南京邮电大学
Nanjing University of Posts and Telecommunications

宽带交换技术
第二章英特网及QoS控制技术

通信与信息工程学院
张喆
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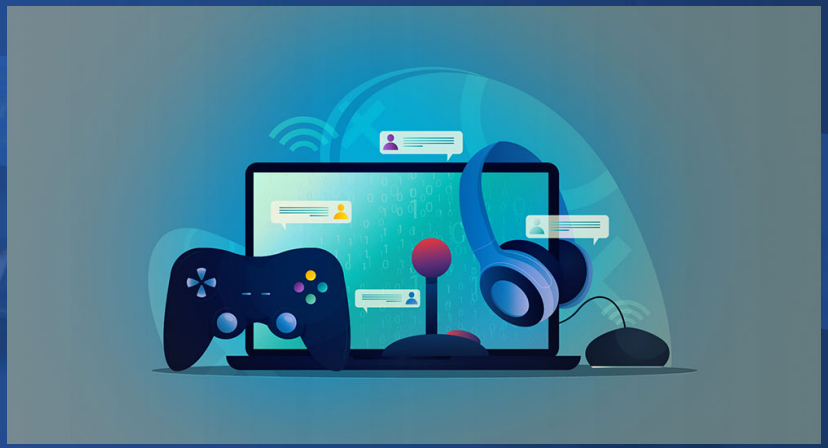
英特网及QoS控制技术

- QoS的基本概念（网络性能参数）
- Traffic Engineering (TE)的基本概念
- 流量控制与拥塞控制的基本方法
- 因特网中的综合服务模型
- 移动性相关的QoS控制

IntServ: background

- 1990s (best-effort):
  - All packets are treated equally
  - No QoS guarantee



- Solution?

- IntServ (Integrated Services) is a Quality of Service (QoS) model used in computer networking to provide end-to-end QoS guarantees for real-time applications such as voice and video.

Integrated Model

How it works?

- **IntServ works by using the Resource Reservation Protocol (RSVP) to reserve network resources such as bandwidth and buffer space along the path that a packet will take through the network.**

- IntServ provides a per-flow QoS guarantee

ReSerVation Protocol (RSVP)

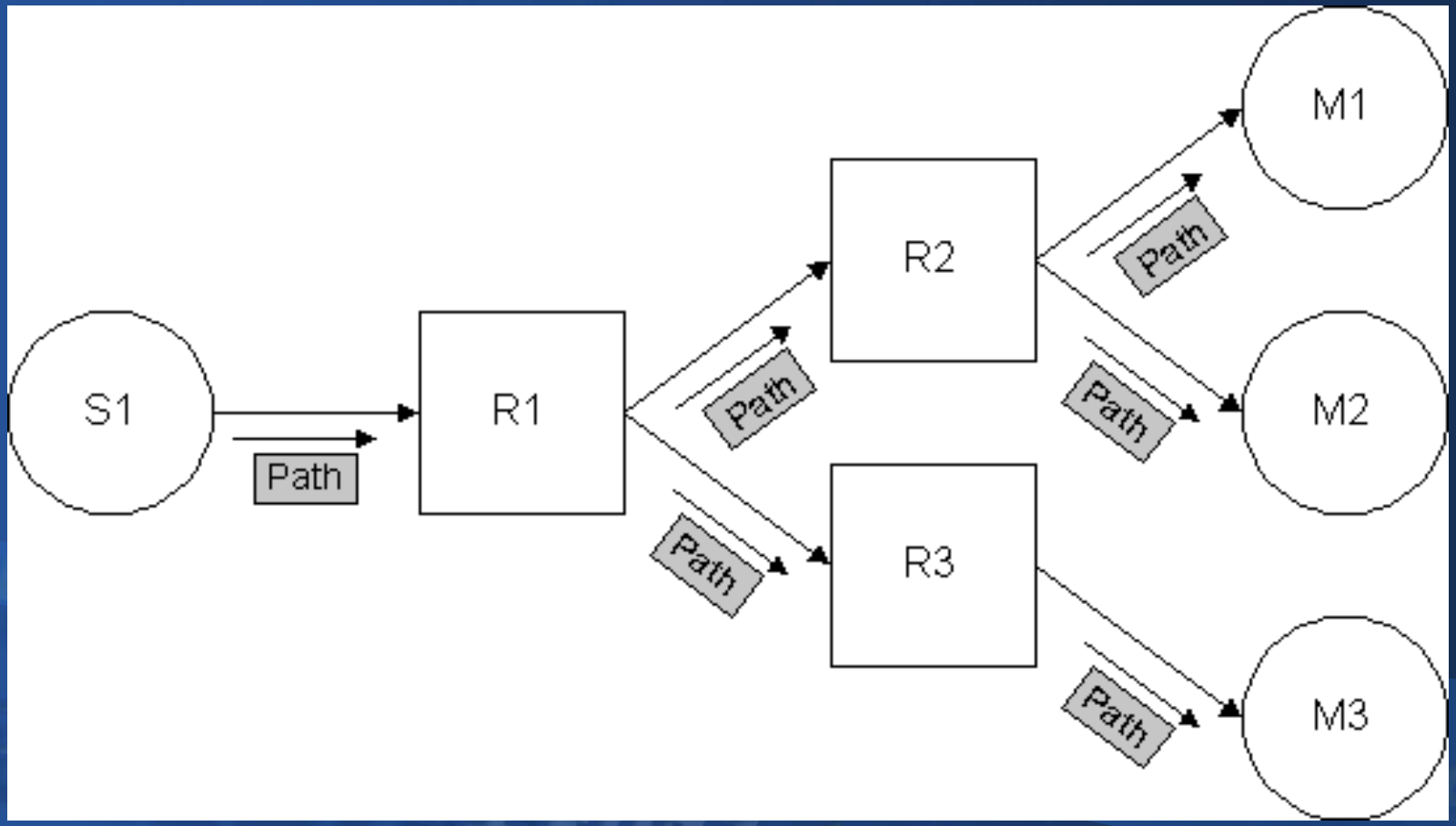
- *RSVP is an IP signaling protocol to setup and maintain flow-specific state in hosts and routers*
  - Establish and maintain reservations
- Used to specify QoS by applications
- Receiver-oriented
  - Application or user sends a reservation request
- Not a routing protocol
  - Internet control protocol
  - Layer 4 protocol -> IntServ operates at layer 4 as well

- RSVP includes two types of messages:
- PATH: The PATH message is sent by the sender of the data flow to request a QoS path through the network.
- RESV: The RESV message is sent by the receiver of the data flow to reserve the network resources needed to receive the data at the desired QoS level.

