CS120: Computer Networks

Lecture 20. QoS

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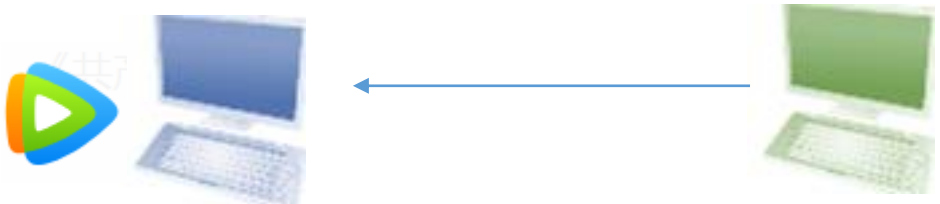
Congestion Control

- Queuing
- Connection Control Methods
  - Congestion Control
  - Congestion Avoidance

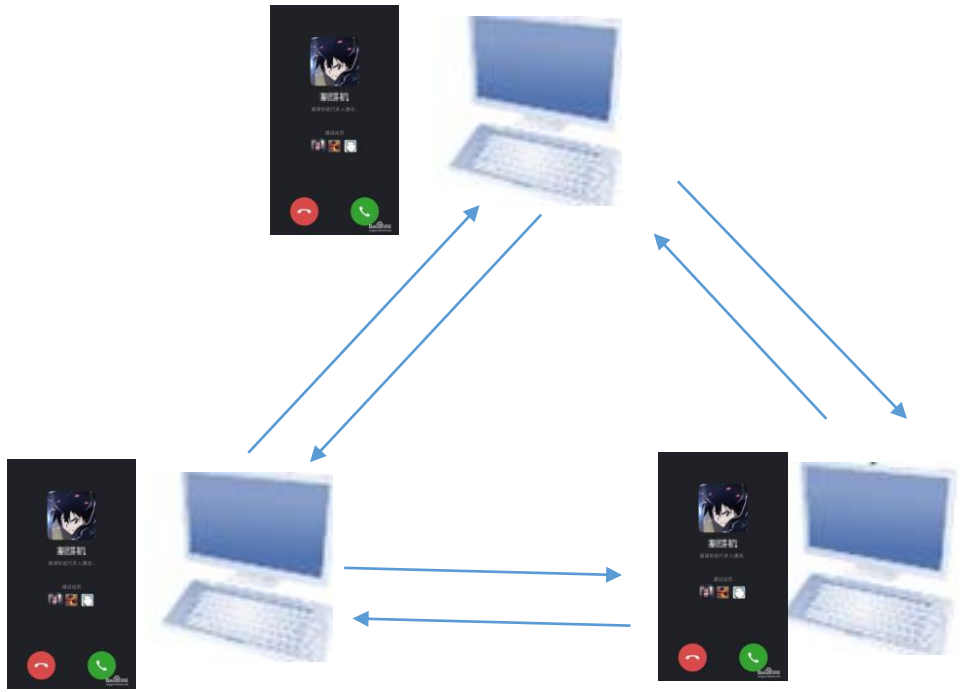
➢QoS

Realtime Application

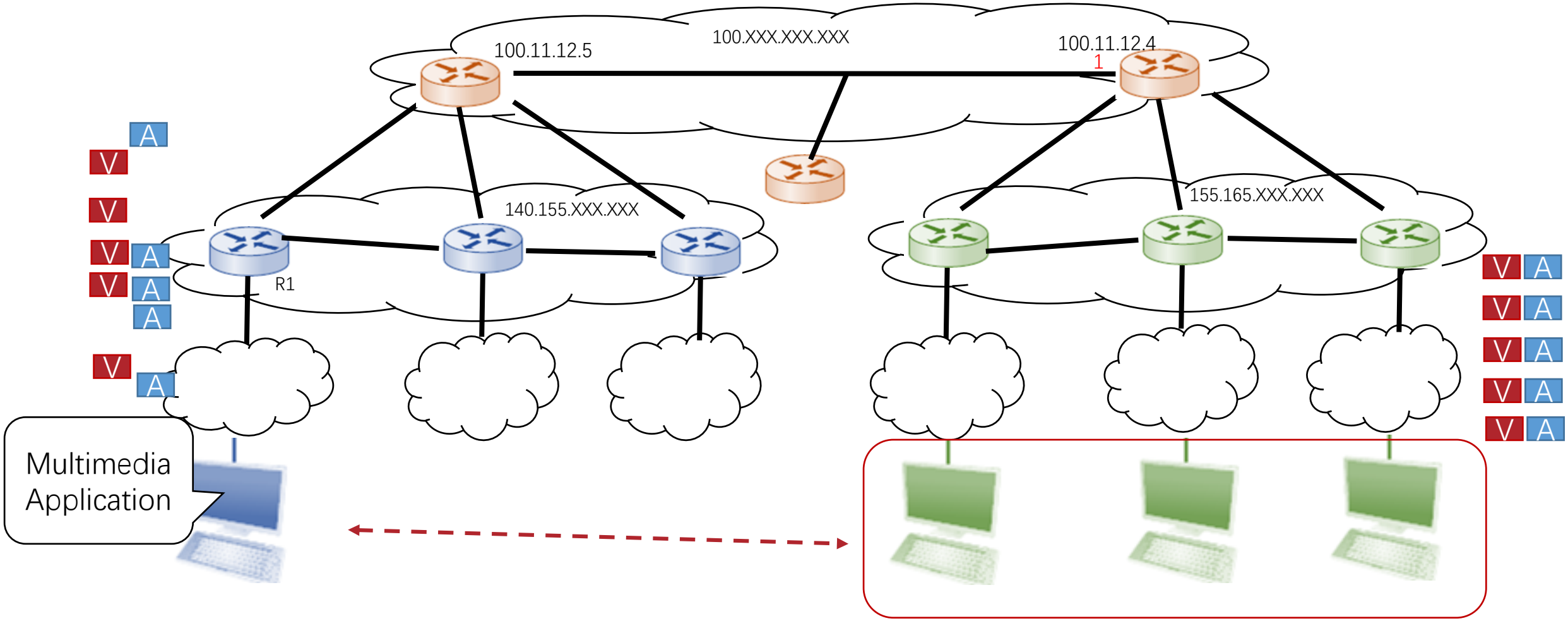
- Target: Multimedia Application
  - Applications involve video, audio, and data.
  - Two Classes:
    - Streaming application
      - TV broadcast, music broadcast
    - Interactive application
      - VoIP



