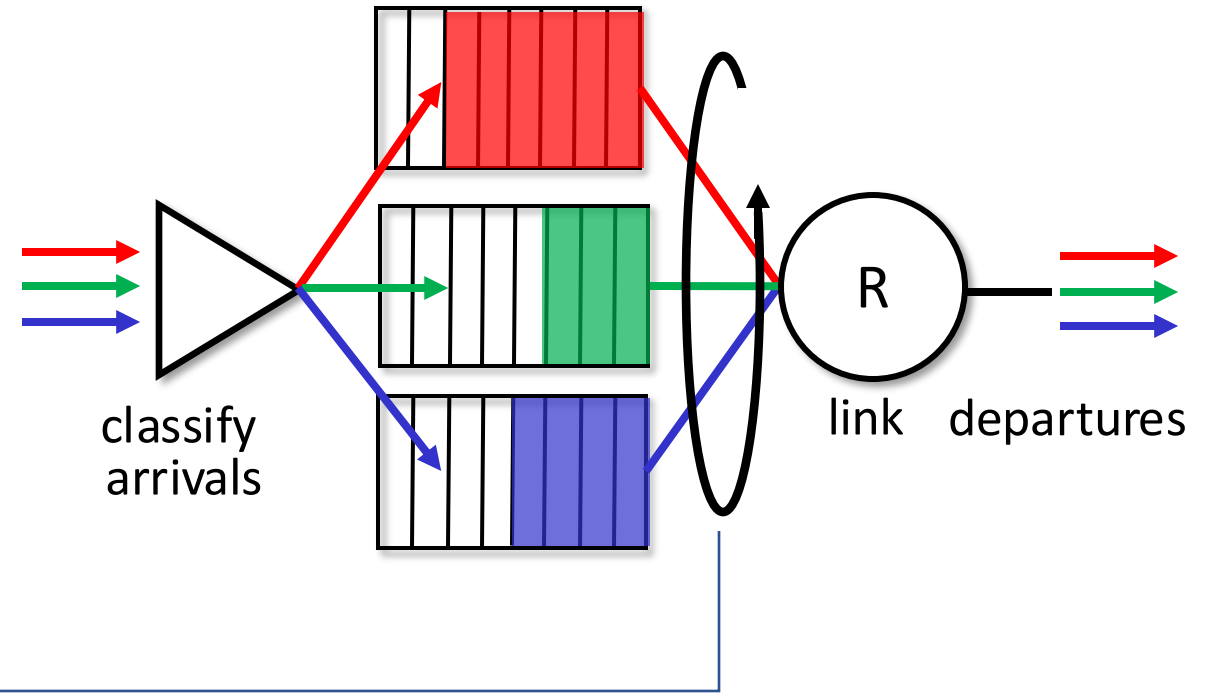# Scheduling policies: priority

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
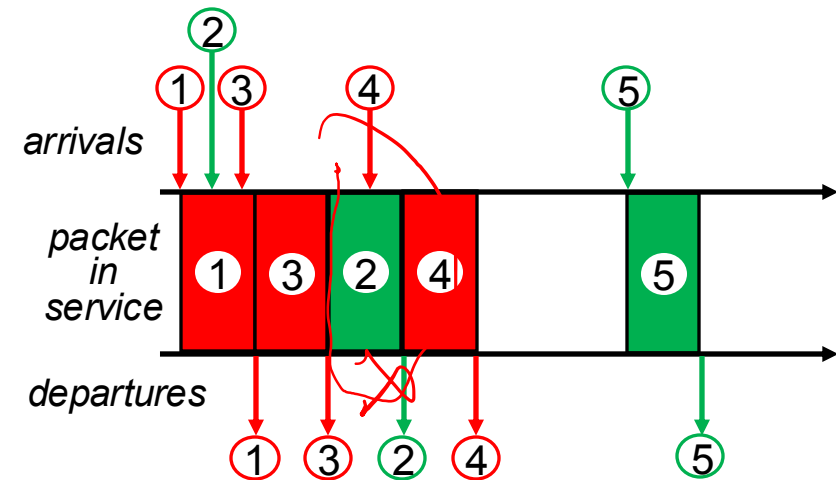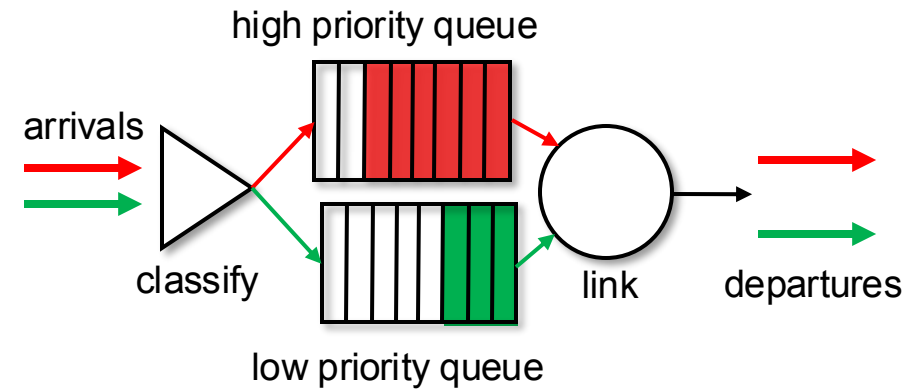
Scheduling policies: round robin

