

# 6.033 Spring 2018

## Lecture #12

- **In-network resource management**
  - **Queue management schemes**
  - **Traffic differentiation**

# Internet of Problems

How do we **route** (and address) scalably, while dealing with issues of policy and economy?



**BGP**

How do we **transport** data scalably, while dealing with varying application demands?



**TCP,**  
**in-network**  
**resource management**

How do we **adapt** new applications and technologies to an inflexible architecture?

**problem:** TCP reacts to drops, and packets aren't dropped until queues are full

# Queue Management

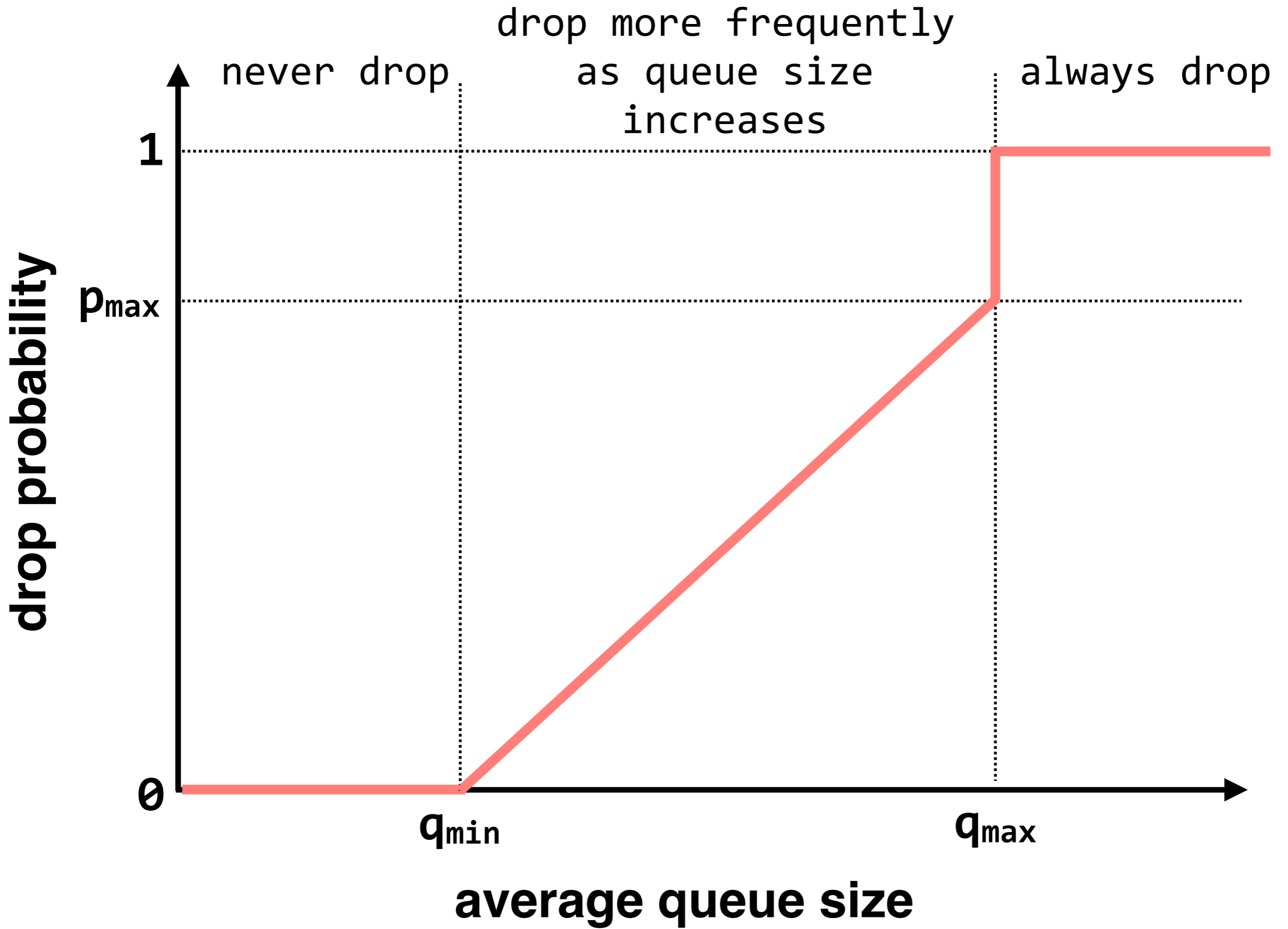
given a queue, when do we drop packets?

