Introduction to Computer Networks

Rate and Delay Guarantees (§5.4.4)

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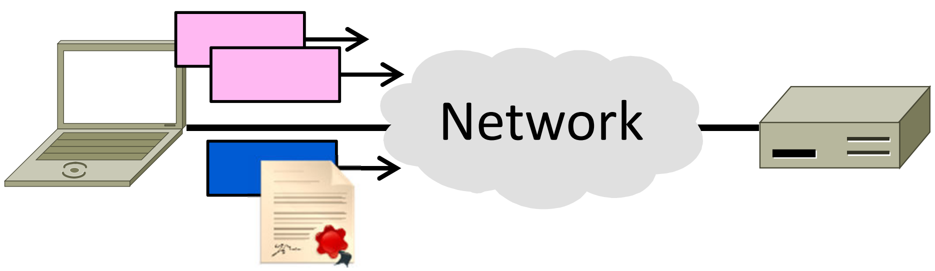
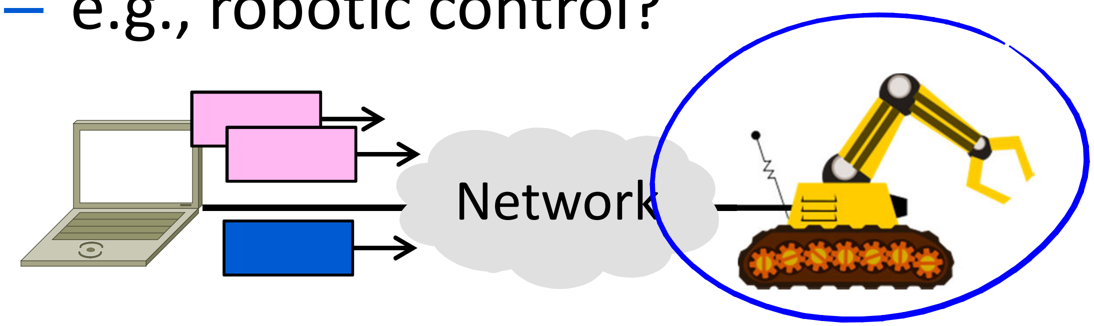
Topic

- Guaranteeing performance for traffic flows across in the network
  - This is "hard QOS" with a firm guarantee for a traffic flow



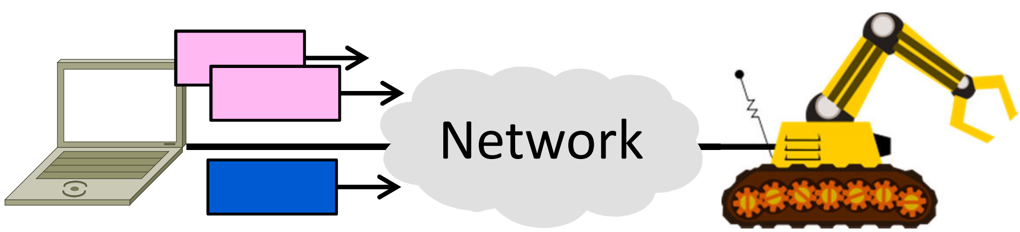
Motivation

- Sometimes we want guaranteed service – like the telephone network
  - Minimum rate and maximum delay regardless of how other flows behave
  - e.g., robotic control?



Motivation (2)

- Could provision a dedicated circuit (or build a network), but expensive
- Can we have statistical multiplexing together with hard guarantees?