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

classify
arrivals

R

link   departures

Scheduling policies: weighted fair queueing
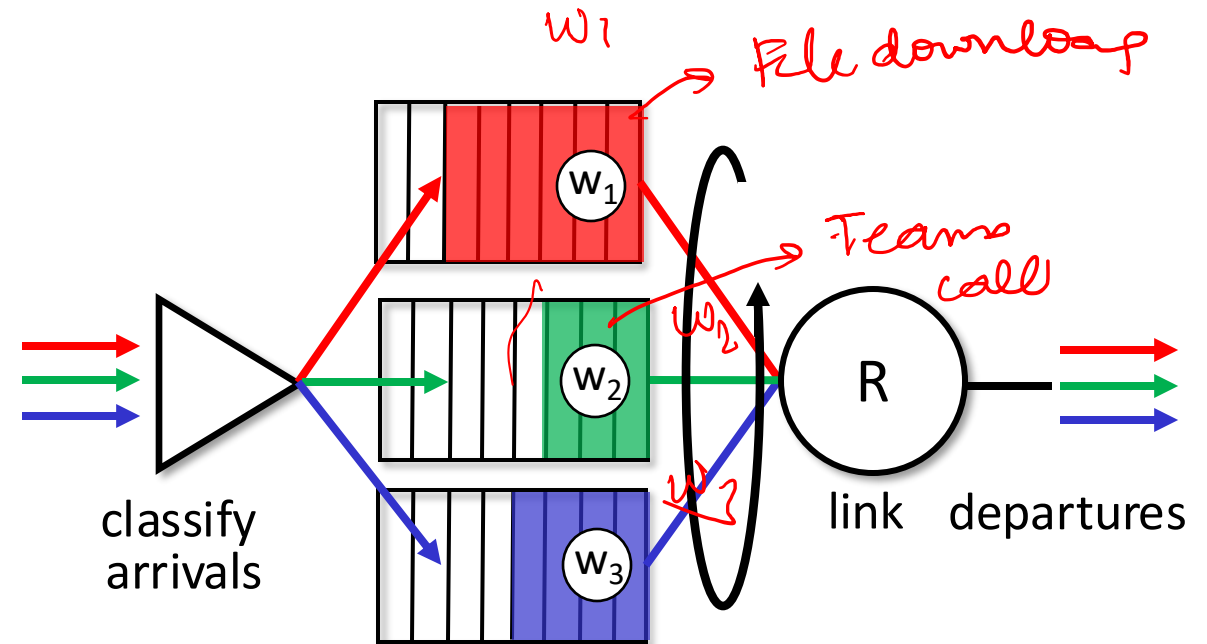
2) Economic angles

OSPF link announcement

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)

W1

File download

Teams call

W2

W?

classify arrivals

link   departures

What about net neutrality?

Sidebar: Network Neutrality

(handwritten, red)
1. Freedom of speed
2. monopolies
   or innovation
   could be stifled
2

What is network neutrality?

Internet service providers (ISPs) must treat all Internet communications equally regardless of content, website, platform, application, type of equipment

Different countries have different "takes" on network neutrality

Network Neutrality: India

ISPs Perspective

In February 2012, at the World Mobile Congress held in Barcelona, the CEO of Bharti Airtel, Sunil Bharti Mittal suggested that services like YouTube should pay an interconnect charge to network operators, saying that if telecom operators are building highways for data then there should be a tax on the highway.[14] In July 2012, Bharti Airtel's Director of Network Services, Jagbir Singh suggested that large Internet companies like Facebook and Google should share revenues with telecom companies. According to him, Internet companies were making big profits from small investments, whereas the telecom companies were actually investing in building networks. He also suggested that the telecom regulator should establish interconnection charges for data services, similar to those applied to voice calls.[15] In August 2012, *The Hindu* reported that according to data from M-Lab, You Broadband, Airtel, and BSNL were throttling BitTorrent traffic.[16]

