Deficit Round Robin

- An improvement on WFQ
- Each queue has a **deficit counter**
- Queues with deficit counter values higher than the packet length are served in round robin fashion (and the deficit counter is reduced accordingly)
- A *quantum* is added to deficit counter of a queue that is skipped
- Complexity: $O(1)$ vs $O(\log N)$ for WFQ
Random Early Detection

- TCP flow control
  - packet loss triggers back-off (rate reduction)
  - it takes time to recognize that packet was lost (network latency, timeouts)

- Possible outcome network synchronization
  - periods of congestion followed by periods of low load caused by a TCP flows backing off

- Solution: 1993 Sally Floyd
  - RED (Random Early Detection)
RED - Goals

Goals:
- Avoid congestion and global synchronization
- Avoid bias against bursty traffic
- Bound on queuing delay

Method
- calculate average queue size
- set two thresholds ($TH_{max}$ and $TH_{min}$) within the queue size
- enqueue or drop packets based on the relation between the average queue size and the thresholds
RED - Details

- **Average queue size**
  - use exponentially weighted average
  - RED uses low weights (0.002)

- **Determining packets to discard:**
  - discards should be regular (so burst are not targeted)
  - … but not too regular (because strict regularity is also undesirable)
Quality of Service in IP

- **Type of Service (TOS) field in IPv4**
  - 8 bits
  - called *Traffic Class* in IPv6
  - priority (3 bits)
  - bits to request high throughput, low latency, low loss, and low monetary cost