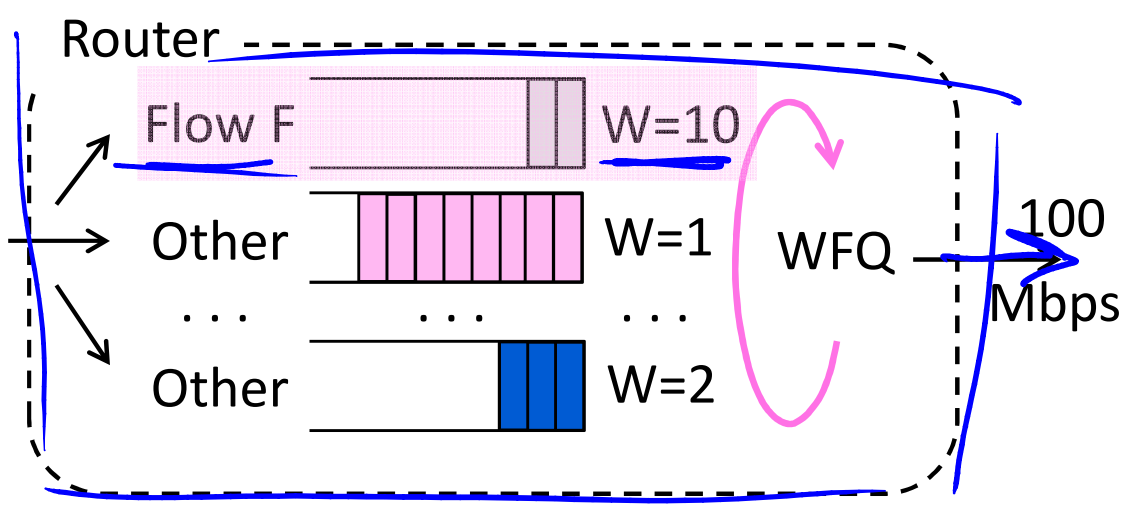


Admission Control

- Suppose we have a flow F that needs rate ≥R Mbps and delay ≤D secs
- We must decide whether to admit or reject it from the network
  - This is admission control
  - Rejecting should be infrequent
- Key point is we need the ability to control load to make guarantees

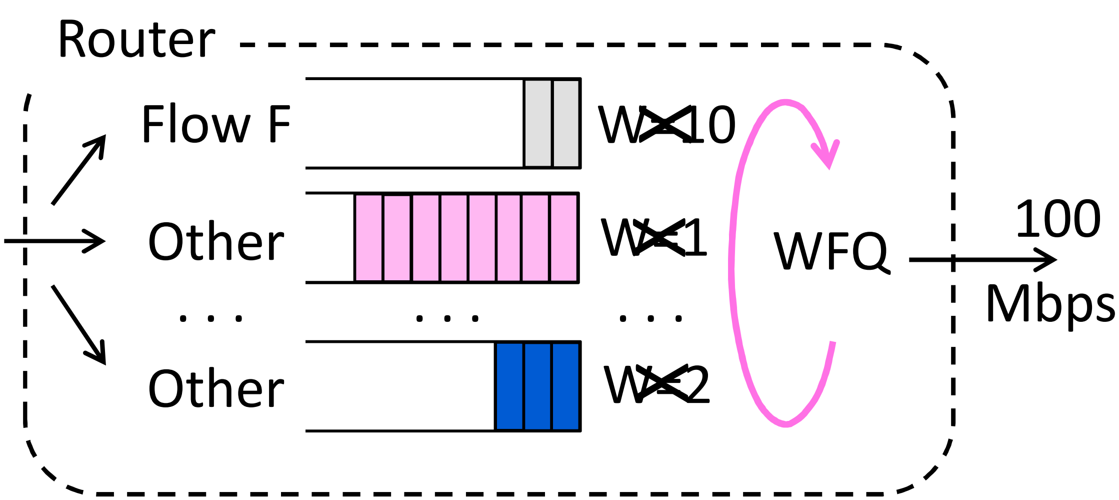
Router Rate Guarantee

- WFQ can guarantee rate at a router
  - What rate will Flow F get?



Router Rate Guarantee (2)

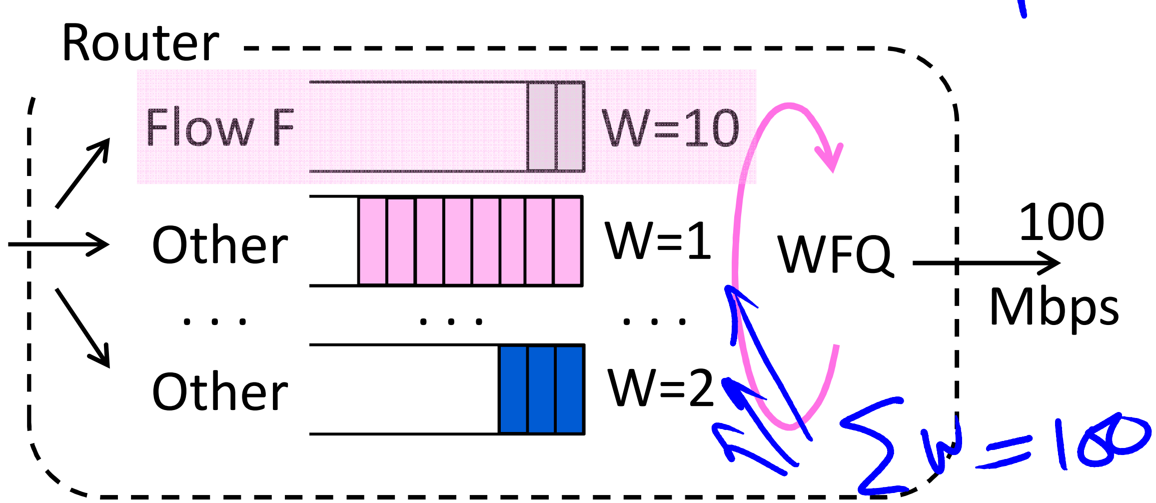
- Consider N flows with weight 1
  - Each flow gets 1/Nth share under load
  - Or at least 100/N Mbps



