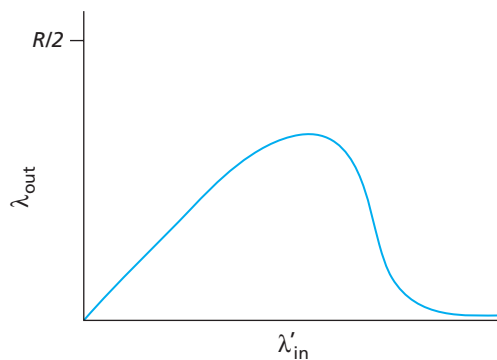


is immediately filled by a B–D packet, and the throughput of the A–C connection at R2 goes to zero. This, in turn, *implies that the A–C end-to-end throughput goes to zero* in the limit of heavy traffic. These considerations give rise to the offered load versus throughput tradeoff shown in Figure 3.48.

The reason for the eventual decrease in throughput with increasing offered load is evident when one considers the amount of wasted work done by the network. In the high-traffic scenario outlined above, whenever a packet is dropped at a second-hop router, the work done by the first-hop router in forwarding a packet to the second-hop router ends up being “wasted.” The network would have been equally well off (more accurately, equally bad off) if the first router had simply discarded that packet and remained idle. More to the point, the transmission capacity used at the first router to forward the packet to the second router could have been much more profitably used to transmit a different packet. (For example, when selecting a packet for transmission, it might be better for a router to give priority to packets that have already traversed some number of upstream routers.) *So here we see yet another cost of dropping a packet due to congestion—when a packet is dropped along a path, the transmission capacity that was used at each of the upstream links to forward that packet to the point at which it is dropped ends up having been wasted.*

### 3.6.2 Approaches to Congestion Control

In Section 3.7, we’ll examine TCP’s specific approach to congestion control in great detail. Here, we identify the two broad approaches to congestion control that are taken in practice and discuss specific network architectures and congestion-control protocols embodying these approaches.



**Figure 3.48** ♦ Scenario 3 performance with finite buffers and multihop paths