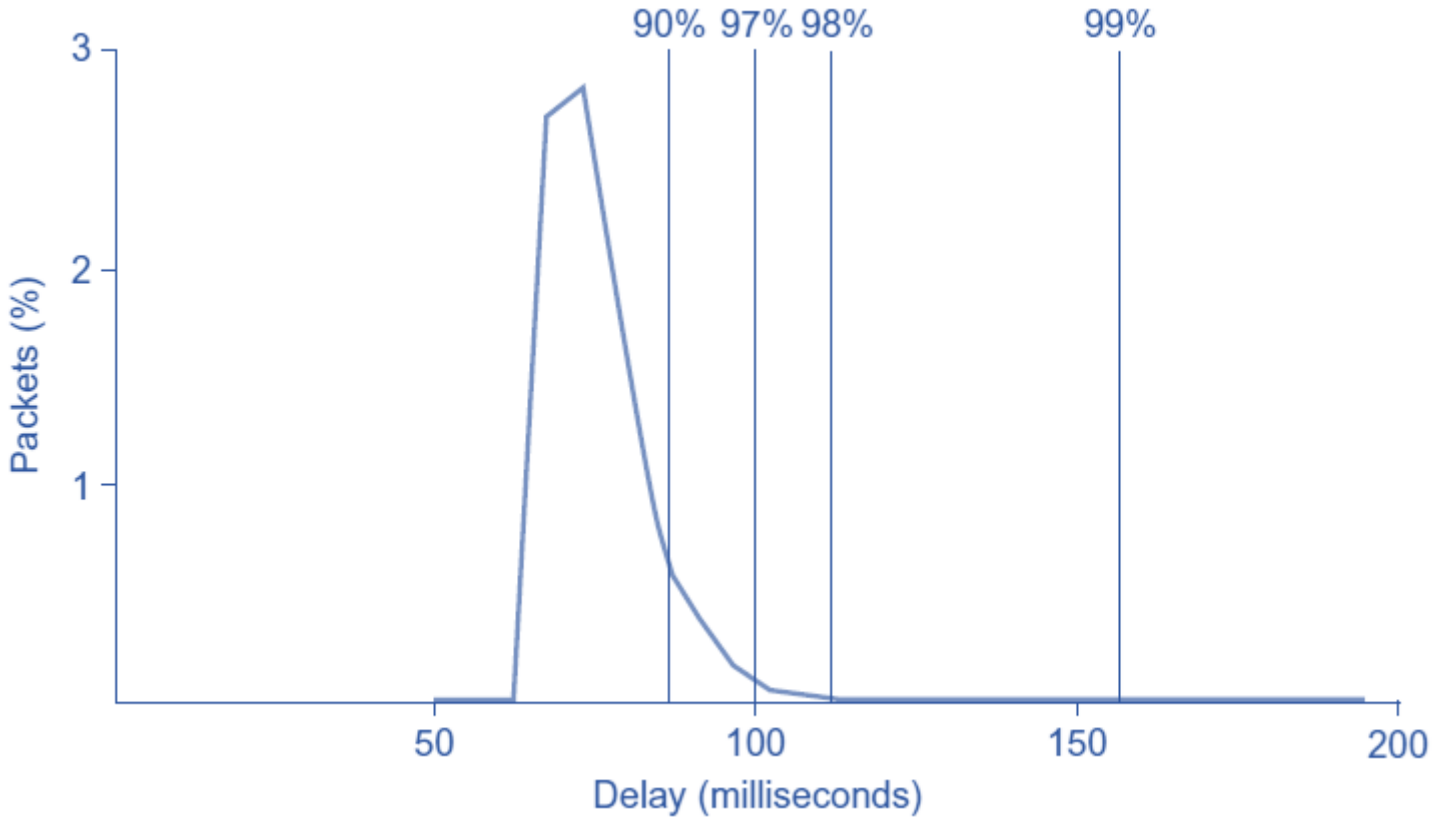
Server



Realtime Application

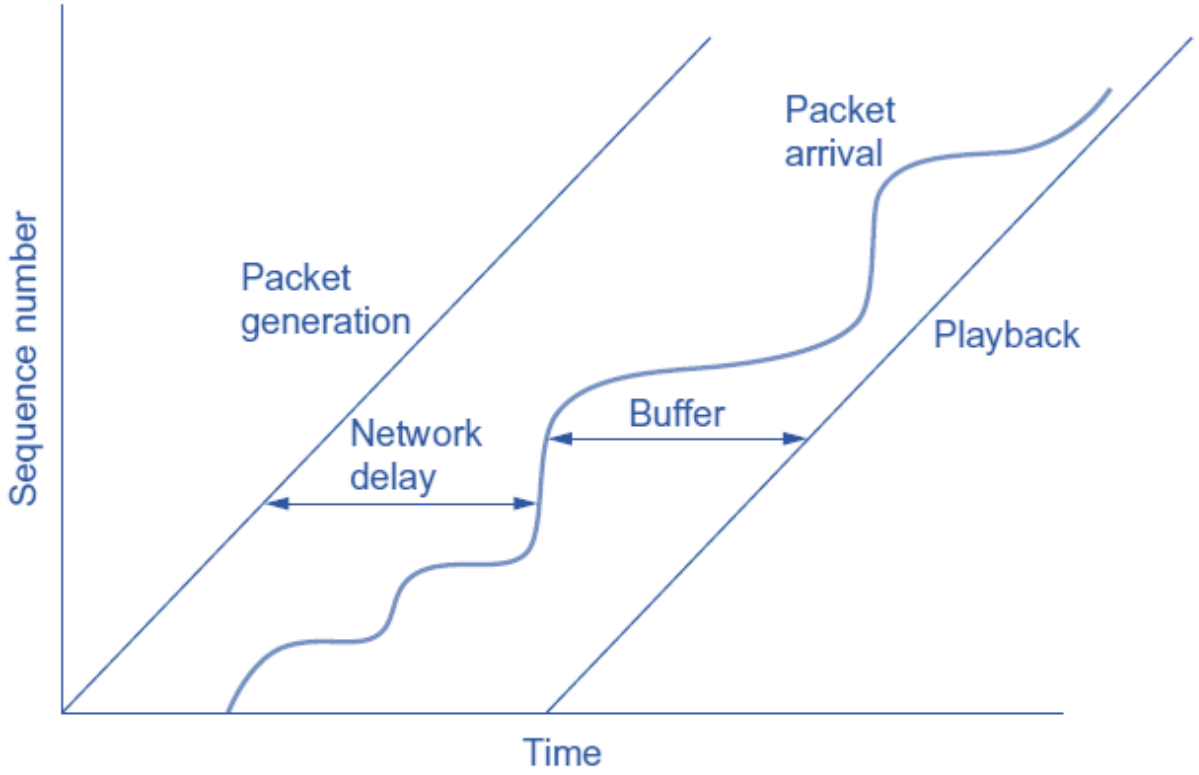


Delay Profile



Destination Playback Buffer

- Buffer can be used to handle delay variance



Destination Playback Buffer

- Buffer does not eliminate delay

Realtime Applications

Quality of Service (QoS)

- Objective: to provide different service (network quality) to different applications
- Service Model
  - Best effort
  - Integrated Services (IntServ)
    - QoS supports every individual applications/flows
  - Differentiated Services (DiffServ)
    - QoS supports multiple/two classes of data or aggregated traffic

Integrated Services (IntServ)

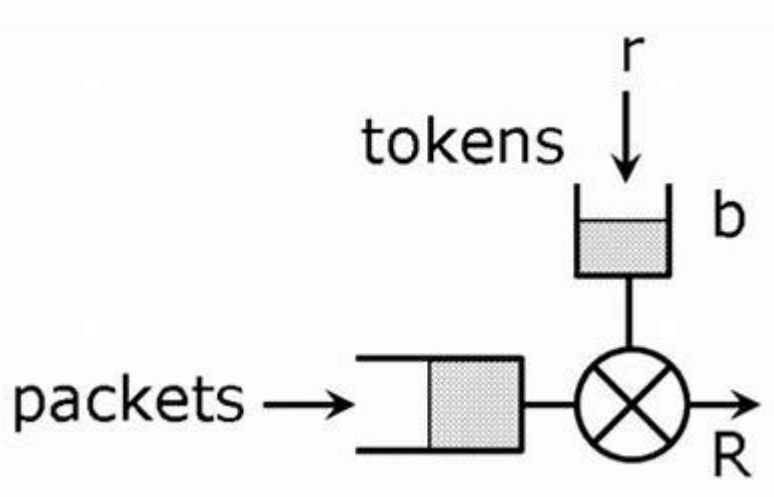
- Flow Specification
  - What is the flow
  - What we want to guarantee for the flow
- Admission Control
  - How network decides if it can accept the flow spec
- Resource Reservation Protocol
  - How service request gets from host to network
- Packet Classification and Scheduling
  - How routers deliver service

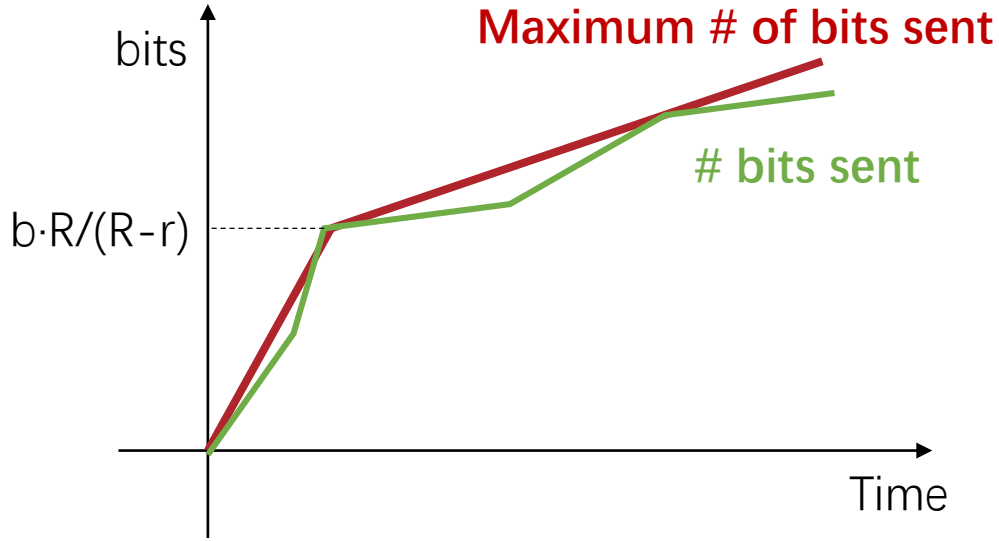
Flow Specification

- Specify the maximum bit rate
  - Maximum bit rate may be much higher than average
  - Reserving for the worst case is wasteful
- Specify the average bit rate
  - Network will not be able to carry bursty traffic
- Specify the burstiness of the traffic
  - Specify both the average rate and the burst size

