Performance of A Local Fairness Algorithm for the MetaRing

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Outline

- Principles of operation
  - Spatial reuse
  - Buffer insertion or slotted ring
- Global fairness for MetaRing
- The local fairness algorithm
- Performance study
- Conclusions
Principles of operation

Spatial Reuse

- Multiple nodes can transmit simultaneously
- Packets are removed by their destinations

Throughput Gain of Spatial Reuse

- For a full-duplex ring with n nodes, uniform destination distribution, and shortest-path routing
  - maximum distance $\frac{n}{2}$, average distance $\frac{n}{4}$
  - $\Rightarrow$ Potentially 4 times the link bandwidth in each direction

- All nodes can transmit simultaneously to their neighbors

Principles of operation

Buffer Insertion Ring with Spatial Reuse

- Local Access Decision
  - Transmit whenever the insertion buffer is empty
- Ring traffic has non-preemptive priority
- Cut-through via intermediate node

Advantages

- Immediate access under light load
- Single active node has access to full capacity
- Variable size packets

Problems

- Fairness (up-stream priority)
Global Fairness for MetaRing

- A single control message: SAT
- SAT is used for regulating the access into the ring
- SAT rotates in opposite direction to data
- SAT creates a *global cycle* of fairness where each node has a given *quota* for transmission in each global cycle

Local Fairness Algorithm

**Motivation**

- Global fairness algorithms have two basic drawbacks:
  - It is *global*
    → impose the same transmission constraints for all nodes
  - It is *continuous*
    → operate even if there is no starvation
- A localized fairness algorithm can utilize the throughput advantage offered by spatial reuse.
Local Fairness Algorithm

Two basic modes:
- Non-restricted buffer insertion without fairness regulation
- Restricted buffer insertion with fairness regulation (triggered only when starvation occurs)

Control Messages:
1. REQ(i) - sent by node i when it is starved
2. GNT - sent when the node is satisfied after being starved

REQUEST PATH

- A REQUEST PATH is formed by a sequence of nodes that have forwarded or received a REQ signal and did not forward or receive the GNT signal.
- Fairness is achieved within each request path by letting each node to transmit only a predefined quota
Optimal fairness

**Max-Min Definition**

Maximize the allocation on path $p_a$ subject to the constraint that: an incremental increase in $p_a$ allocation does not cause a decrease of some other user's allocation on path $p_b$, that is already as small as $p_b$'s or smaller

*ref: "Data Networks," R.G. Gallager and D.P. Bertsekas*

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**Performance Study**

**System configuration**

- Transmission rate: 1 Gbps
- Topology: Uni-directional ring
- Number of stations: 10
- Fiber length: 1 km
- Stations are equally spaced
- Every station always has something to send
Traffic Scenario 1

Traffic pattern

Normalized throughput

- Code id 1 2 3 4 5 6 7 8 9 10 Total
- No fair 1 1 0 0 0 1 0 0 0 4
- Optimal 1 0.5 0.5 0.33 0.33 0.25 0.25 0.25 0.25 4
- Global 0.25 0.25 0.25 0.25 0.33 0.25 0.25 0.25 0.25 4
- Local 1 0.5 0.5 0.33 0.33 0.25 0.25 0.25 0.25 4

Traffic Scenario 2

Traffic pattern

Normalized throughput

- Code id 1 2 3 4 5 6 7 8 9 10 Total
- No fair 1 0 0 0 0 1 0 0 0 4
- Optimal 0.25 0.25 0.25 0.25 0.25 0.33 0.33 0.25 0.25 4
- Global 0.25 0.25 0.25 0.25 0.25 0.33 0.33 0.33 0.7 4
- Local 0.25 0.25 0.25 0.25 0.3 0.3 0.3 0.7 4

Local Fairness Oct. 1993
Traffic Scenario 3

Conclusions

- Local fairness algorithm can achieve the **optimal fair throughput** defined by MAX-MIN.
- Event-driven protocol with free access mode
  \(\Rightarrow\) the ring cannot be under-utilized even with small quotas
  (as opposed to global fairness algorithms)

### Normalized throughput

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