Router Rate Guarantee (3)

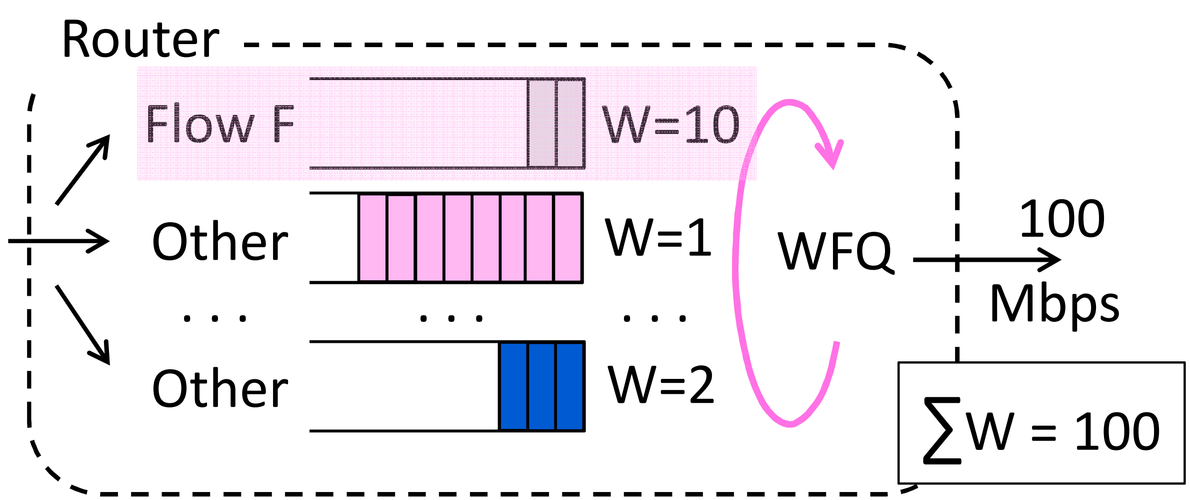
- Consider flow F with weight 10
  - Suppose weight of all flows is 100

Flow F → $10/100 \times 100\text{Mbps} = 10\text{ Mbps}$



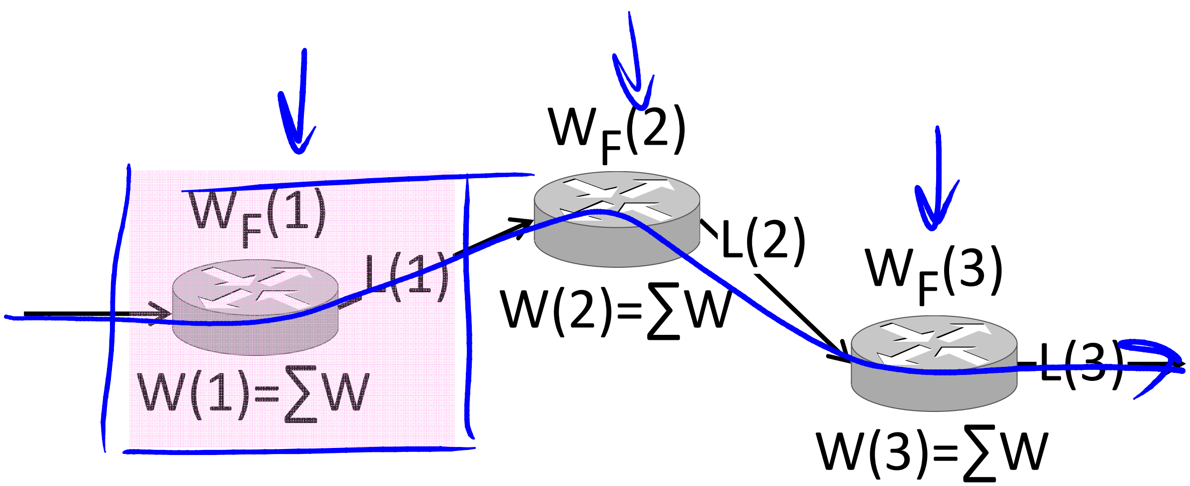
Router Rate Guarantee (4)