RSVP Messages – PATH

- Sent periodically by sender towards all destinations
- Sets up path from sender to each destination
- Gather information about network path
- Contains *TSpec* (traffic specification)
  - TSPEC is used to specify the traffic requirements of an application flow
    - such as its peak, average data rates
    - burst size
    - and delay tolerance

RSVP Messages – PATH



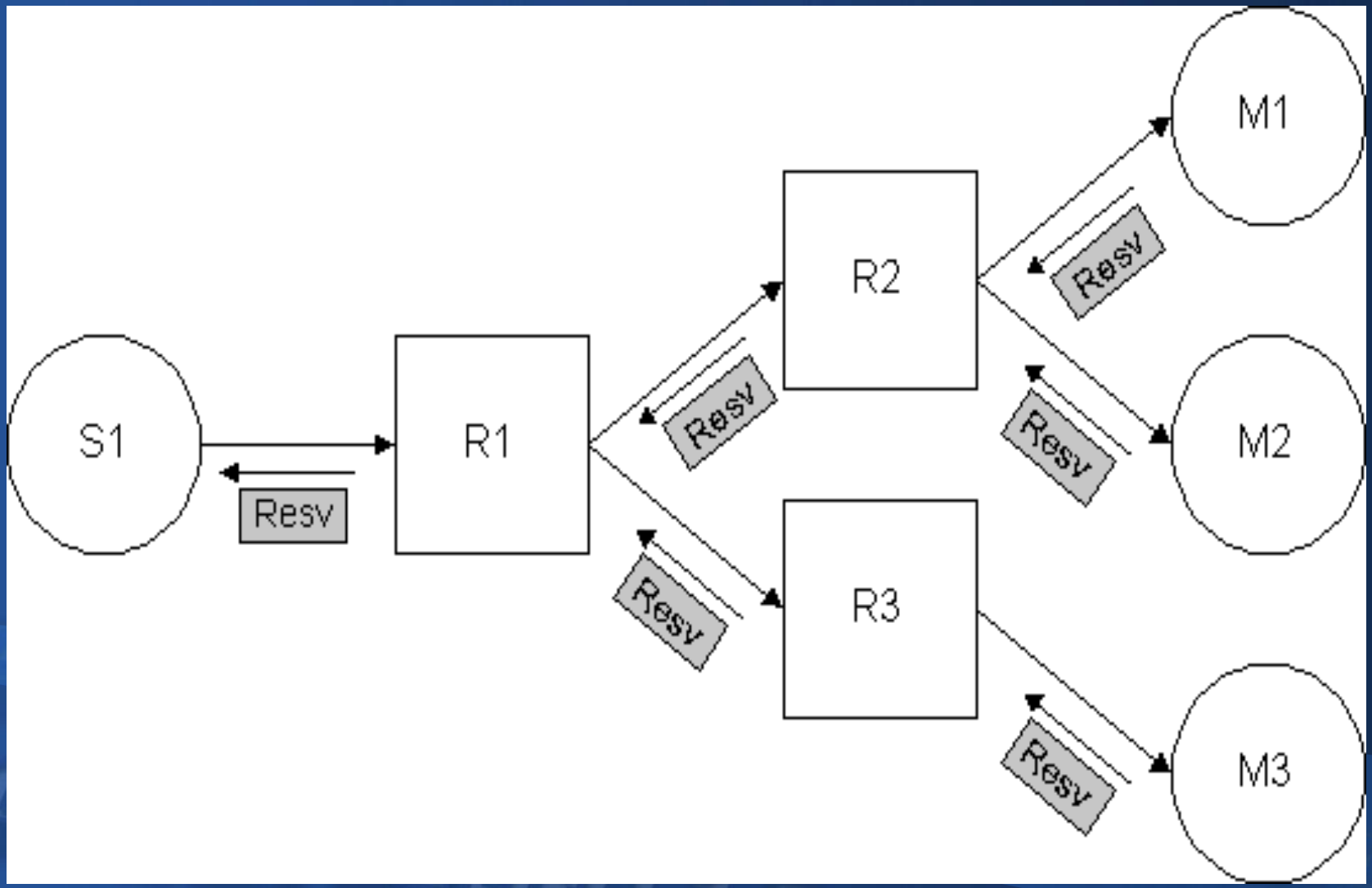
RSVP Messages – RESV

- **Receivers** request for resources using RESV message
- Sent upstream
  - Set by PATH messages
    - ➔ if no senders no reservation could be made
- Contains RSpec (resource specification)
  - Describe the he resources available or required to support a flow

RSVP Messages – RESV

- If the router does not have enough resource, what will happen?
  - RESV will not be passed upstream further
  - RESV_ERR (Reservation Error) message back to the previous hop
  - The receiver can then use the information from the notification message to adjust its transmission parameters

RSVP Messages - RESV



- What will be performed after the flow finish transmitting?

- Tear down resource reservations.

RSVP Messages - Teardown

- Two types of tear down messages
  - *pathtear*
    - Initiated by sender
  - *resvtear*
    - Initiated by receiver

RSVP TE

- RSVP-TE: is an extension of the RSVP to optimize the performance of computer networks
- Establish LSP in MPLS networks
  - MPLS MultiProtocol Label Switching
  - LSP Label Switched Path
- Essentially enables source routing
  - Once path specified incore routers route packets based on labels
  - Used in optical networks

Summary

- Application requests a specific kind of QoS service, through explicit signaling (信令).
- Resource Reservation Protocol (RSVP) is used by applications to signal their QoS requirements to the router.
- Complex to use.
- Difficult to support with a large number of RSVP connections, due to:

  the amount of state information required for every flow.

  the amount of control traffic
- Fine grain, providing strict QoS.

Approaches to QoS support

- Fine grained approaches（细粒度): provides QoS in individual applications or flows:
  … here we find "Integrated Services" (developed in the IETF) and often associated with the *Reservation Protocol* (RSVP)

- Coarse grained approach(粗粒度）: provides QoS to large classes of data or aggregated traffic
  … here we find "Differentiated Services"

  ATM is known to have a rich set of QoS capabilities and is considered in the fine-grained category (since resources are associated with individual VCs).
  ATM is often used to interconnect routers – and may choose to send a highly aggregated traffic down a single VC → so ATM can be used for coarse grained QoS as well.

- Any other solution to address the limitations of IntServ?