Specify Burstiness: Token Bucket

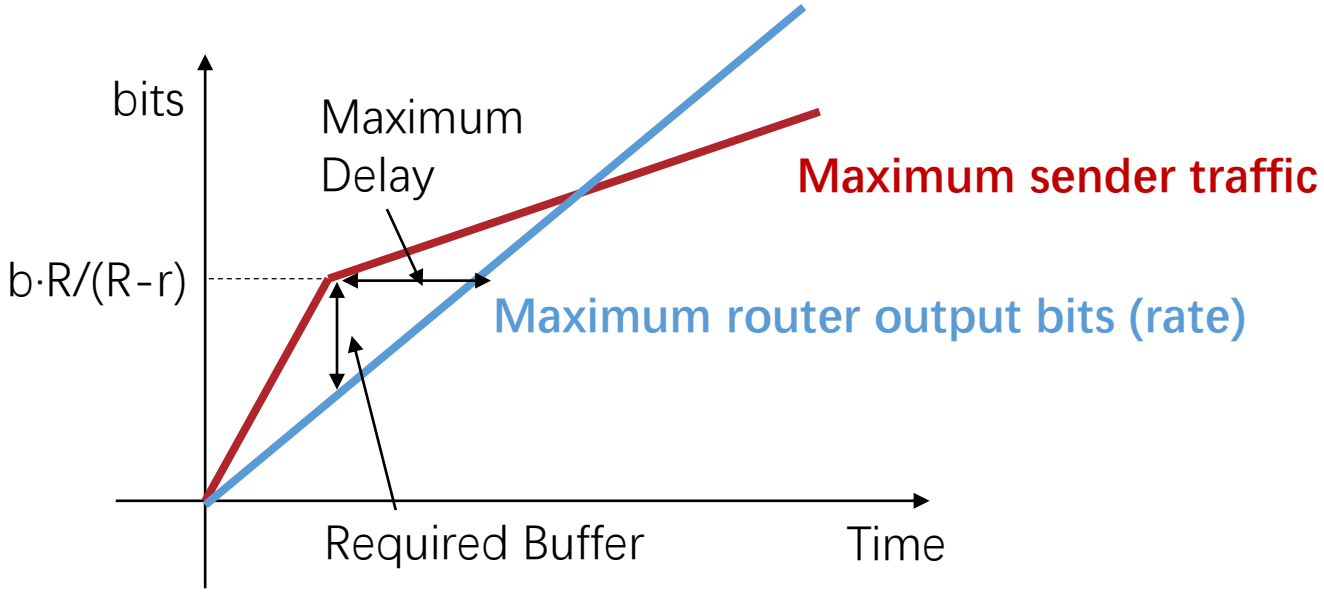
- Parameters:
  - r: average rate, i.e., rate at which tokens fill the bucket
  - b: bucket depth (limits size of burst)
  - R: maximum link capacity or peak rate



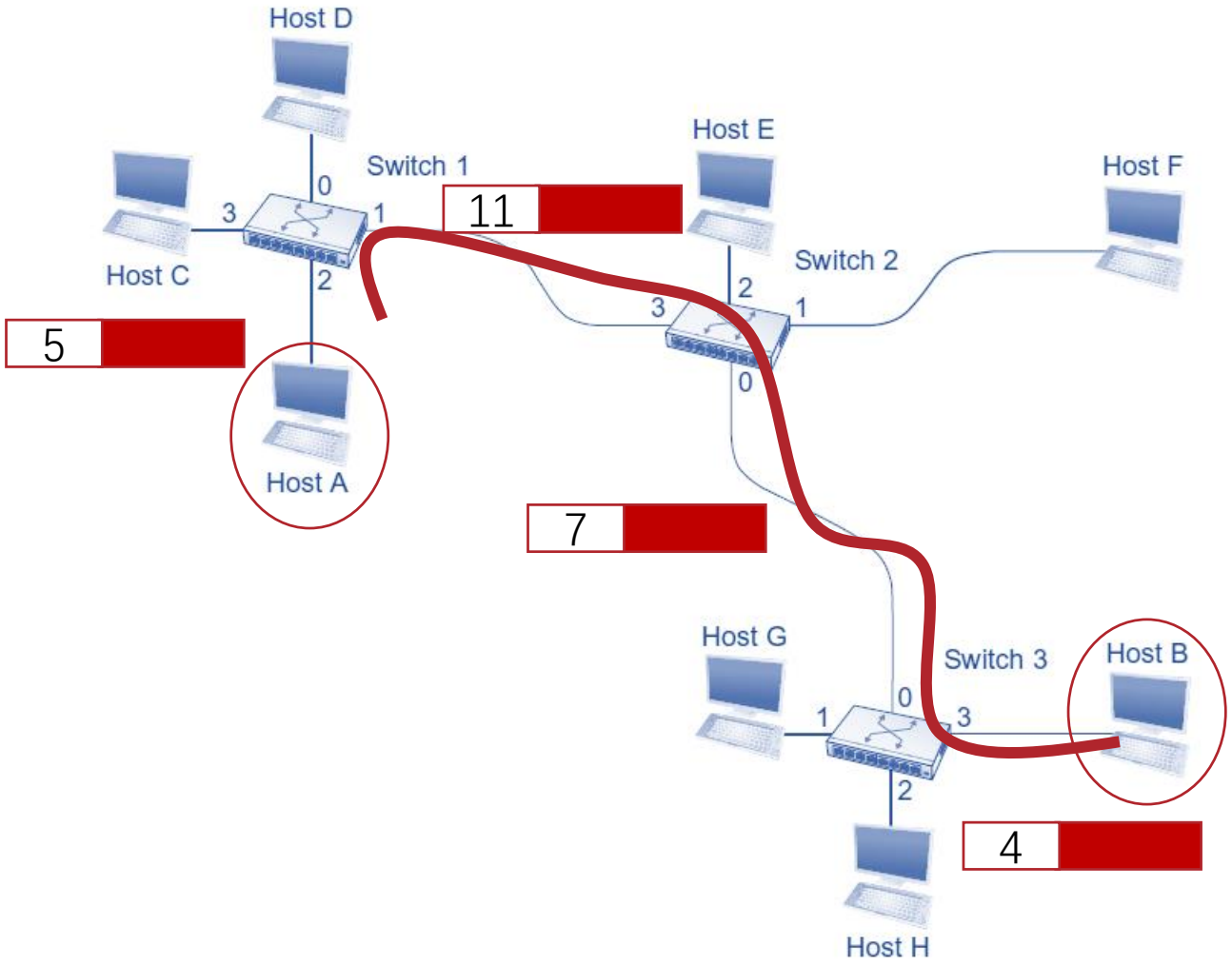


Specify Burstiness: Token Bucket

- Host
  - Specify token bucket to describe its traffic
- Router
  - Allocate buffer and bandwidth to guarantee delay