- Consider flow F with weight 10
  - Flow F gets ≥(10/100).100 = 10 Mbps



Network Rate Guarantee

- We can guarantee a minimum rate for a network path by guaranteeing it at each router

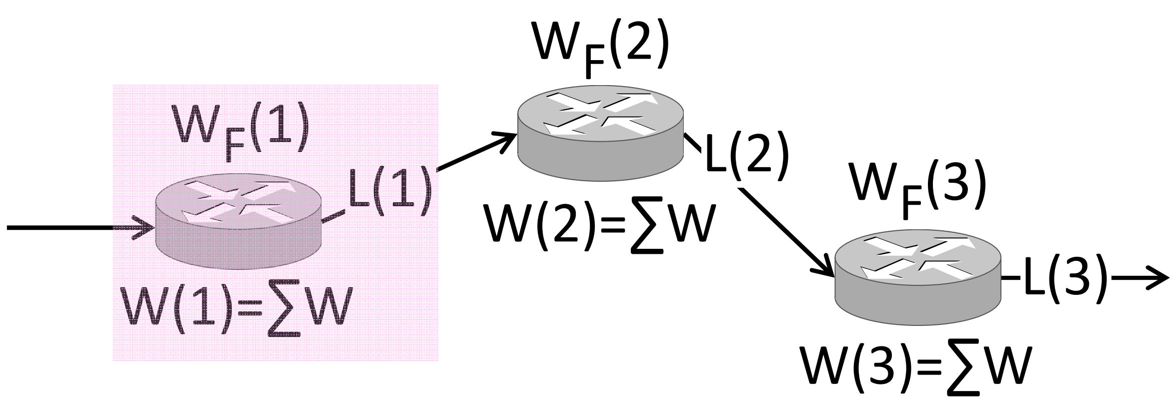


Network Rate Guarantee (2)

- Condition for each router:

For all routers i:

$$W_F(i) \,/\, W(i) * L(i) \geq R \text{ Mbps}$$

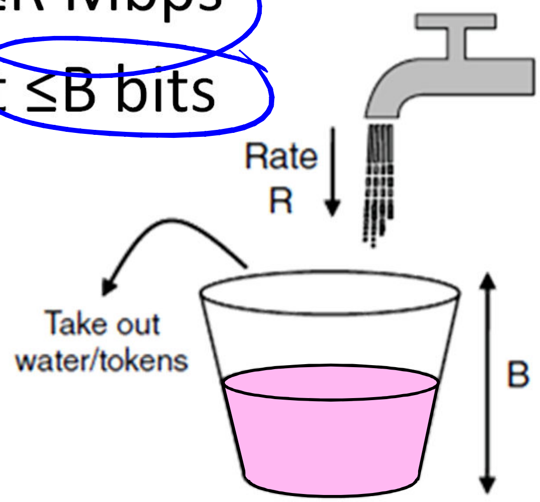


Delay Guarantee

- What about the queuing delay?
  - How much larger than latency might the delay be, given rate guarantee?
- It depends on the traffic flow
  - If exceeds R Mbps then queues may build and delay will grow …
- Need to shape traffic for guarantee
  - We'll use token buckets ☺