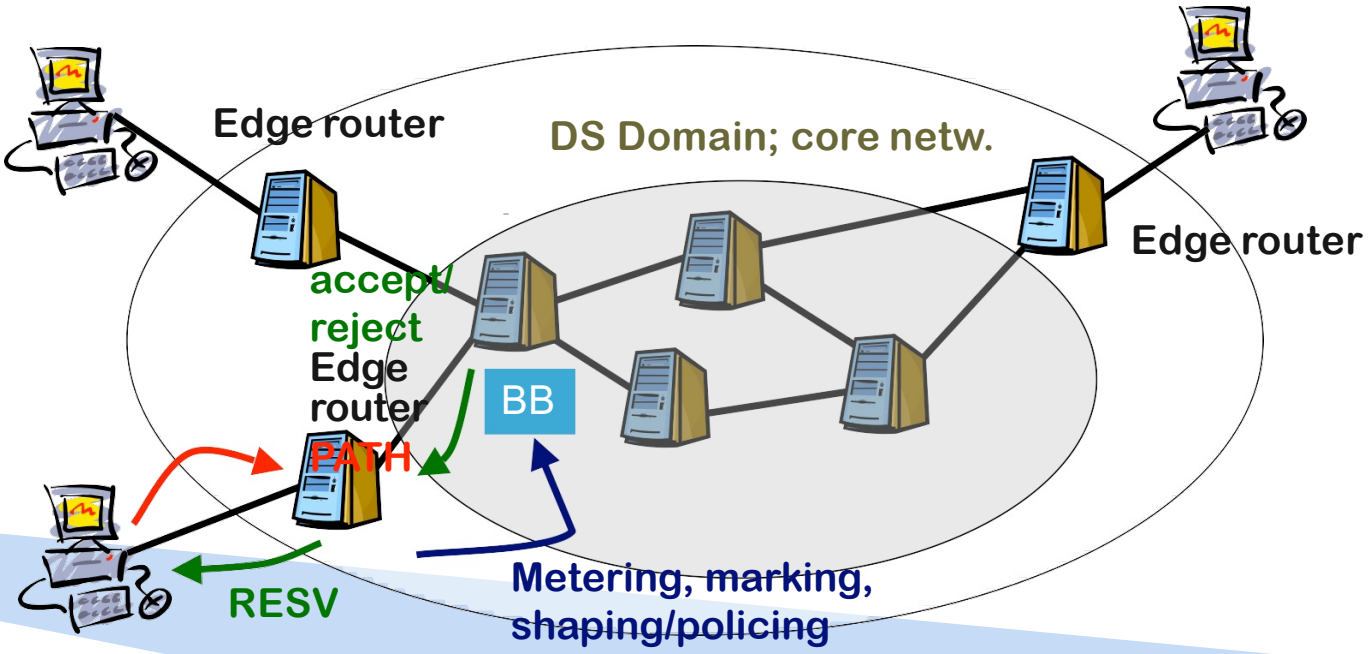
- DiffServ

Differentiated Model

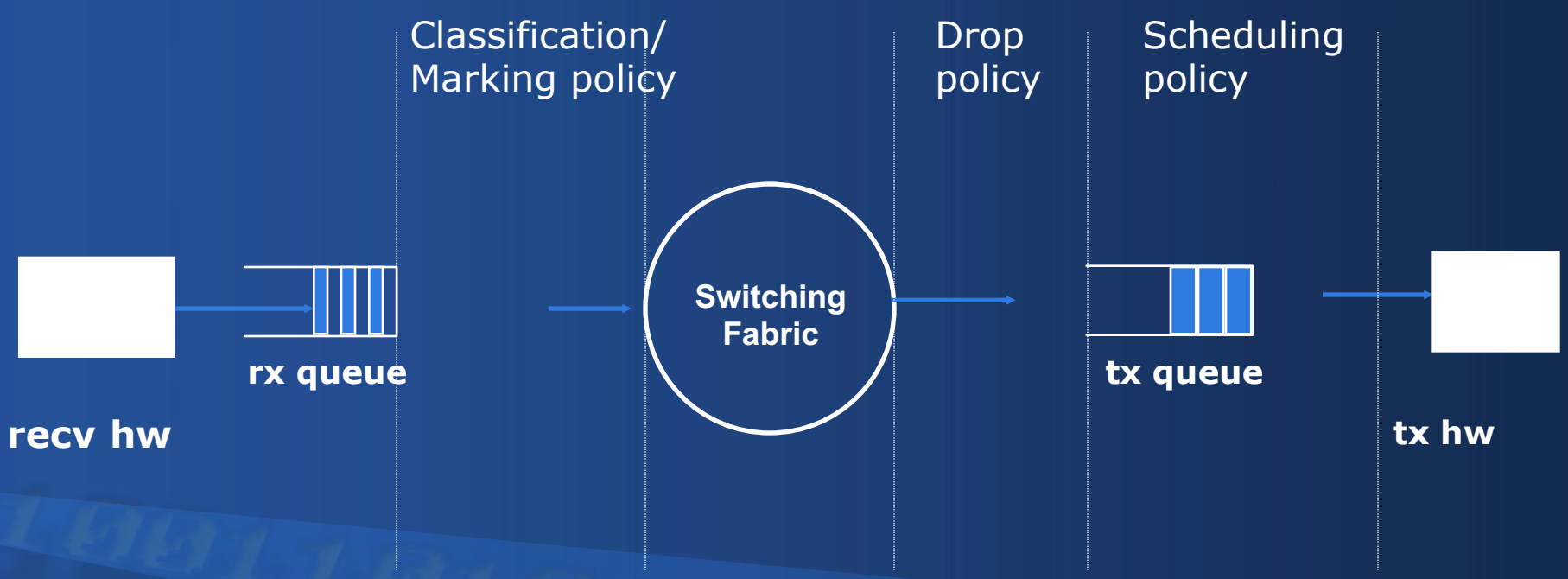
- Qos is provided by differential treatment to each packet or class of packets.
- No explicit signaling from the application.
- This model is appropriate for aggregate flows.
- Coarse grain, not strict QoS (no guarantees , Soft QoS).
- Layer 3 mechanism

- Why DiffServ can be used in large networks?
- DiffServ uses:
  - Per-hop behavior to provide different level of service to different classes at each router
  - No requirement of complex signaling protocols or network state information

DiffServ


Edge router
DS Domain; core netw.
Edge router
accept/
reject
Edge
router
BB
PATH
RESV
Metering, marking,
shaping/policing

Differentiated Model



Differential Model Features

- Classification
- Marking
- Policing and Shaping
- Congestion Avoidance
- Congestion Management

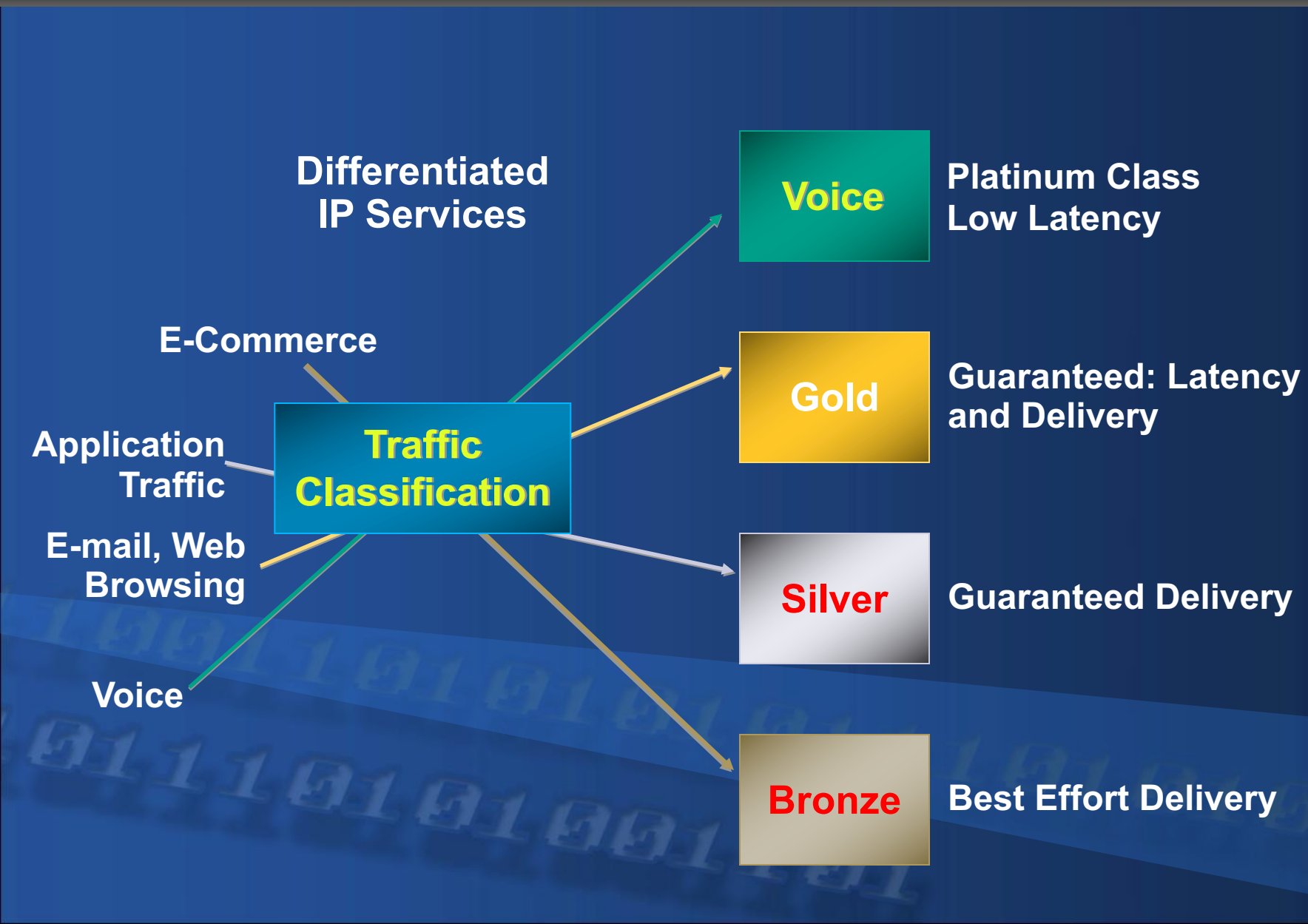
Differentiated Model Features Classification

