4/5/2012
EE597

Backpressure scheduling

- Stability region Λ
  - ↳ set of all arrival rates s.t. ∃ a scheme to ensure queues do not blow up.
  - ~~under s~~

- MaxWeight Algorithm

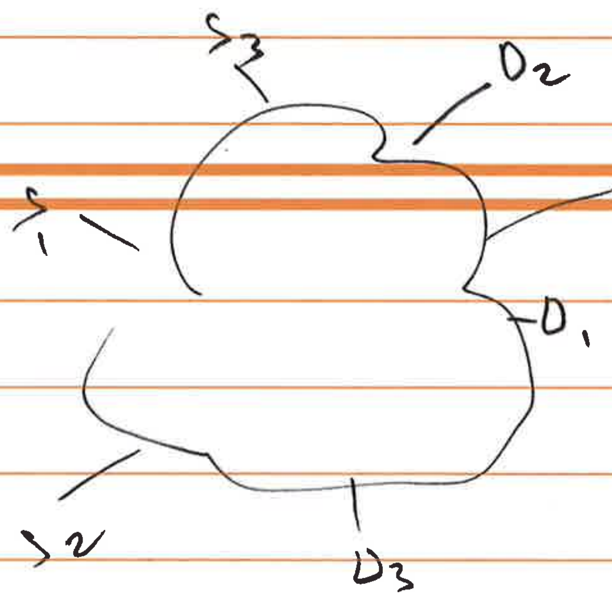
  schedules commodities on independent set of links s.t. $\sum_{i,j,c} w_{ij}^c$ is maximized

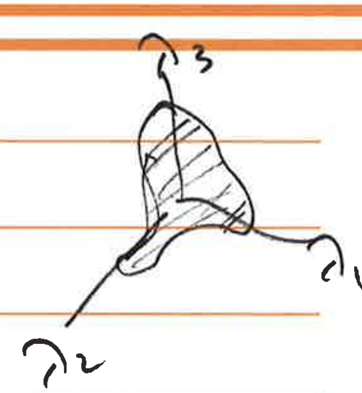
  where $w_{ij}^c = (\varphi_i^c - \varphi_j^c) \cdot R_{ij}$

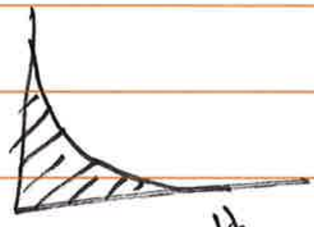
  at each time

- centralized algorithm, NP-hard to compute the MWIS.

- Tassiulas & Ephremides proved in their 93 paper that MaxWeight is Throughput Optimal. i.e., if the arrival rates for all commodities $\vec{\lambda} \in \Delta$, MaxWeight will guarantee stable (bounded) queues.

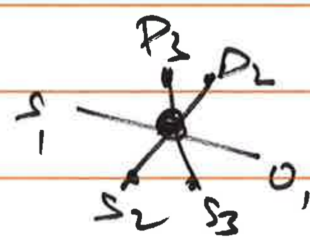






Note: the Backpressure MaxWeight algorithm need not know the stability region!

note also that MaxWeight does not guarantee pkts will go from S^c to D^c along shortest paths. i.e., it's not hop-delay optimal (path-cost)



- Further work has shown how to ~~opt~~ extend MaxWeight to optimize other utility functions, e.g., work by Neely and others.

given $\vec{\lambda} \in \Delta$

$$\min \sum_{ij,t} \left(ETX_{ij}(t) \cdot x_{ij}(t) \right)$$

s.t. ensuring All Queues are stable

$x_{ij}(t)$: 1 or 0 if link ij is used/not to send a pkt. at time t.

assume $R_{ij} = 1 \ \forall ij$

soln turns out to be maxWeight Scheduling, with a modified weight:

$$w^c_{ij} = (Q^c_i - Q^c_j - V \cdot ETX_{ij}) \cdot R_{ij}$$

V: tuning parameter

If V is large, focus more on ETX minimization (i.e. shortest-cost paths)

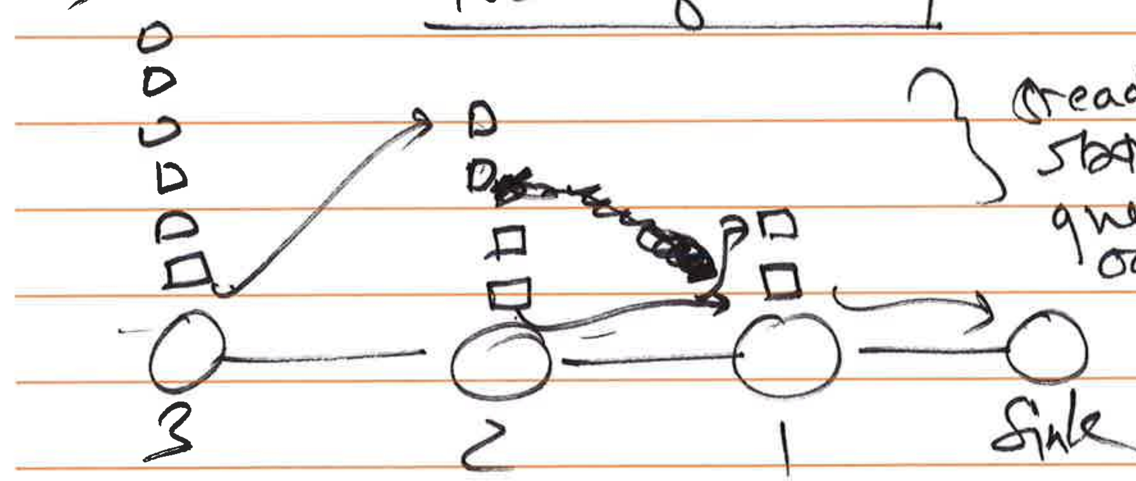
but average queue sizes are large (i.e. average delay is large, by Little's Theorem)

V induces a utility-delay tradeoff

BCP is a distributed, dynamic routing implementation of the Backpressure scheduling idea for a single commodity convergecast WSN.

$$w_{ij} = (Q_i - Q_j - V\,ETX_{ij})\,R_{ij}$$

at each i, pick j that max. w_{ij}. So long as $w_{ij} > 0$, i sends its "Head of line" packet to j.



