Max-Min Fairness

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Fair Allocation of Bandwidth

- In a single link → Allocate equal quantities of bandwidth to all flows
  
  ![Diagram of bandwidth allocation in a single link]

  $x_1 = \frac{C}{2}$  
  $x_2 = \frac{C}{2}$

- This is not possible on a network-wide basis.
  
  - Constraint: a flow traversing multiple links should be allocated the same bandwidth in each link

  ![Diagram of bandwidth allocation in a network-wide scenario]

  $x_1 = \frac{C}{4}$  
  $x_2 = \frac{C}{4}$  
  $x_3 = \frac{C}{4}$  
  $x_4 = \frac{C}{4}$  
  $x_5 = ?$  
  $x_6 = ?$
Max-min Fair Allocation

- Bandwidth allocation is “as balanced as possible”, while allocating as much bandwidth as possible.

- The bandwidth of a flow cannot be increased without decreasing that of a flow with less or equal bandwidth.
How is it derived? → Filling process

- Initially all flows have 0 bandwidth.

- Gradually increase all flows evenly, until some link gets saturated.
How is it derived? \( \rightarrow \) Filling process

- Keep on increasing evenly all **non**-saturated flows, until there are no such flows anymore.
Why is this allocation max-min fair?

- Observations: According to the process
  - For the path of each flow \( i \), there is a link \( l \) that is saturated and the bandwidth of the flow \( i \) is either greater or equal to that of all flows in this link \( l \).
  - Indeed, this is the link where we stop raising the bandwidth of the flow.

- Thus, if the bandwidth of flow \( i \) were to be increased, then in the link \( l \) it can only obtain the extra bandwidth from flows with bandwidth already less than or equal to that of \( i \).
Last Observations

- Some bandwidth may inevitably be left unallocated at the end

- The sharing of bandwidth among ABR virtual circuits in an ATM network applying Explicit Rate congestion control approaches max-min the fair allocation