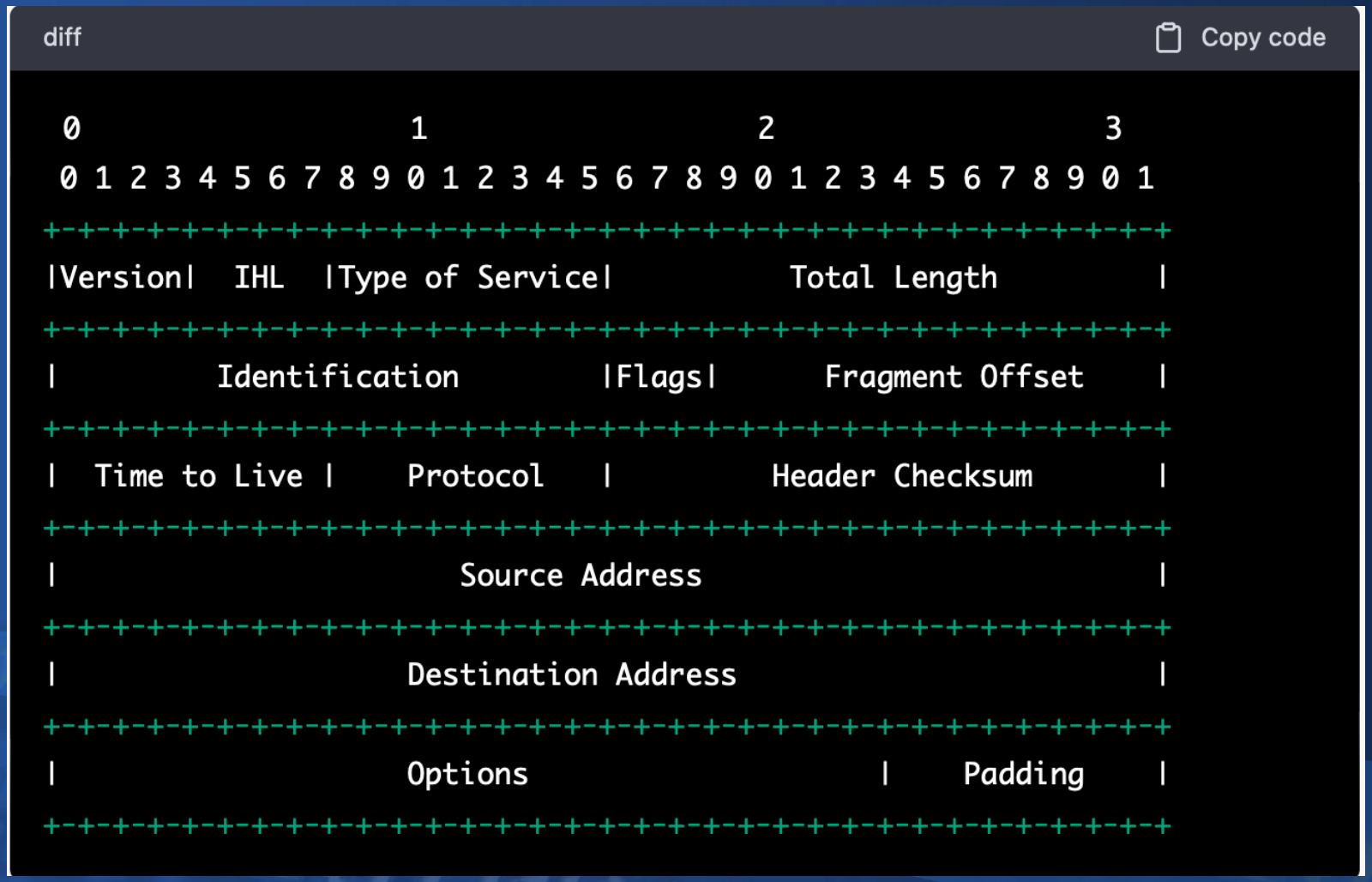
Most **fundamental QoS building block**

The component of a QoS feature that recognizes and distinguishes between different traffic streams

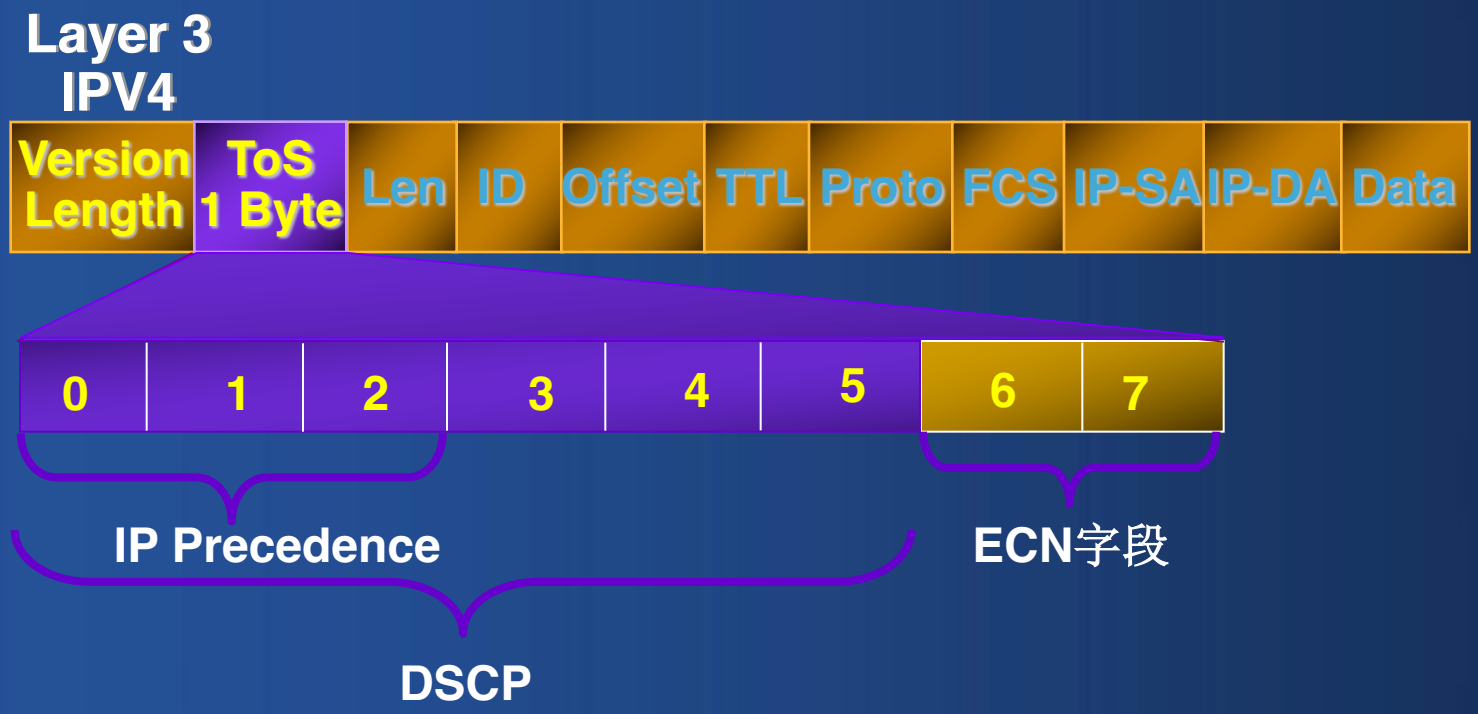
Without classification, all packets are treated the same