## 1. droptail

drop packets only when the queue is full. simple, but leads to high delays and synchronizes flows.

## 2. RED

drop packets before the queue is full



# Queue Management

given a queue, when do we drop (or mark) packets?

## 1. droptail

drop packets only when the queue is full. simple, but leads to high delays and synchronizes flows.

## 2. RED (drops) / ECN (marks)

drop (or mark) packets before the queue is full: with increasing probability as the queue grows. prevents queue lengths from oscillating, decreases delay, flows don't synchronize, but complex and hard to pick parameters

**what if we want to give **latency**  
guarantees to certain types of  
traffic?**

**(or at least try to prioritize latency-sensitive traffic)**

# Delay-based Scheduling

how could we give latency guarantees for some traffic?

## 1. **priority queueing**

put latency-sensitive traffic in its own queue and serve that queue first. does not prevent the latency-sensitive traffic from “starving out” the other traffic (in other queues).



**what if we want to allocate different  
amounts of **bandwidth** to different  
types of traffic?**

# Bandwidth-based Scheduling

how can we allocate a specific amount of network bandwidth to some traffic?

## **1. round-robin**

can't handle variable packet sizes (and in its most basic form doesn't allow us to weight traffic differently)

## **2. weighted round-robin**

can set weights and deal with variable packet sizes

# Weighted Round Robin

**in each round:**

**for each queue  $q$ :**

$$q.\text{norm} = q.\text{weight} / q.\text{mean\_packet\_size}$$

**min = min of  $q.\text{norm}$ 's over all flows**

**for each queue  $q$ :**

$$q.\text{n\_packets} = q.\text{norm} / \text{min}$$

**send  $q.\text{n\_packets}$  from queue  $q$**

# Bandwidth-based Scheduling

how can we allocate a specific amount of network bandwidth to some traffic?

## **1. round-robin**

can't handle variable packet sizes (and in its most basic form doesn't allow us to weight traffic differently)

## **2. weighted round-robin**

can set weights and deal with variable packet sizes, but needs to know mean packet sizes

## **3. deficit round-robin**

# Deficit Round Robin

```
in each round:  
  for each queue q:  
    q.credit += q.quantum  
    while q.credit >= size of next packet p:  
      q.credit -= size of p  
      send p
```

# Bandwidth-based Scheduling

how can we allocate a specific amount of network bandwidth to some traffic?

## 1. round-robin

can't handle variable packet sizes (and in its most basic form doesn't allow us to weight traffic differently)

## 2. weighted round-robin

can set weights and deal with variable packet sizes, but needs to know mean packet sizes

## 3. deficit round-robin

doesn't need mean packet sizes. near-perfect fairness and low packet processing overhead

# Delay-based Scheduling

how could we give latency guarantees for some traffic?

## 1. priority queueing

put latency-sensitive traffic in its own queue and serve that queue first. does not prevent the latency-sensitive traffic from “starving out” the other traffic (in other queues).



**can solve this problem by doing something similar to bandwidth-based scheduling across the two queues**

# In-network Resource Management

## Queue Management

switches can signal congestion before queues are full

DropTail  
RED  
ECN

## Delay-based Scheduling

switches can prioritize latency-sensitive traffic

Priority Queueing

## Bandwidth-based Scheduling

switches can enforce (weighted) fairness among different types of traffic

Round-robin  
Weighted Round-robin  
Deficit Round-robin

**in-network resource management:  
a good idea?**



- Active **queue management schemes**, such as **RED** or **ECN**, drop or mark packets before a queue is full, in hopes of getting TCP senders to react earlier to congestion. They are difficult to get to work on the Internet-at-large, but the ideas can be useful in other types of networks.
- **Traffic differentiation** requires a scheduling discipline, such as **weighted round robin** or **deficit round robin**. The goal of these schemes is to give weighted fairness in the face of variable packet sizes while having low processing overhead
- Both of these are examples of **in-network resource management**