Facebook Free Basics   AIB video on network neutrality:

Facebook's proposed Free Basics is a new avatar of its internet.org initiative which allows customers to access a slew of apps for free. However, activists are pushing back this initiative arguing that with Free Basics, Facebook would become a gatekeeper, deciding who would not be on the Free Basics platform and in the process, make or break fortunes of several startups.[60] As a result, Facebook has challenged the TRAI after releasing its Free Basics zero-rating app "which provides access to a host of Internet services like Wikipedia, the BBC, health sites and weather reports, and, of course, Facebook. The services are lightweight versions of the originals that load quickly and perform well on less robust 2G and 3G networks."[61] The TRAI blocked Free Basics on the basis that although the service is free, there are specific sites that cannot be accessed unless the consumer pays. Zuckerberg countered this argument by releasing a statement saying, "It's not an equal Internet if the majority of people can't participate."[61] Towards the

Net Neutrality: India

- In 2016, TRAI ordered in favour of Net Neutrality

In their latest ruling,[10] they have stipulated that:

1. No service provider can offer or charge discriminatory tariffs for data services on the basis of content.
2. No service provider shall enter into any arrangement, agreement or contract, by whatever name called, with any person, natural or legal, that the effect of discriminatory tariffs for data services being offered or charged by the service provider for the purpose of evading the prohibition in this regulation.

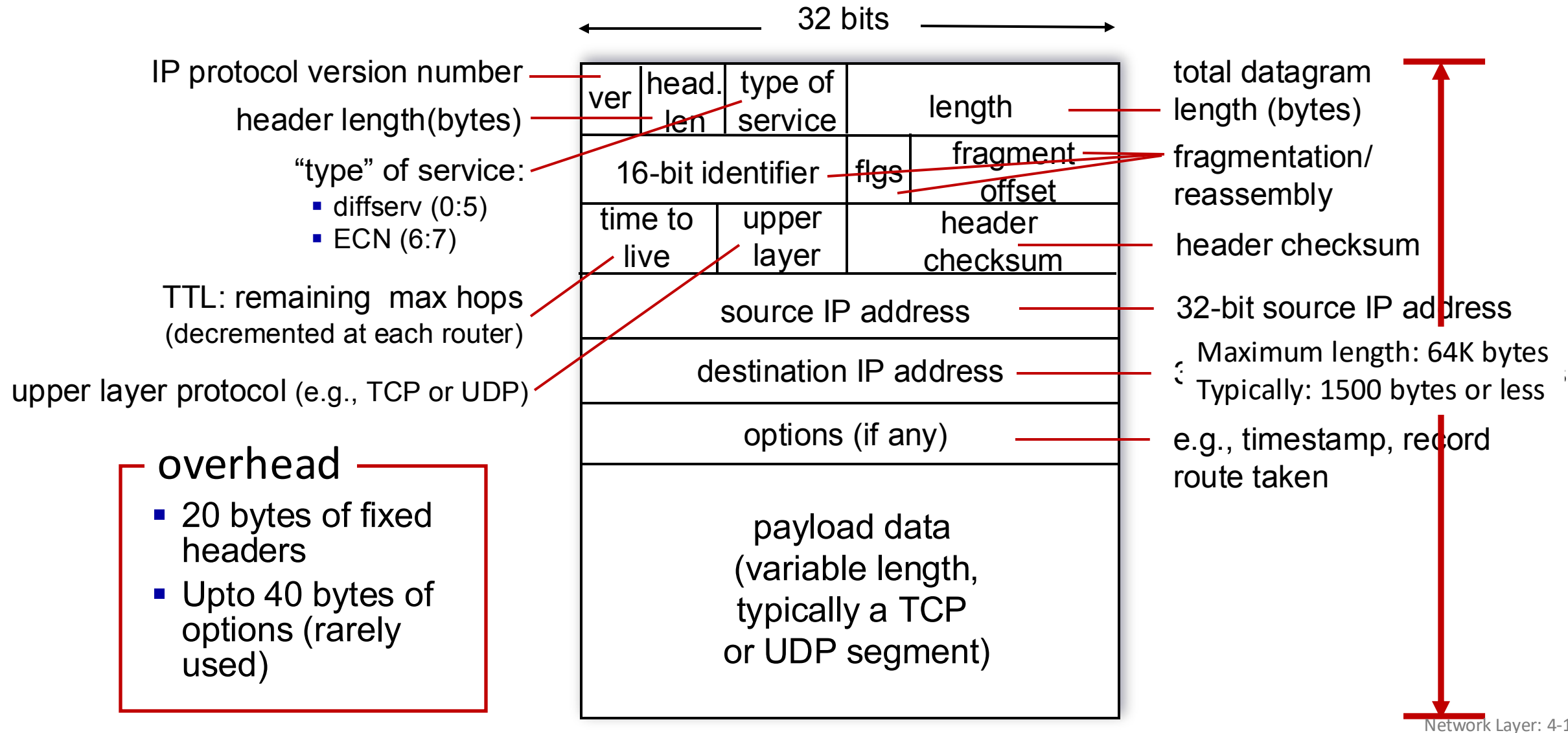- In July 2018, Department of Telecommunications approved TRAI recommendations