Differentiated Model Divide Traffic into Classes




diff
Copy code
0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
Version	IHL	Type of Service	Total Length
Identification	Flags	Fragment Offset
Time to Live	Protocol	Header Checksum
Source Address
Destination Address
Options	Padding

Differentiated Model Features Marking



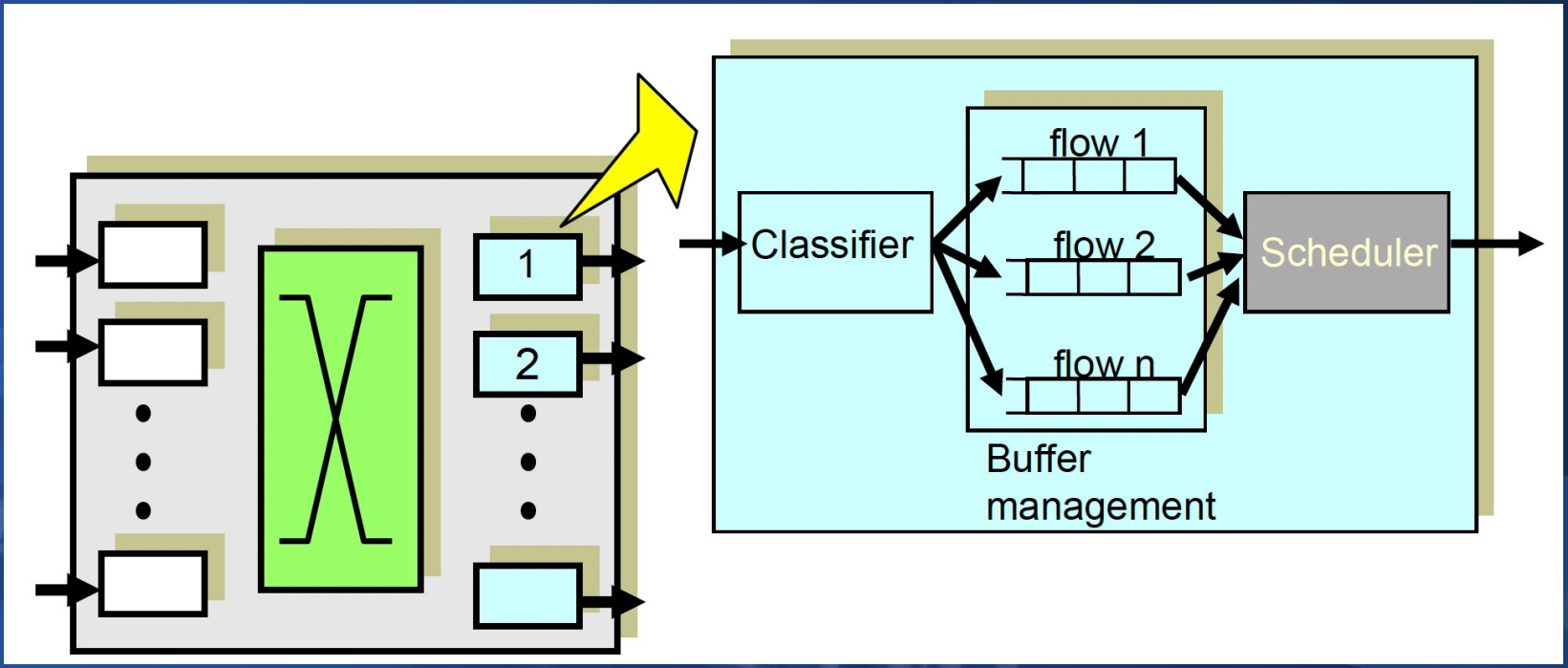
- IP Precedence：表示8个优先级（7-0），其中7和6为路由选择或者新网络控制通信保留，用户级应用只能使用0-5.
- ToS域中还包括D、T、R三个比特：
  - D表示延迟要求（delay，0:正常，1:低延迟）
  - T表示吞吐量（throughput，0:正常，1:高吞吐量）
  - R表示可靠性（reliability，0:可靠，1:高可靠）

Differentiated Model Features Policing and Shaping

- Policing(流量控制) is the QoS component that limits incoming traffic flow to a configured bit rate
  - Actions: drop, mark as low priority, pass it through
- Shaping(流量整形) is the QoS feature component that regulates outgoing traffic flow to a configured bit rate

Router Mechanism

- Queuing management:
  - When and which packet to drop
- Scheduling:
  - Which packet to transmit next



Differentiated Model Features Congestion Avoidance

Queuing Management Policies

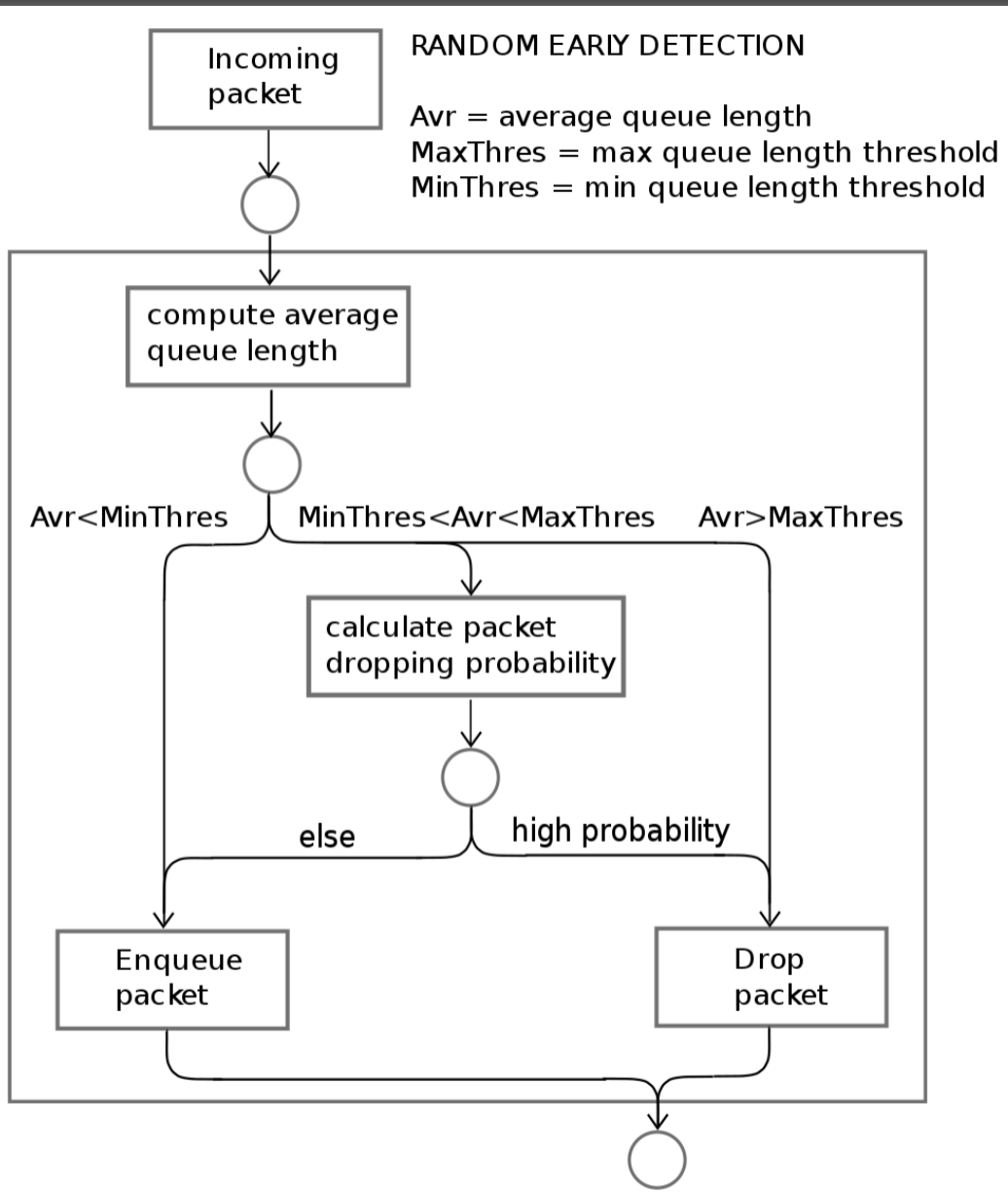
- Tail Drop
- Random Early Detection (RED)
- Weighted Random Early Detection (WRED)