Virtual Circuit



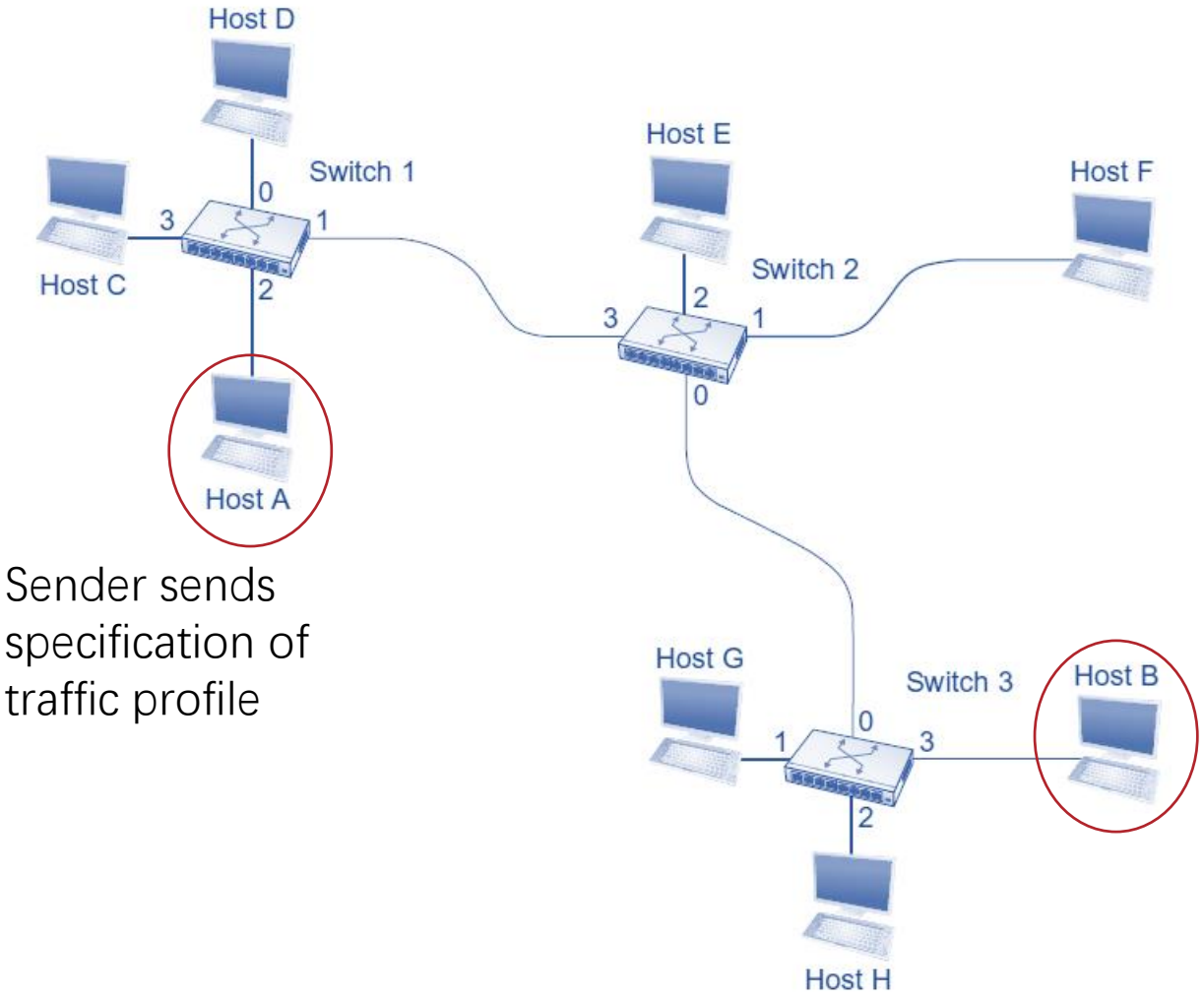
Virtual Circuit Table

Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Incoming VCI
2	5	1	11

Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Incoming VCI
3	11	0	7

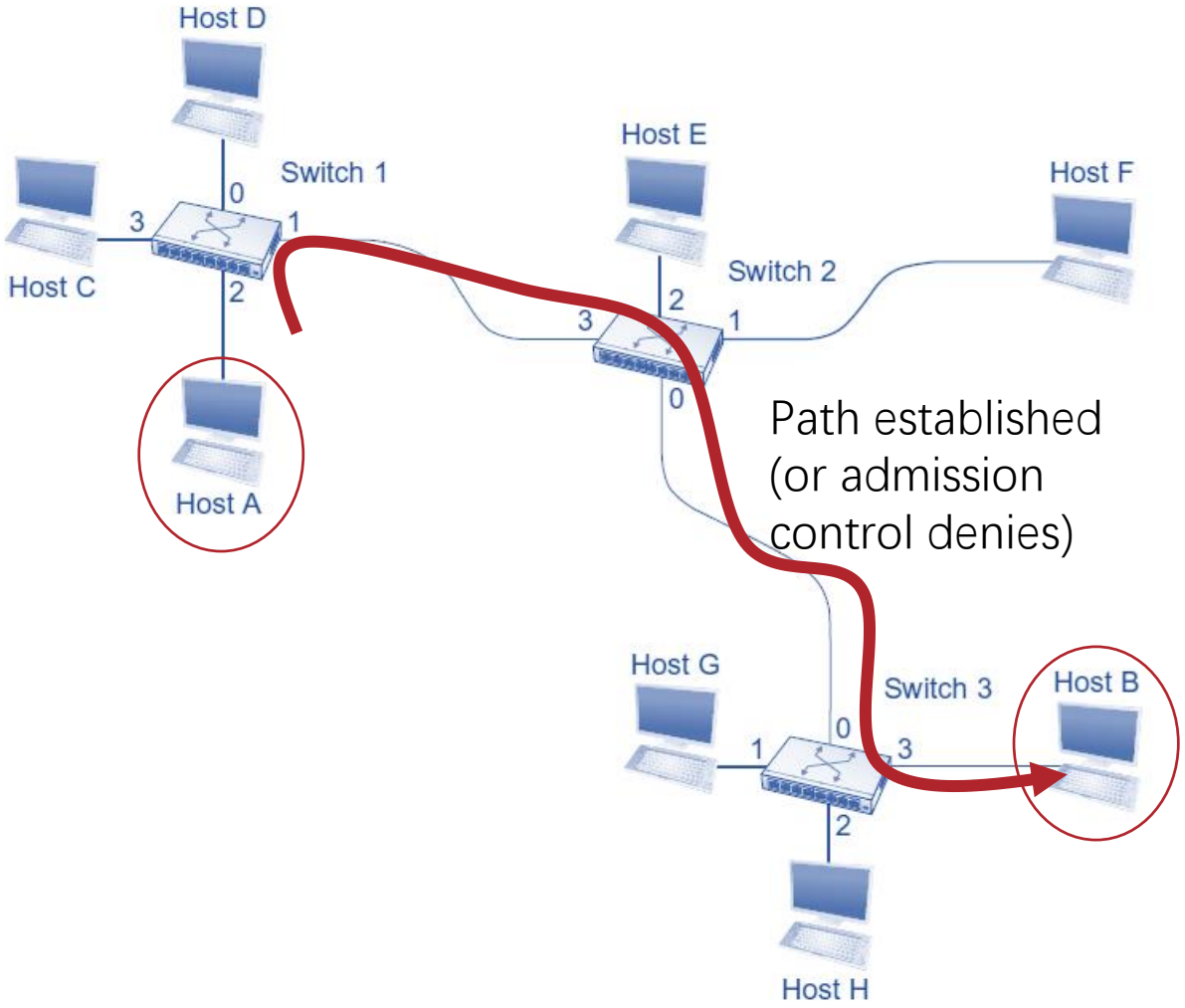
Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Incoming VCI
0	7	3	4