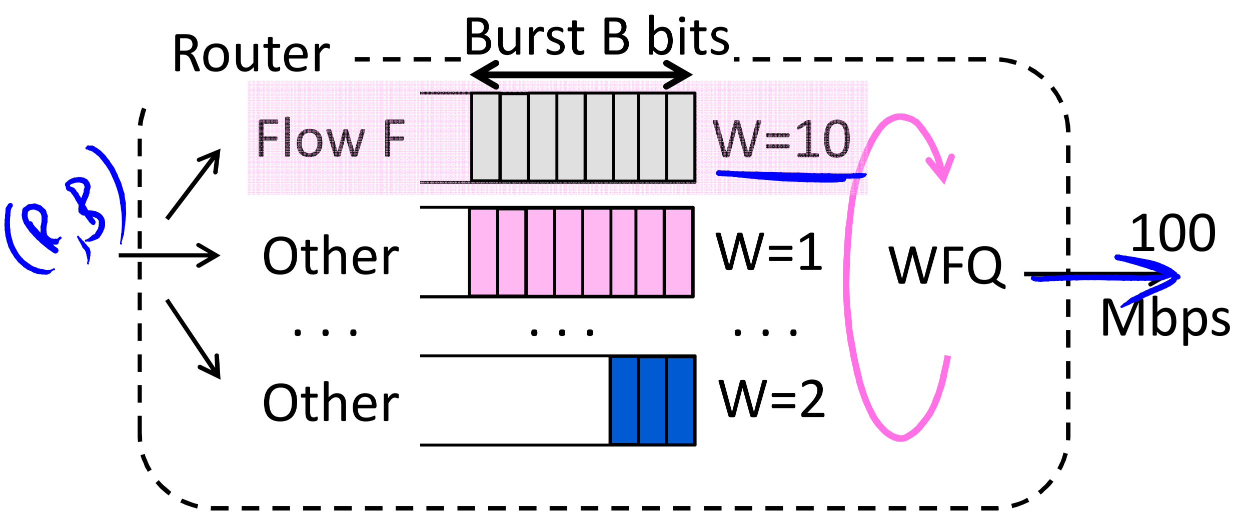
Router Delay Guarantee

- Assume traffic flow F is shaped by an (R, B) token bucket
  - Long-term rate ≤R Mbps
  - Short-term burst ≤B bits



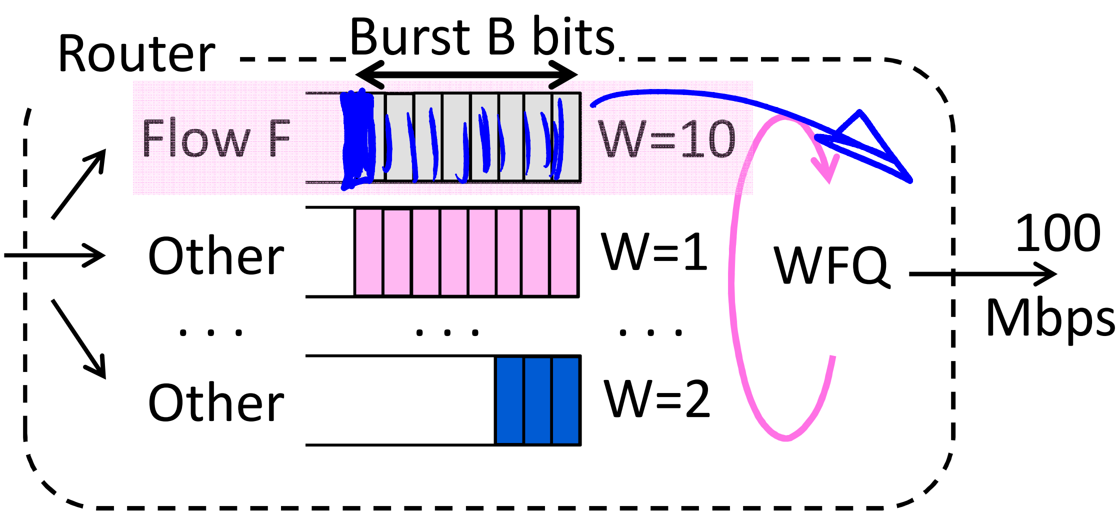
Router Delay Guarantee (2)

- What is delay of flow F at a router?
  - Traffic shaped by (R, B) token bucket
  - WFQ with weight set for rate ≥ R Mbps