Differentiated Model Features Congestion Avoidance

- **Tail Drop:**
  - **Arriving packets get dropped when queue is full regardless of flow or importance**

RED

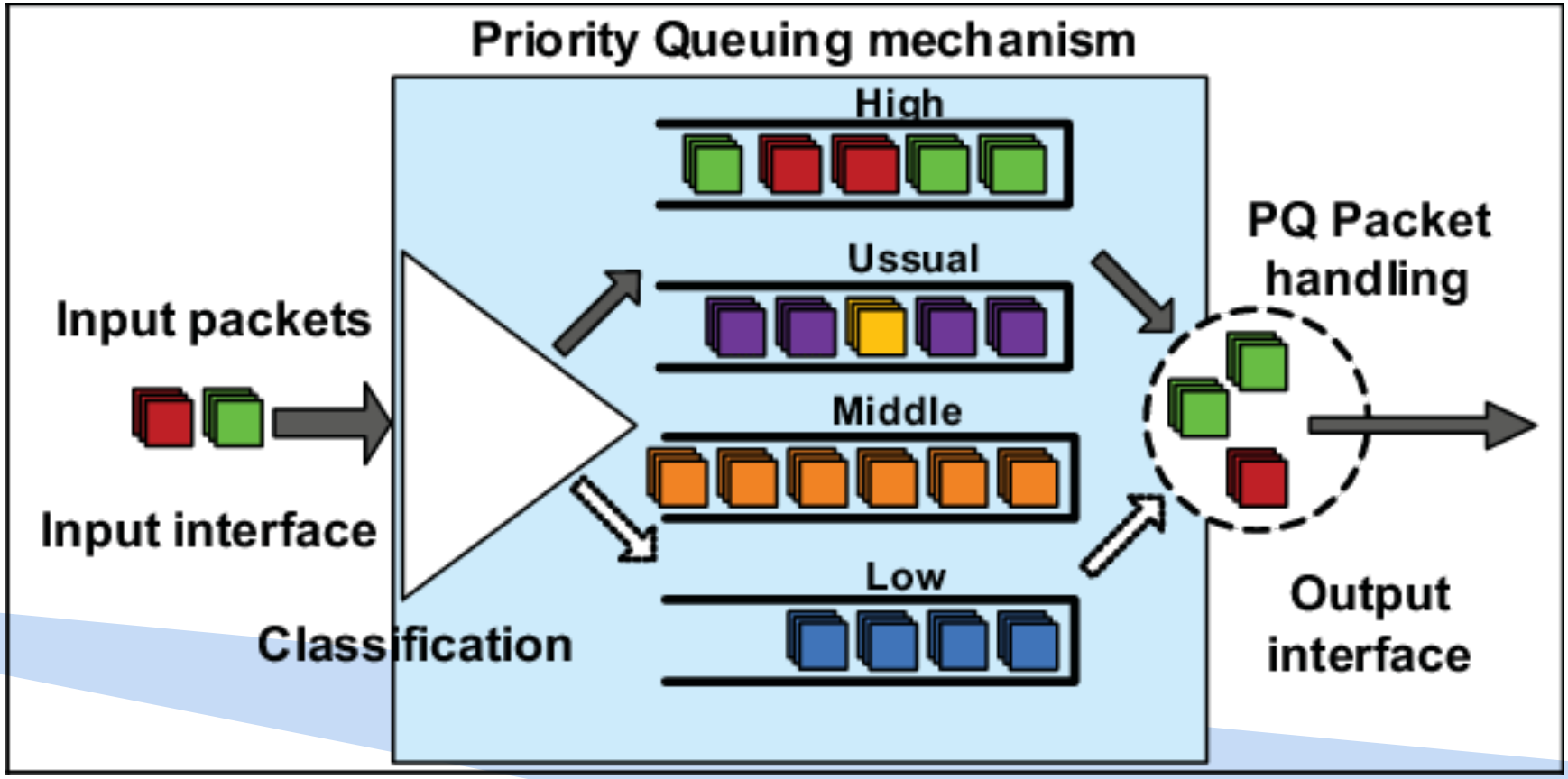
- Random Early Detection，为避免发生网络中的全局同步现象，在路由器采用的一种措施。
- 计算平均队长的目的就是为了反映拥塞状况，根据拥塞的程度来计算丢弃分组的概率，从而有效地控制平均队列长度。
- RED有两个和队列长度相关的阈值：MINth和MAXth
  - avgQ< MINth，则没有分组需要丢弃；
  - MINth≤avgQ≤MAXth时，计算出概率P，并以此概率丢弃分组；
  - 当avgQ>MAXth时，丢弃新到packet。


RANDOM EARLY DETECTION
Avr = average queue length
MaxThres = max queue length threshold
MinThres = min queue length threshold
Incoming packet
compute average queue length
Avr<MinThres
MinThres<Avr<MaxThres
Avr>MaxThres
calculate packet dropping probability
else
high probability
Enqueue packet
Drop packet

RED

- How about burst traffic (突发流量)
- Weighted Random Early Detection (WRED):
  - An extension of RED
  - Uses differentiated drop policies (probabilities) for different IP precedence values.
  - Packets with a lower IP precedence are more likely to be dropped.