Resource Reservation Protocol

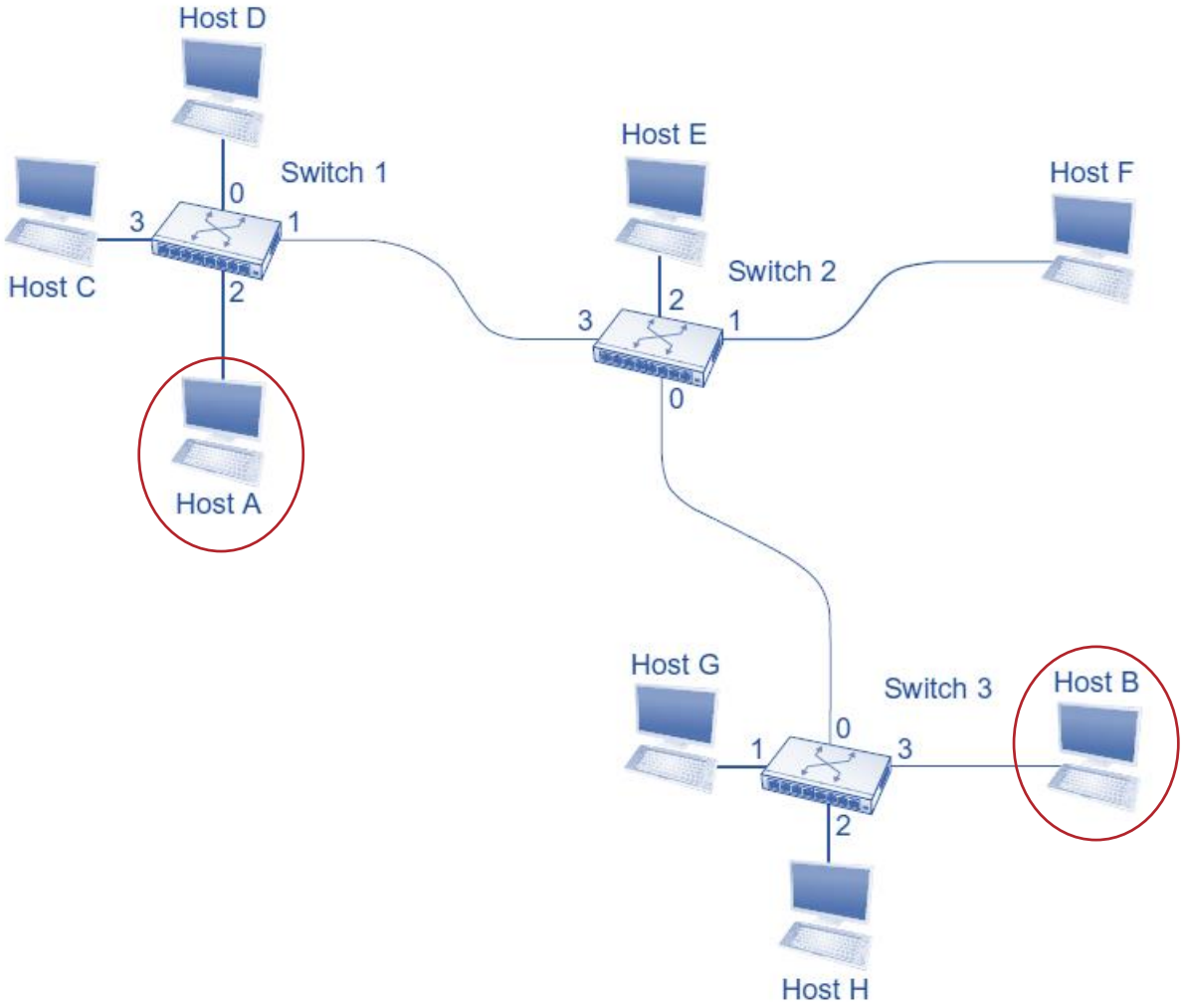


Sender sends specification of traffic profile

Resource Reservation Protocol

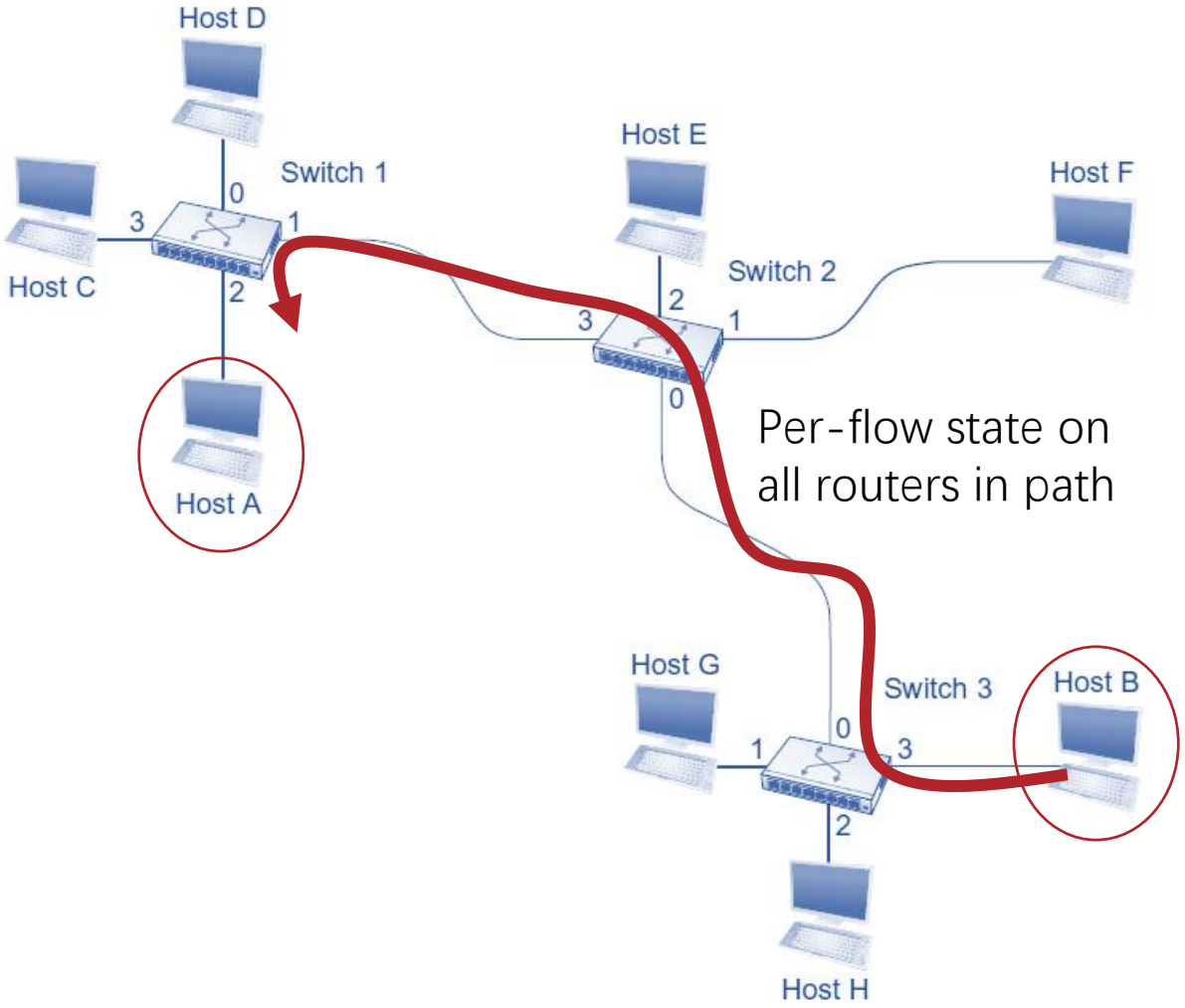


Resource Reservation Protocol

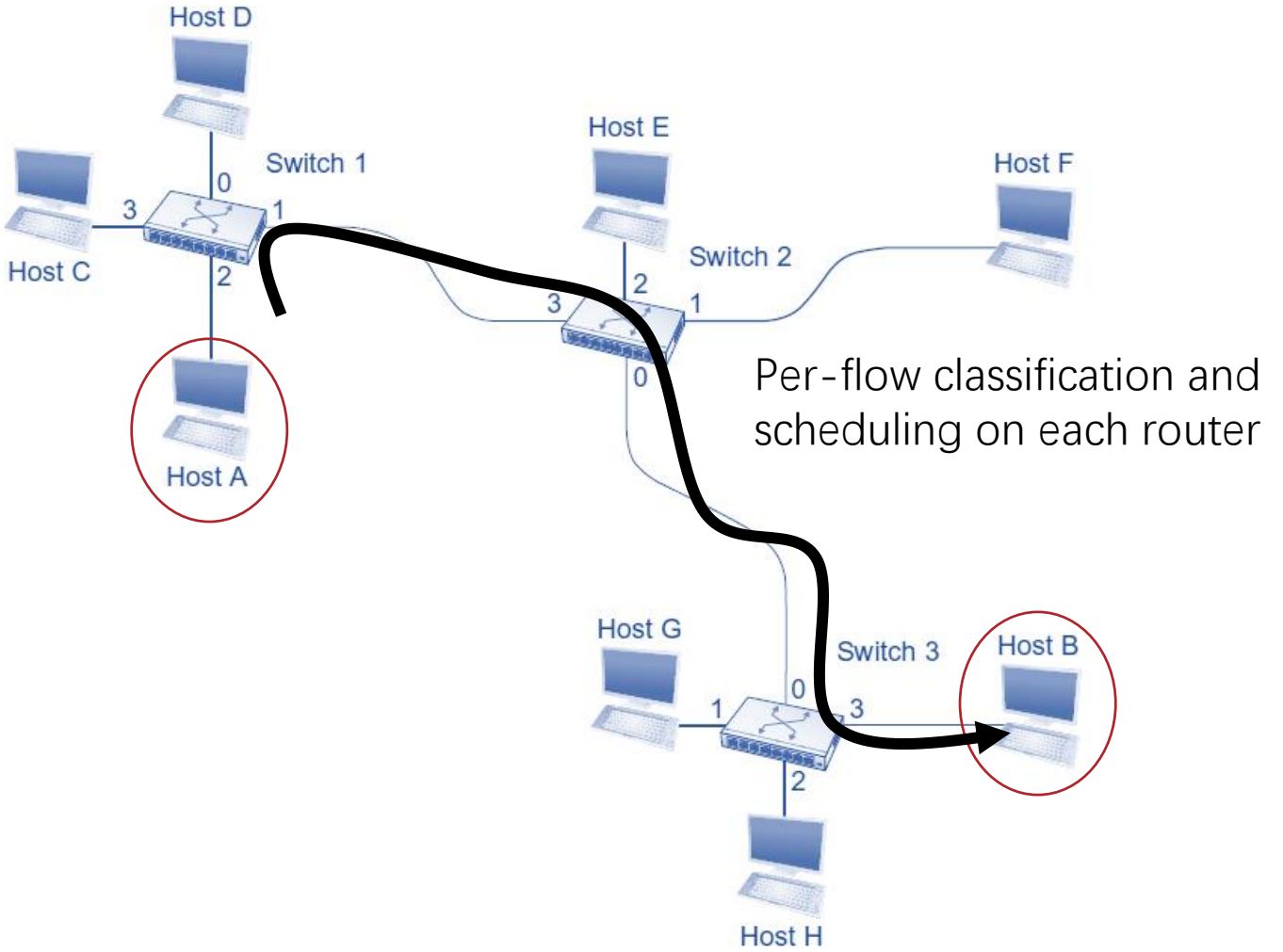


The receiver signals reservation request

Resource Reservation Protocol



Resource Reservation Protocol

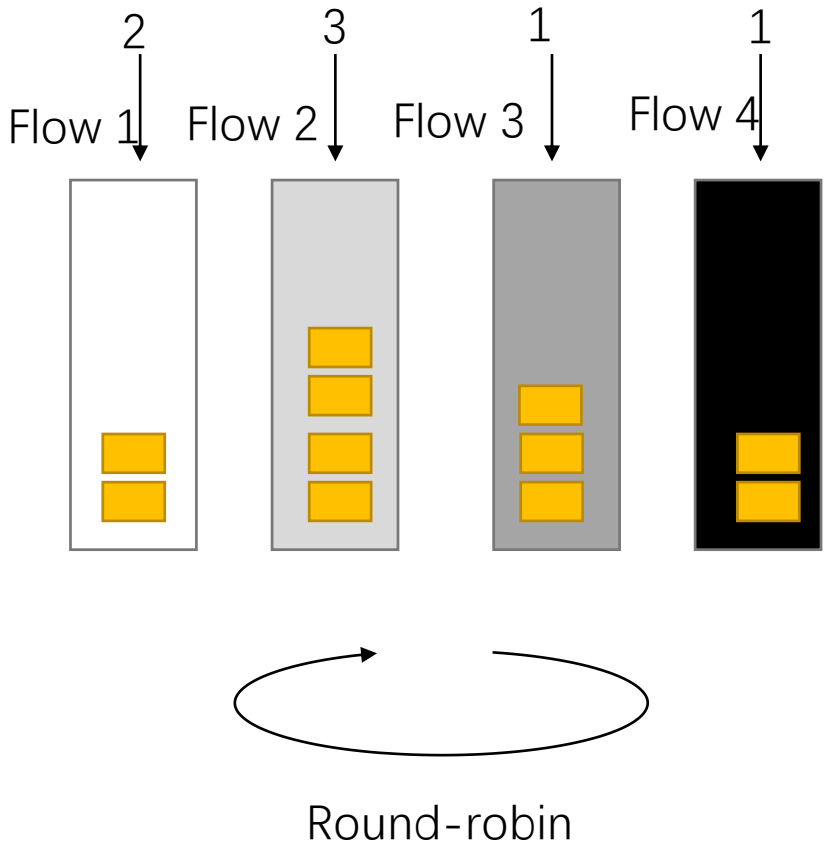


Packet Classification

- Classify Packets into Flows according to
  - Source Address
  - Destination Address
  - Protocol Number
  - Source Port
  - Destination Port

Packet Scheduling

- Implementation Dependent
  - e.g., Fair Queue



Scalability Issues

- Specify service for every flow is not scalable in Internet