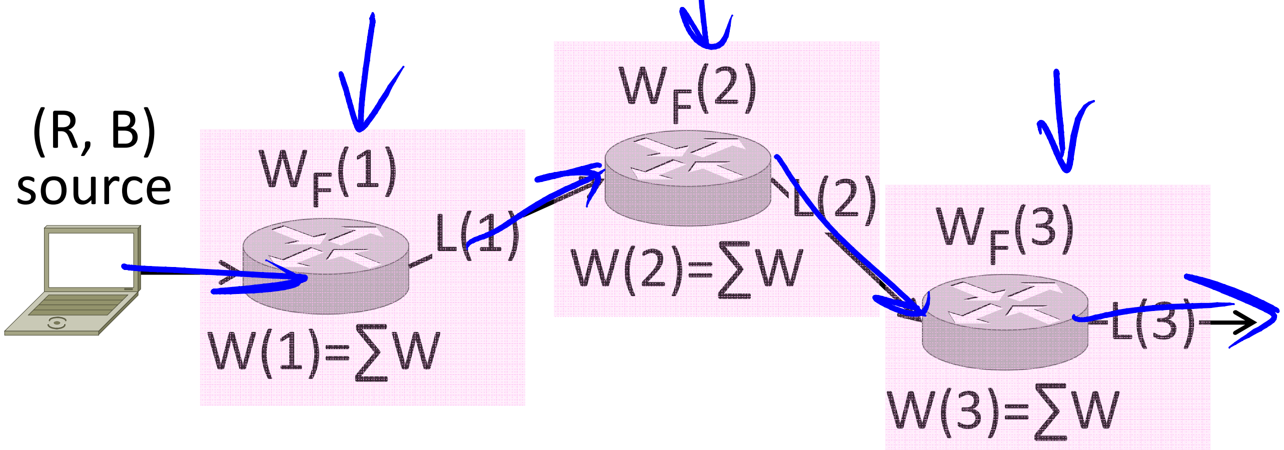
Router Delay Guarantee (3)

- In worst case B arrives all at once
  - So queuing delay is $\le$B/R seconds



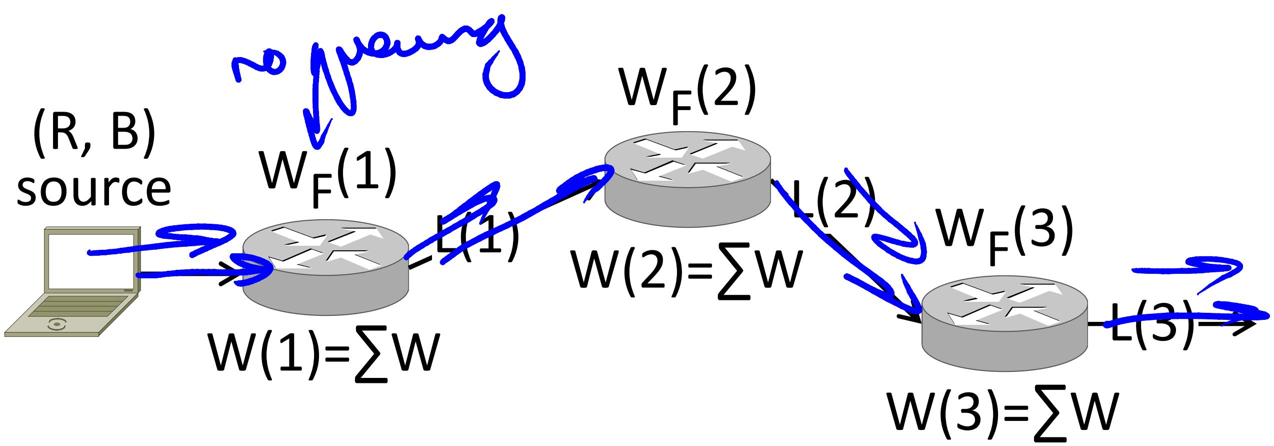
Network Delay Guarantee

- What is the delay across N routers?
  - This is tricky! Each router add delays
  - Bound of $\boxed{N*B/R}$ is too loose
  - Intuitive argument follows …



