Analysis of QoS Routing Approaches and Algorithms

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Background

- Current Internet routing protocols forward packets to the shortest path based on hop count.

- **QoS routing** is a routing scheme, under which paths for flows would be determined based on some knowledge of resource availability in the network, as well as the QoS requirements of the flow.
Metrics

• To find feasible paths, the QoS requirements have to be represented by metrics
• The metrics define the types of QoS guarantees the network is able to support
• The metrics should be selected so that requirements can be represented by one metric or a reasonable combination of them
Metrics

• Metrics commonly used in QoS routing are divided to three categories:

  • Path constraints
    1. Additive: \( w(P) = w(i,j) + w(j,k) + \ldots + w(l,m) \)
       » Delay, cost, hop-count
    2. Multiplicative: \( w(P) = w(i,j) \cdot w(j,k) \cdots w(l,m) \)
       » Reliability

  • Link constraints
    3. Concave: \( w(P) = \min\{w(i,j),w(j,k),\ldots,w(l,m)\} \)
       » Bandwidth
Link State Information

- In order to compute routes supporting the QoS requirements, a router needs information about the availability of resources in the network.

- Extensions on the link state advertisements to include information about the metrics.
  - When to inform about changes
    - Threshold based triggers
    - Class based triggers
    - Timer based triggers
  - Scope of Link state advertisement
Single metric routing problems

- Link optimization routing problem
  - Largest available bandwidth
- Link constrained routing problem
  - Available bandwidth larger than constraint C
- Path optimization routing problem
  - Shortest delay, smallest hop-count
- Path constrained routing problem
  - Delay/hop-count smaller than constraint C
## Routing problems with two metrics

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Heuristics: Jaffe’s algorithm

\[ w(P) = d_1 \cdot w_1(P) + d_2 \cdot w_2(P) \]
Heuristics: TAMCRA

\[ w(P) = \left( \left( \frac{w_1(P)}{C_1} \right)^q + \left( \frac{w_2(P)}{C_2} \right)^q \right)^{\frac{1}{q}} \]
Bandwidth and hop count as metrics

Widest path
- dap
  - hop count limit
- wsp
  - Sequential optimization
  - Bandwidth Link weights
- swp
  - Sequential optimization

Shortest path
- ebsp
  - Penalize longer paths
- bsp
  - Bandwidth inversion link weights
Cost of QoS routing

• Factors contributing to cost and overhead
  – Computational cost
    • Path selection algorithm: cost-efficiency trade-off
    • Path computation: On-demand vs pre-computation
    • Flexibility in routing: accounting for inaccuracy etc.
  – Protocol overhead
    • Triggers for link state update messages
    • Scope of link state update messages
• “Processing cost remains well within the capabilities of medium-range processors” (Apostolopoulos et al. 1999)
Inter-class effects

• In an environment with both QoS guaranteed traffic and best-effort traffic, the task of routing is to maximize the resource efficiency.

  1. Minimize the call-blocking ratio of QoS flows
  2. Optimize the throughput and fairness for best-effort flows

➢ Routing algorithms: ebsp, multiclass routing

➢ Trunk reservation
  • Own contribution: effect of reservation level on blocking of QoS guaranteed traffic and bandwidth available for low priority traffic
QoS traffic’s blocking vs available bandwidth for low priority traffic

![Graph showing the relationship between average available bandwidth for low priority traffic and blocking probability of guaranteed traffic. The graph includes lines for different traffic rates (0.50C, 0.75C, and 1.00C) and illustrates how blocking probability increases with decreasing available bandwidth.](image-url)