  - Routers must keep the state of every passing flow

Quality of Service (QoS)

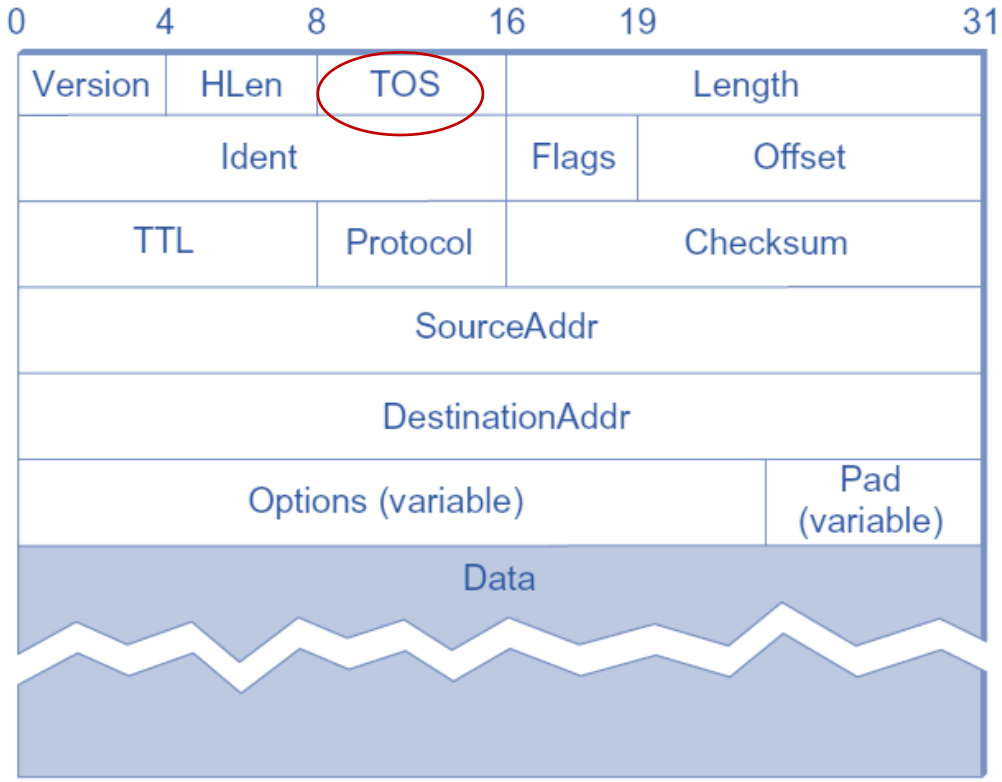
- Objective: to provide different service (network quality) to different applications
- Service Model
  - Best effort
  - Integrated Services (IntServ)
    - QoS supports every individual applications/flows
  - ➢Differentiated Services (DiffServ)
    - QoS supports multiple/two classes of data or aggregated traffic

Differentiated Services (DiffServ)

- Problem with IntServ: scalability
  - Maintain per-flow state
  - Per-flow classification
- DiffServ Approach
  - Segregate packets into a small number of (two) classes
    - Premium
    - Other
  - Class of certain packet (state) is kept in packet header
    - ToS