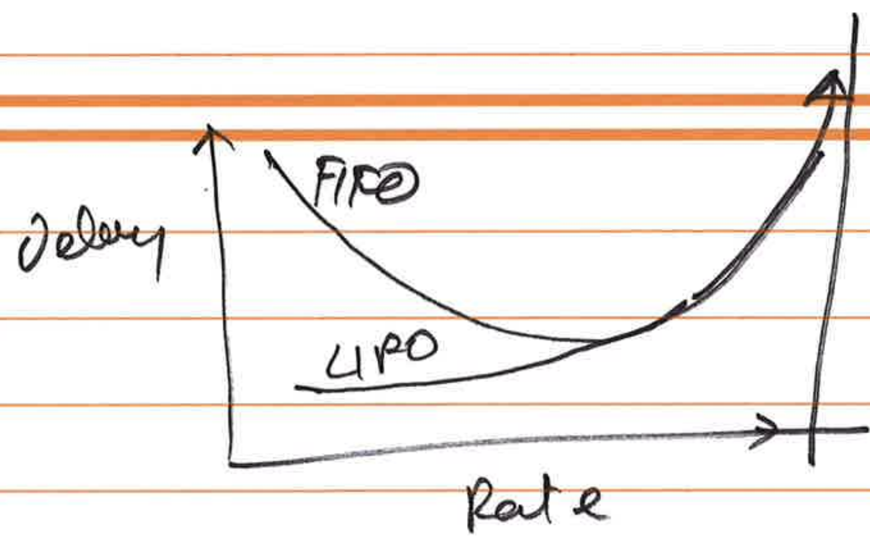
} steady state queue occupancy follows the V·ETX gradient

$R_{ij} = 1$ $ETX_{ij} = 1$, $V = 2$.

With FIFO queueing service

- the last ($\sum_i V_i \cdot cumETX_i$) pkts stay stuck in the network

- The Delay is really bad at low arrival rates !



LIFO queueing service.

- The first set of pkts will be stuck in the network to form the gradient
- But the Delay is very good

Static wireless mesh/ sensor Networks

- ETX metric for existing shortest path routing protocols such as OSPF
- Anypath Routing
- Backpressure Routing

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mobile Ad hoc Network.

The topology changes rapidly due to node movement.

Topology change Time Constant $T_{T.C}$

Routes/ Flow duration D

$D \ll T_{T.C}$ ~ Proactive Routing Protocols ~ Static / Quasi Static

$D \sim T_{T.C}$ — Reactive Routing Protocols

$D \gg T_{T.C}$ ~ Flooding!

Reactive Routing: only create routes when needed; repair when they break.

- Route Discovery
- Route Repair

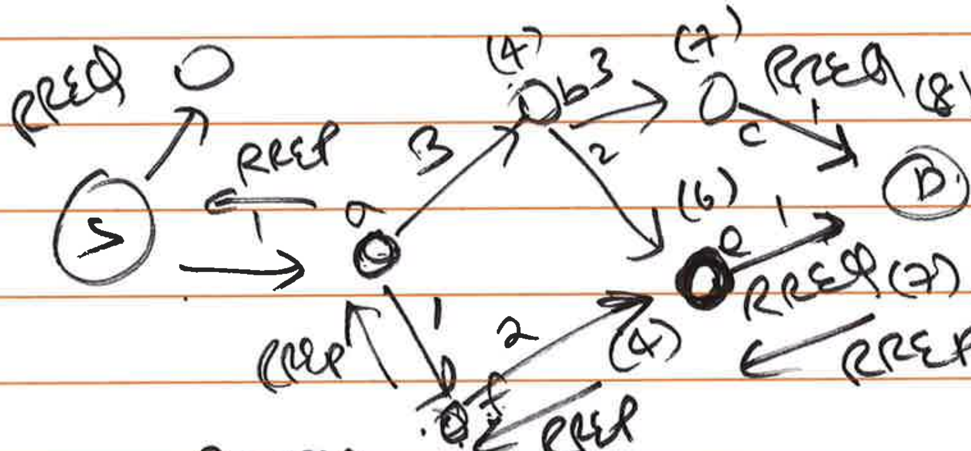
DSR – Dynamic Source Routing
AODV – Ad Hoc On Demand Distance Vector

Assumption: Link Quality determined at link layer through Beacons

~~DSR~~ :

AODV:

Route discovery phase:



Source

- floods a RREQ (route request) pkt for the Destination of interest. Only low cost RREQ pkts are forwarded.
- Destination, upon receipt of the RREQ pkts, generates a RREP (route reply) packet in response, & sends it back on "preferred" route. Each node does the same & sets up the route.
- Eventually source gets the RREP packet & starts to send pkts.