Packet Scheduling: Problem Overview

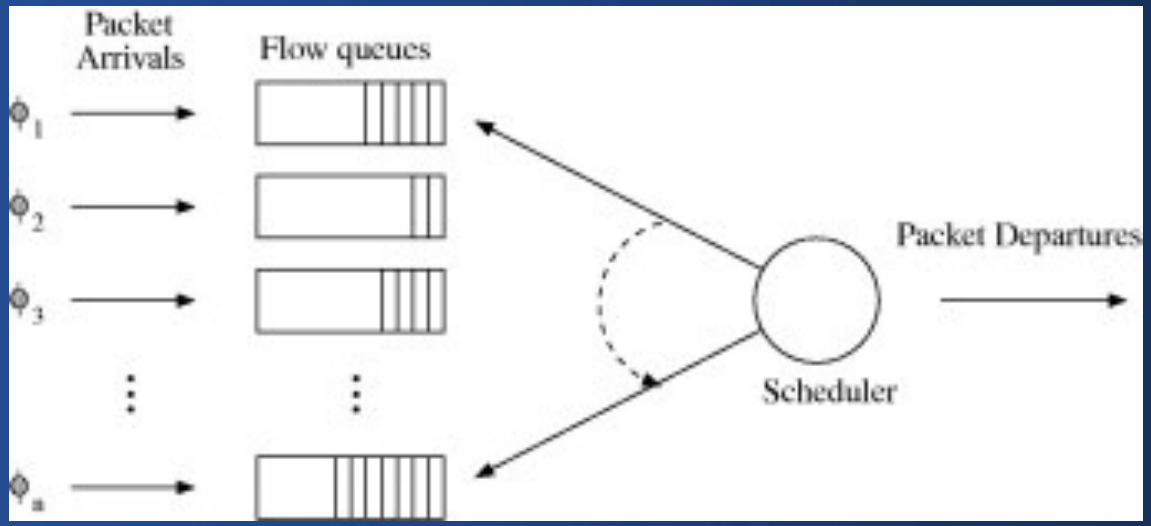


Differentiated Model Features Congestion Management

Scheduling Policy（调度策略）

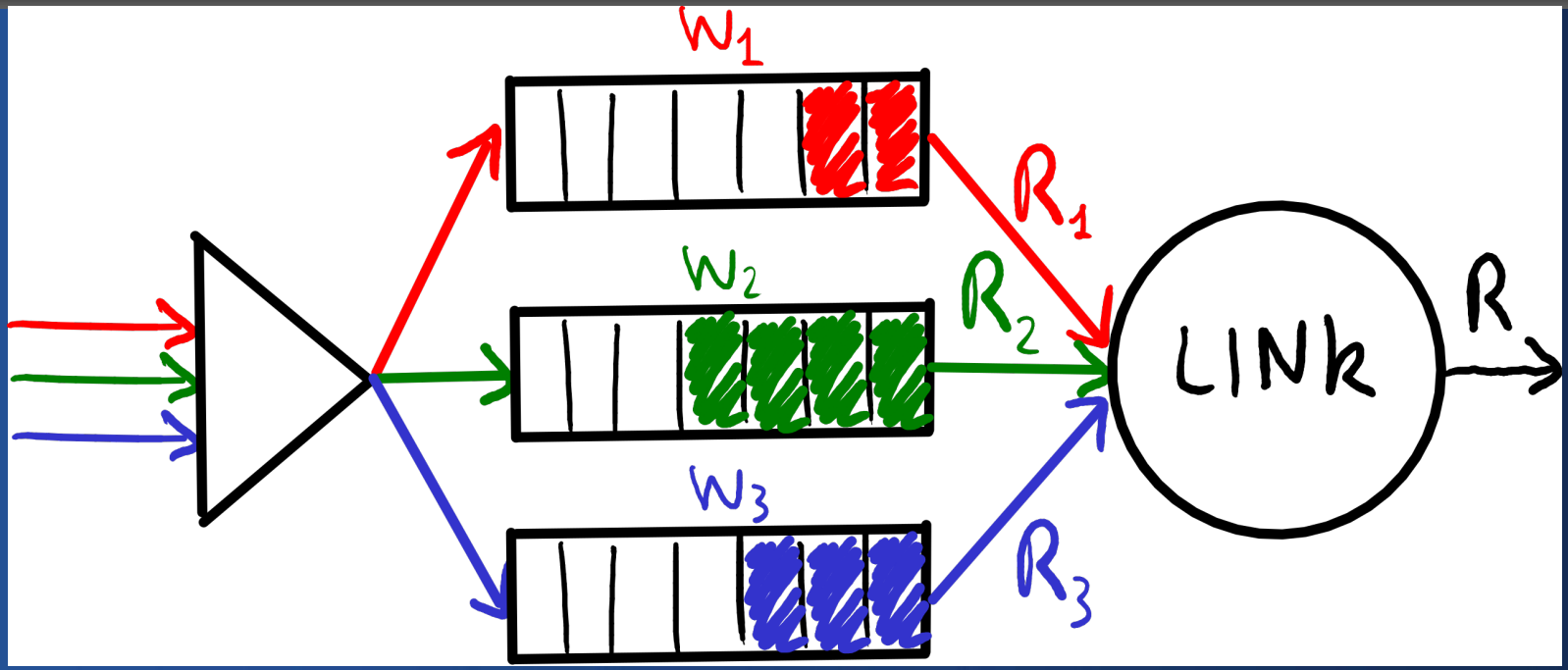
- FIFO
- Fair Queuing
- Weighted Fair Queuing (WFQ)
- Class Based Weighted Fair Queuing (CBWFQ)
- Low Latency Queuing (LLQ)

Fair queuing



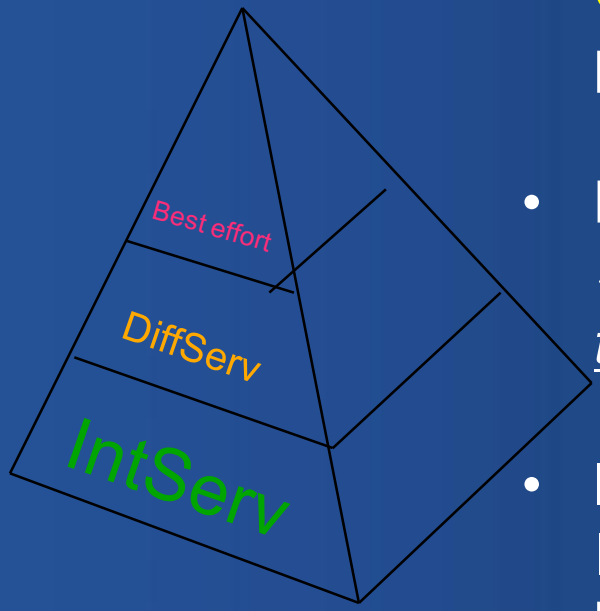
- Multiple FIFO sub-queues for each input class
- All class inputs equally share the bandwidth

WFQ



- Each flow i given a weight (importance) w_i
- WFQ guarantees a minimum service rate to flow *i*
- $r_i = R * w_i / (w_1 + w_2 + ... + w_n)$

Quality of Service (QoS)



- **Best-Effort**—Best-Effort does not provide QoS, because there is no reordering of packets.
- **Differentiated Services (DiffServ:区分服务、差分服务)**—differentiates between multiple *traffic flows*.
- **Integrated Services (IntServ：集成服务)**—IntServ is often referred to as "Hard QoS," because it can make strict bandwidth reservations.
- Needs signaling first.
- Must be configured on every router along a path. The main drawback of IntServ is its lack of scalability. Bandwidth reservation based on application level.