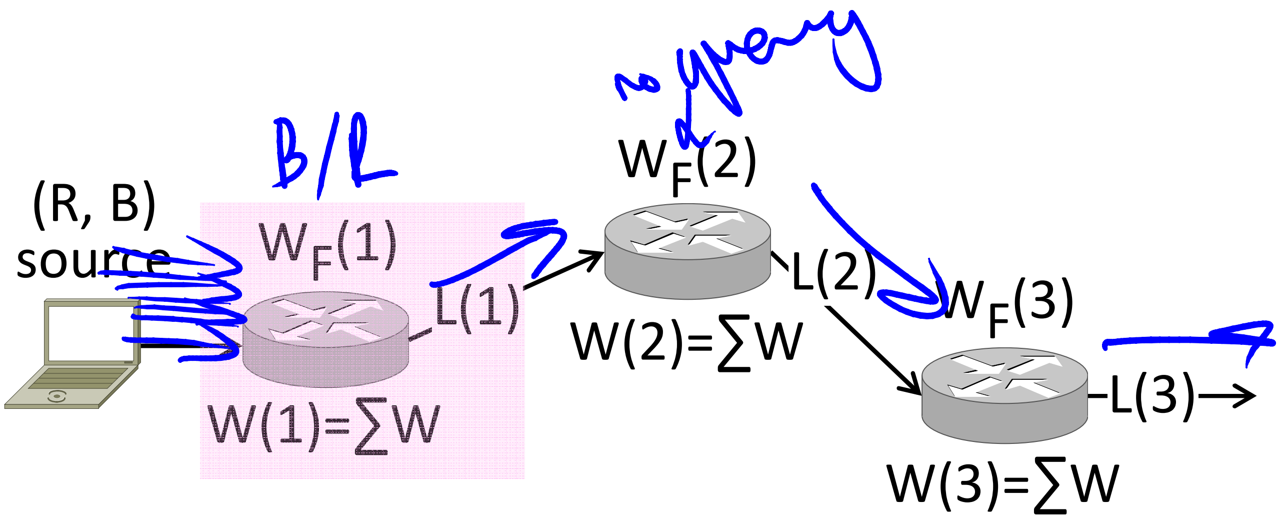
Network Delay Guarantee (2)

- If traffic is perfectly smooth at rate R (no bursts) then queuing delay is zero
  - Packet enters router just in time to leave
  - Delay is latency (propagation, transmission)



Network Delay Guarantee (3)

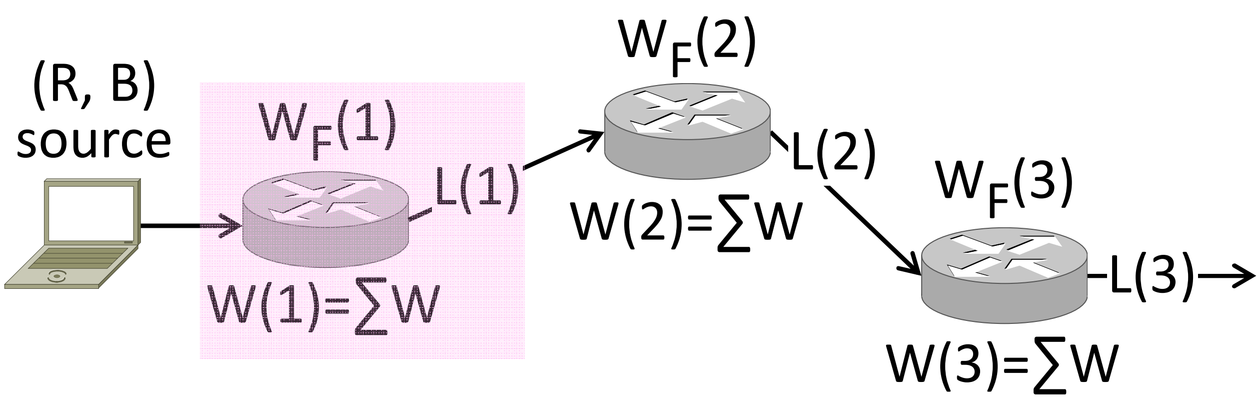
- Observe if traffic pays for burst B at one router, it is smoothed for the next
  - Burst delay is only paid once!



Network Delay Guarantee (4)

- Delay across N routers:

$$\boxed{\text{Delay} \le \text{Latency terms} + B/R}$$



Rate/Delay Guarantee

- Given a network with:
  - (R, B) shaped traffic flow
  - WFQ routers with proper weights
  - Sharing via statistical multiplexing
- We can guarantee the flow a minimum rate and maximum delay
  - Rate is ≥R Mbps
  - Delay is ≤ latency + B/R secs
  - Regardless of how other flows behave

END

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