Per Hop Behavior

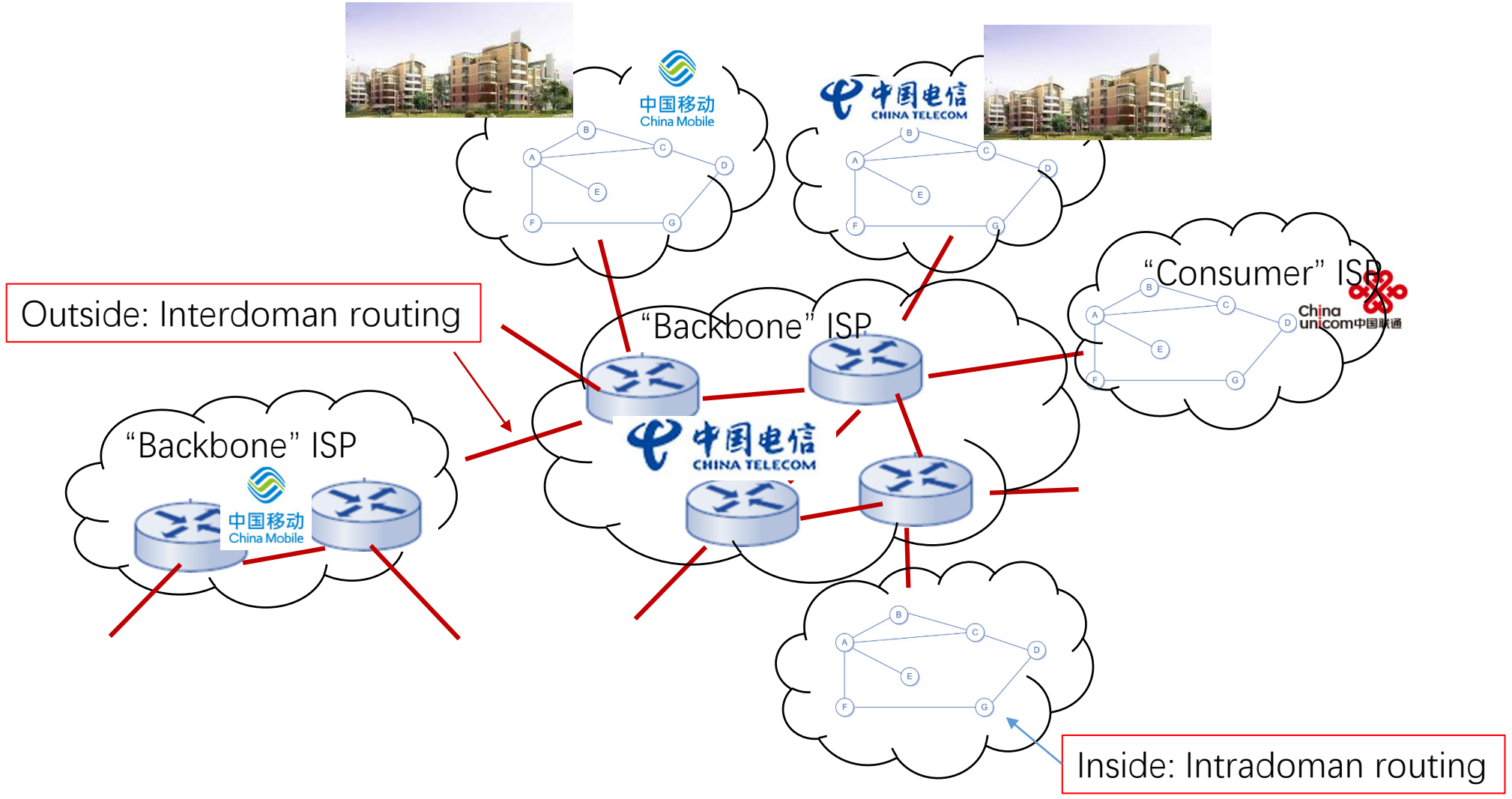
- Reuse ToS Field
  - 0-5bit: Differentiated Service Field
  - 6-7bit: Explicit Congestion Notification
- DS field encodes Per-Hop Behavior (PHB)
  - Expedited Forwarding (all packets receive minimal delay & loss)
  - Assured Forwarding (packets marked with low/high drop probabilities)



Set Packet Class

- Edge Routers
  - Set Differentiated Service Code Point (DSCP) in IP header
    - Maybe because the user paid the ISP
- Core Routers
  - Implement Per Hop Behavior (PHB)
    - According to DSCP (some bits in ToS Field) of packets

The Real Internet: Network of Network



Commonly used DSCP values

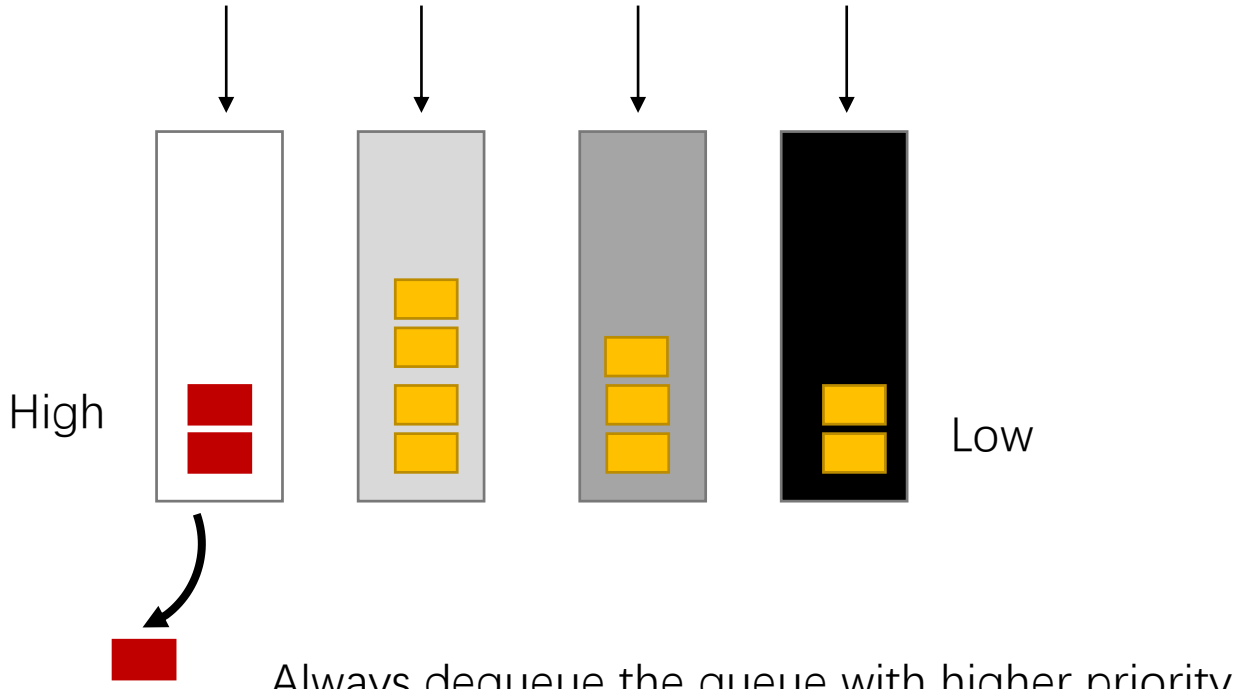
DSCP value	Hex value	Decimal value	Meaning	Drop probability	Equivalent IP precedence value
101 110	0x2e	46	Expedited forwarding (EF)	N/A	101 Critical
000 000	0x00	0	Best effort	N/A	000 - Routine
001 010	0x0a	10	AF11	Low	001 - Priority
001 100	0x0c	12	AF12	Medium	001 - Priority
001 110	0x0e	14	AF13	High	001 - Priority
010 010	0x12	18	AF21	Low	010 - Immediate
010 100	0x14	20	AF22	Medium	010 - Immediate
010 110	0x16	22	AF23	High	010 - Immediate
011 010	0x1a	26	AF31	Low	011 - Flash
011 100	0x1c	28	AF32	Medium	011 - Flash
011 110	0x1e	30	AF33	High	011 - Flash
100 010	0x22	34	AF41	Low	100 - Flash override
100 100	0x24	36	AF42	Medium	100 - Flash override
100 110	0x26	38	AF43	High	100 - Flash override

Implementation of PHB

- Expedited Forwarding (EF) PHB
  - Highest Priority
- Assured Forwarding (AF) PHB
  - Different levels of priorities, drop probabilities, bandwidth, etc.