Since 12 July 2018 Net Neutrality has been in effect in India. These rules ban any form of data discrimination. ISPs which violate these rules can have their licenses cancelled. Though these rules do not apply to "critical IoT services" or "specialized services" such as autonomous vehicles and remote surgery operations.[69]

Summary

- Control plane functions
  - Inter-domain vs intra-domain routing

- Data plane functions
  - Prefix lookup
  - Switching
  - Buffering
  - Scheduling ..

- Future class: Per-router control plane vs centralized control plane [SDN]
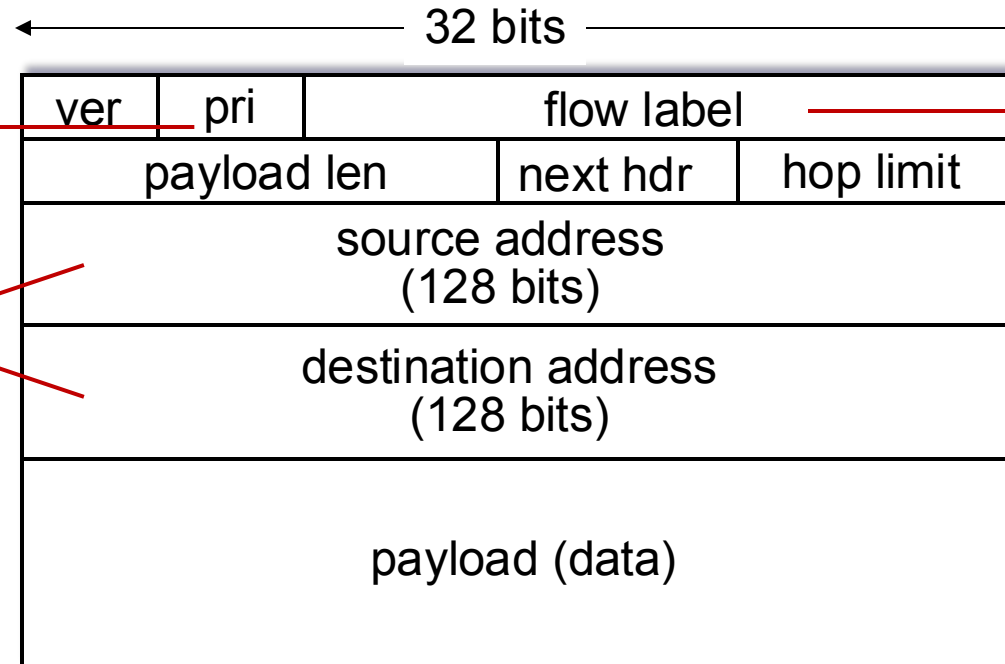
IPv4 Datagram format

IP protocol version number

header length(bytes)

"type" of service:
- diffserv (0:5)
- ECN (6:7)

TTL: remaining max hops
(decremented at each router)

upper layer protocol (e.g., TCP or UDP)

overhead
- 20 bytes of fixed headers
- Upto 40 bytes of options (rarely used)

32 bits

ver	head. len	type of service	length
16-bit identifier		flgs	fragment offset
time to live	upper layer	header checksum
source IP address
destination IP address
options (if any)
payload data (variable length, typically a TCP or UDP segment)

total datagram length (bytes)

fragmentation/ reassembly

header checksum

32-bit source IP address

Maximum length: 64K bytes
Typically: 1500 bytes or less

e.g., timestamp, record route taken

IPv6 datagram format

priority: identify priority among datagrams in flow

128-bit IPv6 addresses

flow label: identify datagrams in same "flow." (concept of "flow" not well defined).