Comparison of IntServ & DiffServ Architectures

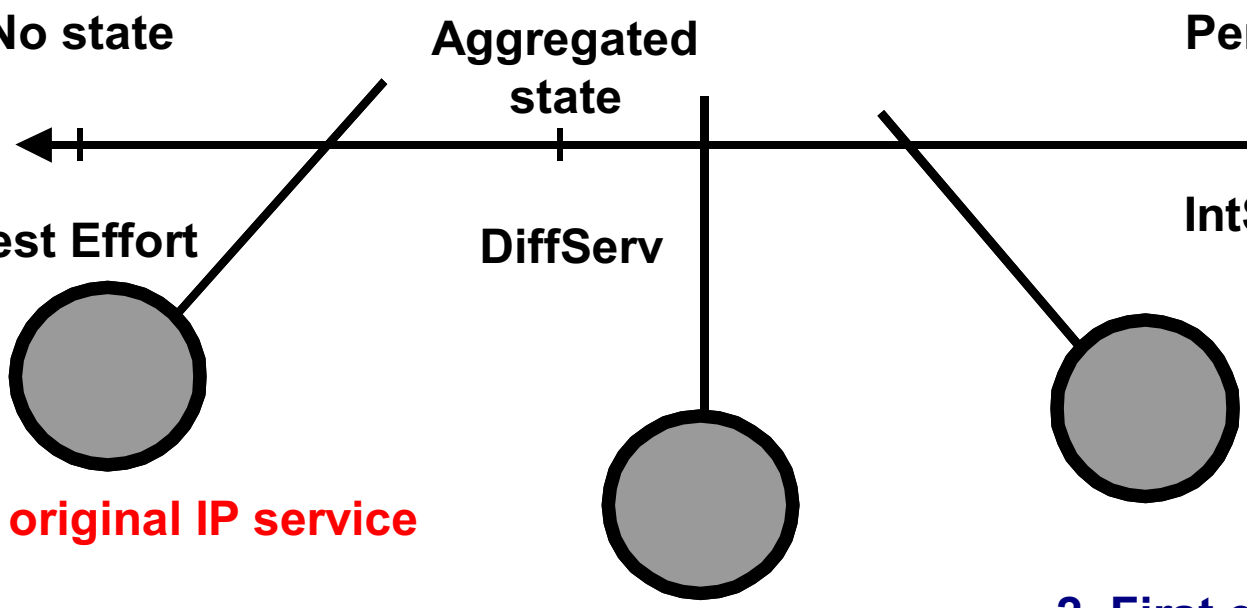
	IntServ	DiffServ
Coordination for service differentiation	End-to-End	Local (Per -Hop)
Scope of Service Differentiation	A Unicast or Multicast path	Anywhere in a Network or in specific paths
Scalabilty	Limited by the number of flows	Limited by the number of classes of service
Network Accounting	Based on flow characteristics and QoS requirement	Based on class usage
Network Management	Similar to Circuit Switching networks	Similar to existing IP networks
Interdomain deployment	Multilateral Agreements	Bilateral Agreements

access network

core network

The QoS Pendulum

Time



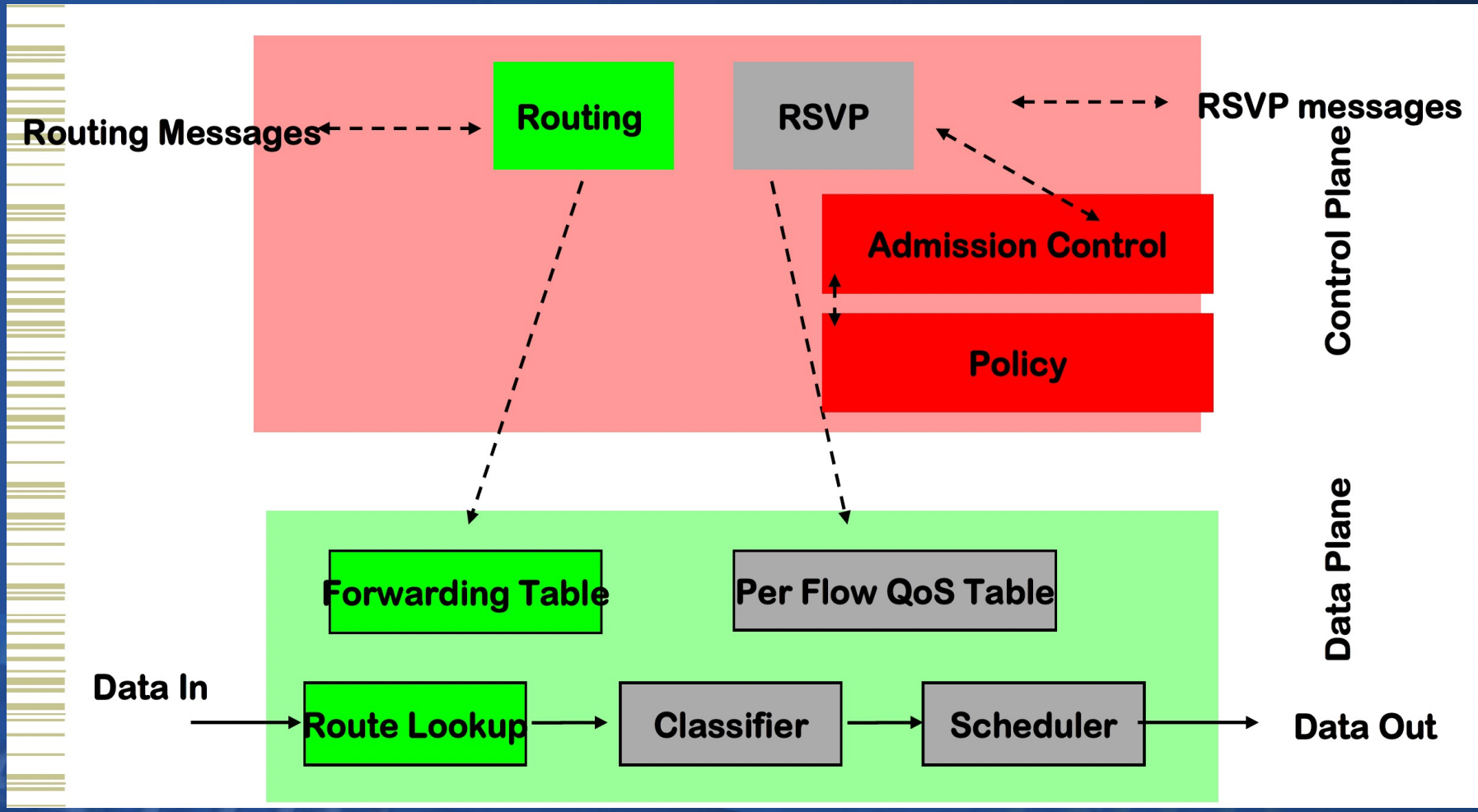
1. The original IP service

2. First efforts at IP QoS

3. Seeking simplicity and scale

4. Bandwidth Optimization & e2e SLAs
((IntServ+DiffServ+ Traffic Engineering))

How things fit together



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- QoS的基本概念（网络性能参数）
- Traffic Engineering (TE)的基本概念
- 流量控制与拥塞控制的基本方法
- 因特网中的综合服务模型
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移动性给QoS带来的问题

- 网络节点的物理位置变化，会给业务流的时延、丢包率等QoS特性产生不容忽视的影响，给QoS保障带来了很大的挑战。
- 移动性管理：通过确定的主机标识找到移动的节点位置以向其传递数据，并保持通信的连续性。包括位置管理和切换管理。
- 从网络协议的链路层、网络层、传输层和应用层提出不同的实现技术。
- QoS体系结构的集成模型和差分服务模型都没有考虑移动环境下的QoS保障，因此需要修改才能用于无线移动网络。
- -需要结合移动性管理讲解（后面课程讲解）

IMS中的QoS控制机制

- IMS体系结构中保障QoS的有两个层面-控制面和数据面
- IMS在各个层面和层次上都有相应的QoS保障措施
- 数据面：
  - 网络层采用DiffServ, RSVP完成
  - 传输层采用SCTP协议
- 控制面：
  - 通过策略控制完成QoS的保障；通过PDP功能实体完成

Summary

- 理解QoS的概念，网络各项性能和那些因素有关
- 理解流量控制的一般方法
- 了解产生拥塞的原因
- 理解拥塞控制算法的原理
- 掌握IntServ跟DiffServ两种服务模式
- IP QoS控制模型