Smart Network Tools Project

WQRSP
WIRELESS QoS ROUTING AND SCHEDULING PROTOCOL

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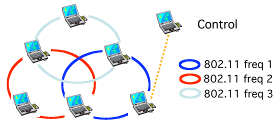
A.1. WQRSP

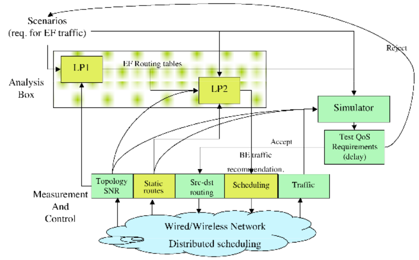
- Two types of traffic: Expedited Forwarding (EF) and Best Effort (BE)
- Static routes for BE traffic
- Centralized resources reservation for EF traffic (EF requirements)
- Centralized QoS routing for EF using Linear Programming (LP1). Test delay with simulator.
- Weights for local schedulers calculated centrally to maximize carried traffic: Linear Program (LP2)
- Distributed scheduling in each cell: shared media access

A.2. Scenario

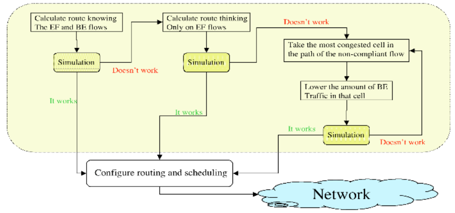


- Centralized control: EF routing, EF reservation and network optimization with BE flows
- Inside each cell: distributed scheduling to share medium providing enough bandwidth to flows with QoS requirements

A.3. Big Picture

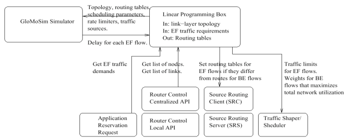


A.4. EF routing: LP1 Control Loop



A.5. EF routing: LP1

Flows with QoS requirements:
Minimum Bandwidth: $e_{sd} \geq p_{sd}$
Maximum delay (tested on simulator)
We will choose the paths (source-destination based routing)



A.6. EF routing: LP1

• **Constraints:**

• Bandwidth and spreading per cell:
$$\sum_{e \in cell_i} \sum_{(s,d)} f^{s,d}(e) \leq C + k_i \quad \forall i \text{ cell}$$

• Flow conservation:
$$\sum_{e=(u,v)} f^{s,d}(e) - \sum_{e=(v,q)} f^{s,d}(e) = \begin{cases} p_{s,d} & \text{if } v = d \\ -p_{s,d} & \text{if } v = s \\ 0 & \text{otherwise} \end{cases} \quad \forall (s,d) \in P$$

• Spreading: $k_i \leq K \quad \forall i$ cell

• Bounds: $K \geq 0$
$f^{s,d}(e) \geq 0 \quad \forall e \in E, \forall (s,d) \in P$
$k_i \geq -C \quad \forall i$ cell

• **Objective:** $\min \left\{ K + \sum_i k_i \right\}$

A.7. Maximum network utilization with BE traffic: LP2

• **Constraints:**

• Bandwidth per cell:
$$Path_{s \to d} = \{(s,n_0),(n_0,n_1)...(n_k,d)\} \qquad C_z = \{(i,j): \text{ links in cell z}\}$$
$$\sum_{(i,j) \in C_z} \left[\sum_{s,d/(i,j) \in Path_{s \to d}} [e_{sd} + b_{sd}] \right] \leq BW_z$$

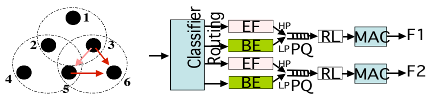
• Spreading: $\sum_{s,d/(i,j) \in Path_{s \to d}} b_{s,d} \leq k_{i,j} \qquad k_{i,j} \leq K \qquad \forall (i,j)$ link

• Bounds: $e_{s,d} \geq p_{s,d} \qquad k_{i,j} \geq 0 \qquad K \geq 0 \qquad b_{s,d} \geq 0$

• **Objective:** $\max \left\{ \sum_{(s,d)} b_{s,d} - K \right\}$

A.8. Distributed Scheduling

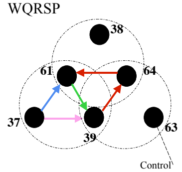
- Distributed scheduling: all nodes in one cell exchange information about their flows from measurements
- Flow limitation per node and priority queuing



A.9. Implementation

- 7 laptops with Linux RedHat 7.2
- Static routes for BE
- Monitoring and control daemons in each laptop
- Central control server
- Source&Destination based forwarding for EF flows
- Scheduling in each interface: distributed scheduling, priority queueing and rate limiting
- Video client-server MPEG1 using 3 Mbps flows

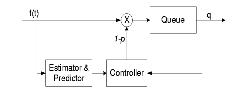
A.10. Demo

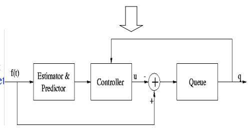


- 1.- BE flow 2Mbps
- 2.- EF flow 3Mbps, reduce congestion
- 3.- EF flow 3Mbps
- 4.- EF flow 1Mbps, limiter

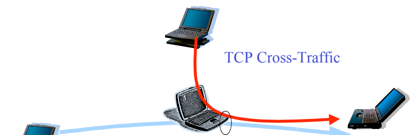
B.1 Exploiting LRD in Active Queue Management

- Design objective:
  - Keep the queue length of a router at a stable level.
  - Reduce the packet loss ratio while sustaining link utilization.
- Approach used:
  - Predict the future traffic periodically with the use of LMMSE predictor.
  - Figure in the prediction result in the calculation of the packet dropping probability used for the next interval.





B.2 Demo Scenario on Wireless Test



Queue management at the output interface with predictive AQM or RED

B.3 Purpose of Demo

- We show
  - The correlation structure present in long-range dependent traffic can be detected on-line and used to accurately predict the future traffic.
  - The prediction results can be factored into the calculation of the packet dropping probability to
    - Stabilize the instantaneous queue length (and hence reduce the delay jitter).
    - Reduce packet losses, while sustaining the same level of link utilization.

B.4 Demo Scenario on Wireless Testbed

- We measure at the router
  1. the instantaneous queue length,
  2. the packet loss ratio,
  3. the amount of traffic that arrives in an interval of 10 ms,

  We also compare item (2) against the corresponding prediction.
- We measure and compare the distribution of delay jitter at the end-hosts of PAQM with RED..