32 bits

ver	pri	flow label
payload len	next hdr	hop limit

source address (128 bits)

destination address (128 bits)

payload (data)

What's missing (compared with IPv4):
- no checksum (to speed processing at routers)
- no fragmentation/reassembly (let the host figure it out)
- no options (available as upper-layer, next-header protocol at router)

IPv6 adoption

- Google[1]: ~ 40% of clients access services via IPv6 (2024)
- India tops the world in IPv6 adoption rates (73% adoption)

Native: 46.77% 6to4/Teredo: 0.00% Total IPv6: 46.77% | Aug 24, 2024
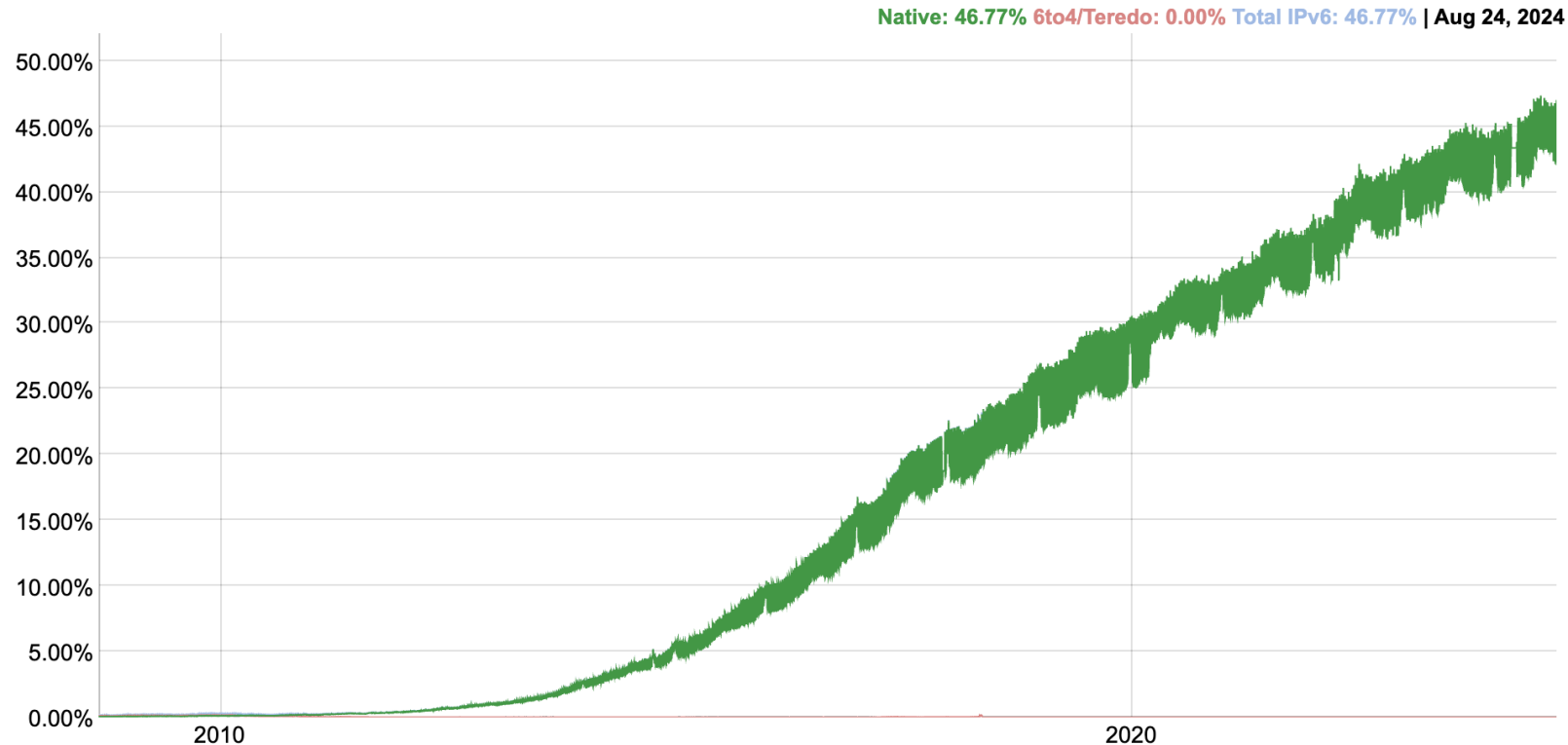
Don't all routers in the network path need to be IPv6 compatible for this to work?

Transition from IPv4 to IPv6

- not all routers can be upgraded simultaneously
  - no "flag days"
  - how will network operate with mixed IPv4 and IPv6 routers?

- tunneling: IPv6 datagram carried as *payload* in IPv4 datagram among IPv4 routers ("packet within a packet")
  - tunneling used extensively in other contexts (4G/5G)

IPv4 header fields
IPv4 source, dest addr

IPv6 header fields
IPv6 source dest addr
UDP/TCP payload

IPv4 payload

IPv6 datagram

IPv4 datagram