Implementation of EF

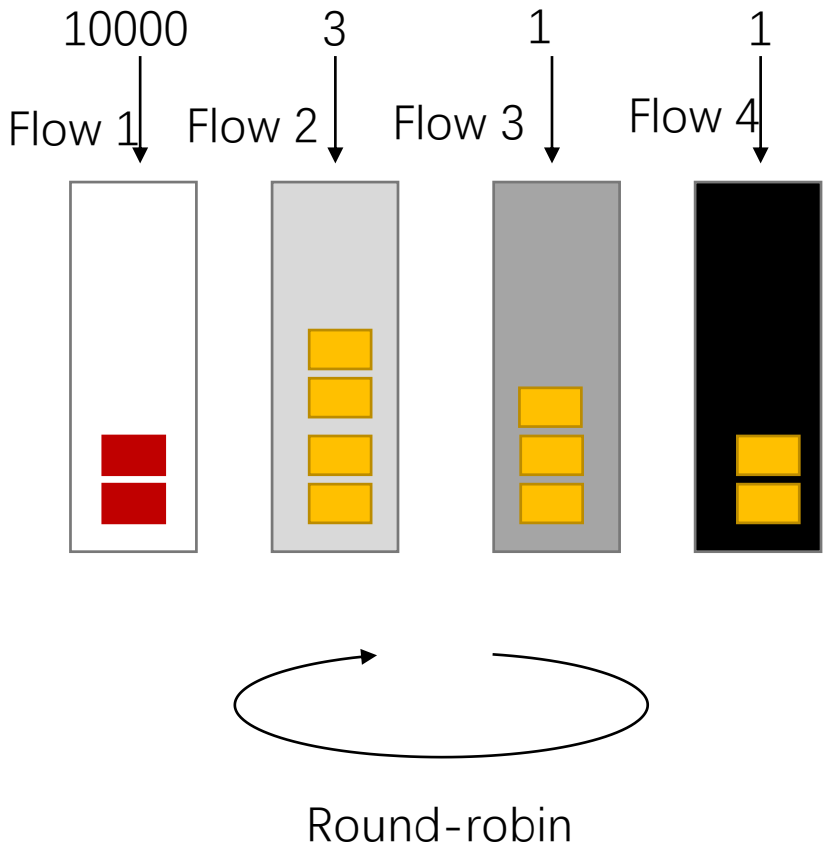
- First-In-First-Out (FIFO) with Priority



Always dequeue the queue with higher priority unless it is empty

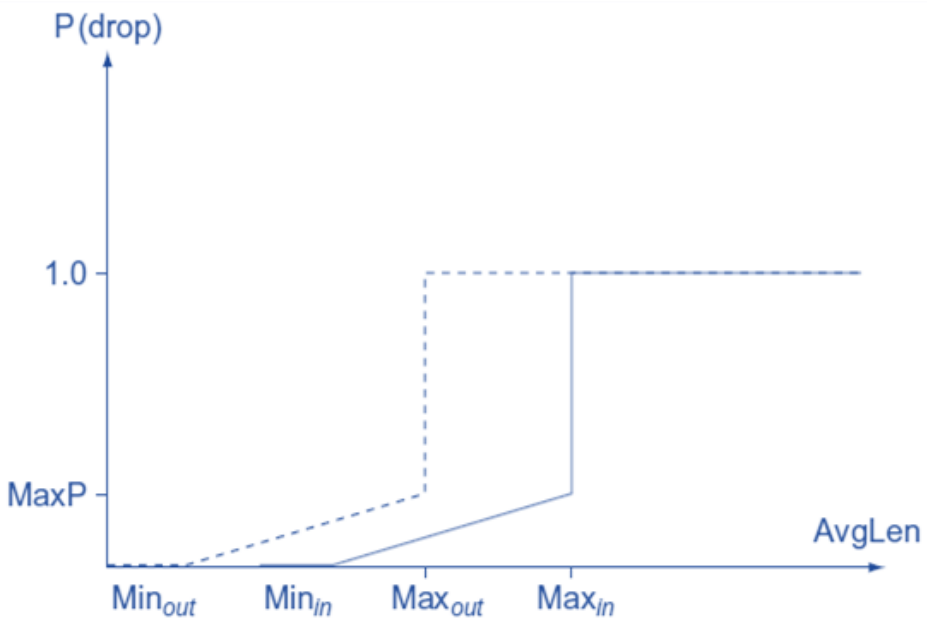
Implementation of EF

- Weighted Fair Queuing (FQ)



Implementation of AF

- RED with In and Out (RIO)



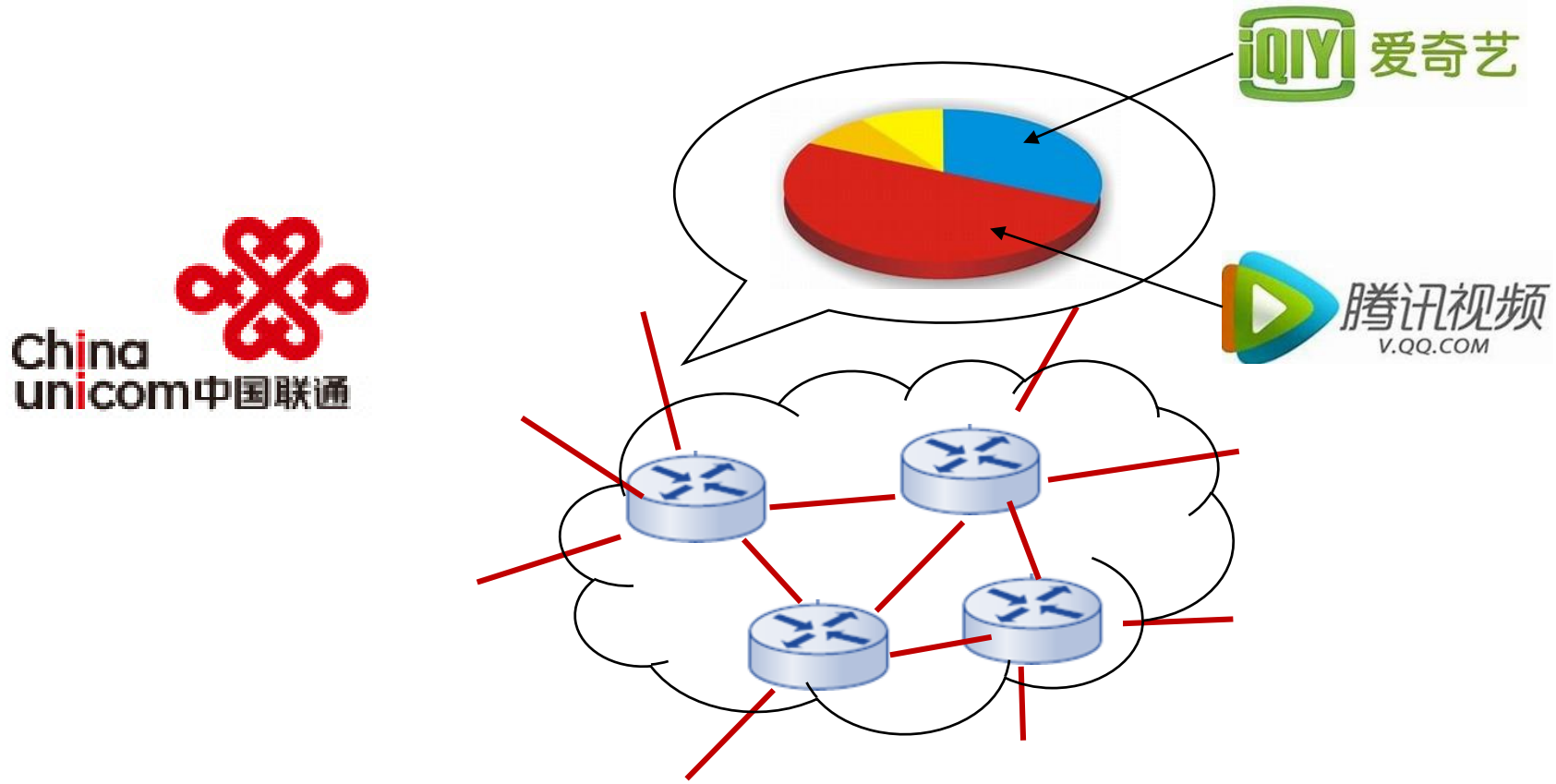
月基本费		258元 188元
包含	国内流量	1GB
	国内通话	800分钟
	本地流量	本地流量无限量权益 （用满40GB后限速）

QoS Deployment

- End-to-end QoS across multiple providers/domains is not available today
  - Complexity
    - Routers, Polices, etc.
  - Not so demanding…
    - Current network resource is affluent for VoIP etc.
    - Remaining problem: QoS under wireless conditions

Network Neutrality

- Network Neutrality
  - ISPs supply non-discriminated IP connectivity



Network Neutrality

- Opposite Counterpoint
  - ISPs only allows you to access their (often value-added) services

China unicom中国联通

Reference

- Textbook 6.5