* For multiple flows sharing the same link, who allocate the link resource to those flows? (Not a single router, or chromecast) Say two flows share 10 Mbits/s. Then,it could possibly be:
  + 5 Mbit/s + 5 Mbit/s
  + 2.5 Mbit/s + 7.5 Mbit/s
  + 0 Mbit/s + 10 Mbit/s
  + 0 Mbit/s + 5 Mbit/s (this is a collapse)
  + 0 Mbit/s + 10 Mbit/s but every packet is sent twice (throughput 10 Mbit/s but “goodput” 5 Mbit/s, this is also a collapse)
* Maximize total utility

  + If , this gives because has diminish return ( decreases as increases)
* What happens if a host does not follow the congestion control? (Eventually ISP may regulate the host, but) congestion control is a voluntary restraint.
* Real-life congestion control: we don’t know the bottleneck link rate, or how many people are sharing the link. Then, how do we decide what is the “right” speed to send data?
* From last week: Single-flow, single-hop model
  + S(ender) —--------- X(router) —---------- R(receiver) with r = 1 Gbit/s and propagation delay = 1 second
  + The sender sends a datagram, still waiting for the corresponding ackno, where could the datagram be (in the sender’s mind):
    - Propagating on the link
    - Waiting at the router queue (bottleneck queue)
    - Could have been received by the receiver, but ackno still on the way back
    - Or the datagram or the ackno is lost/dropped
* Easiest approach of flow-control: window\_size.
  + We could have both: 1) receiver’s window and 2) “congestion window”. The minimum of the two cap the actual window.
  + “Self-clocking”: a new byte is sent only after a byte is acked (or judged lost)
  + Wrong window size is okay (see below), but wrong rate would lead to more dangerous situations (e.g. queue overflow).
* How much data can be “on the link”?
  + The BDP (Bottleneck link rate Delay Product):
* The ideal value for window size for one flow
  + If the window size is greater than BDP, packets queue up at routers. (At the steady state, window size - BDP bytes is queued at the bottleneck, not so bad).
  + If the window size is smaller than BDP, the bottleneck link may be idle. (Some part of the link would be wasted, bust still not so bad)
  + With one flow, BDP is the ideal window. Any window less than BDP + max queue size is “no loss” window.
* Say two flows share 10 Mbits/s and RTT = 100ms.
  + One flow, good window ~ 10 Mbit/s \* 100ms = 1 Mbit = 100 kByte
  + Two flow, good window: 50 kByte for each flow
* BUT, the “ideal” window is unknown at runtime. How to approximate the right congestion window without knowing: RTT, bottleneck link rate, and number of flows
* Ideas for congestion signals:

  + (experienced) RTT starts increasing
  + Packet loss