Analysis of QoS Routing Approaches and Algorithms

Ilmari Juva

Networking Laboratory

Supervisor: Professor Samuli Aalto

Contents

- Background
- Metrics
- Link state information
- Routing problems
- Heuristics for complex routing problems
- Cost of QoS routing
- Inter-Class effects

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: $w(P)=w(i,j)\ w(j,k)\ldots w(l,m)$
       - » 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

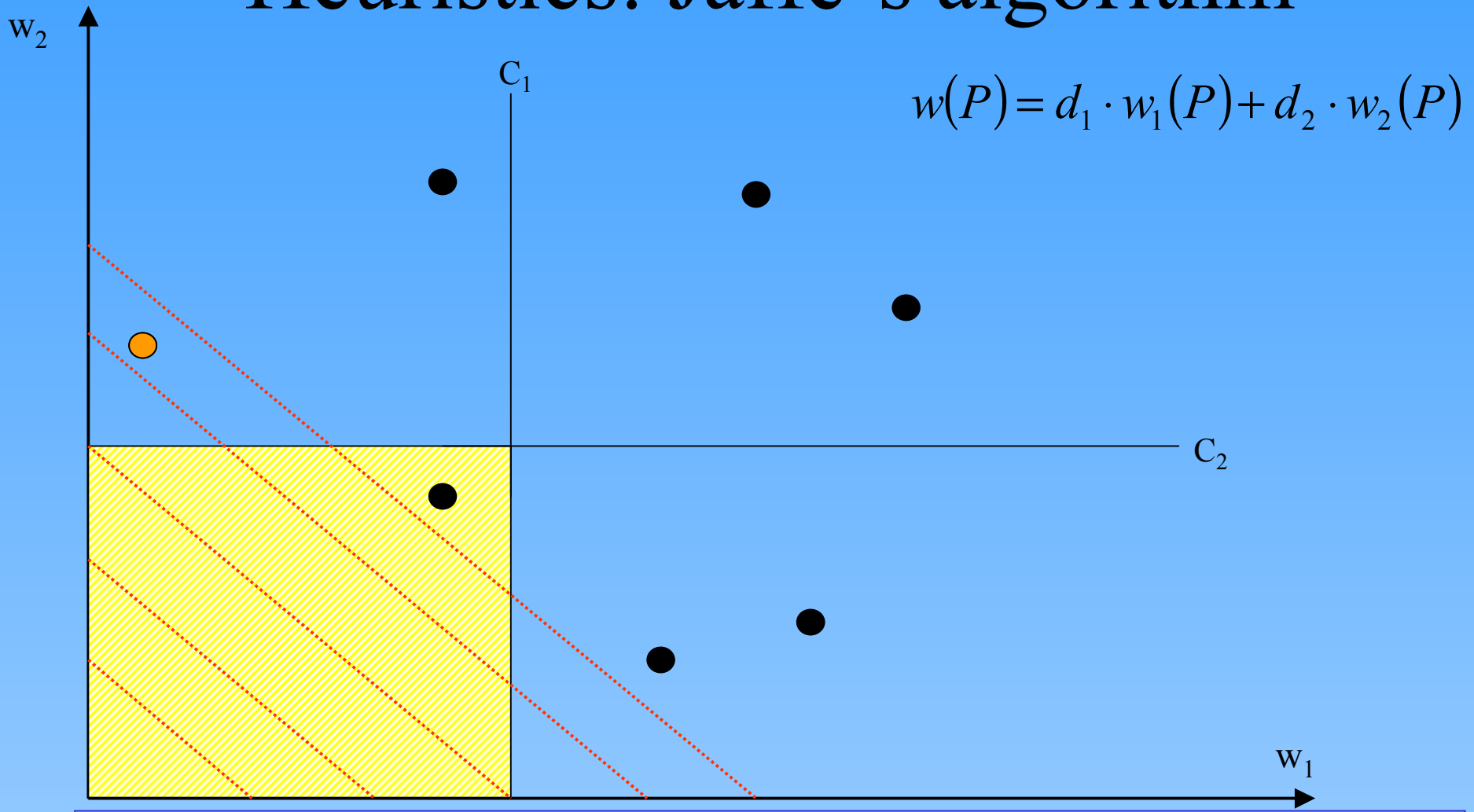
Single metric routing problems

- 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

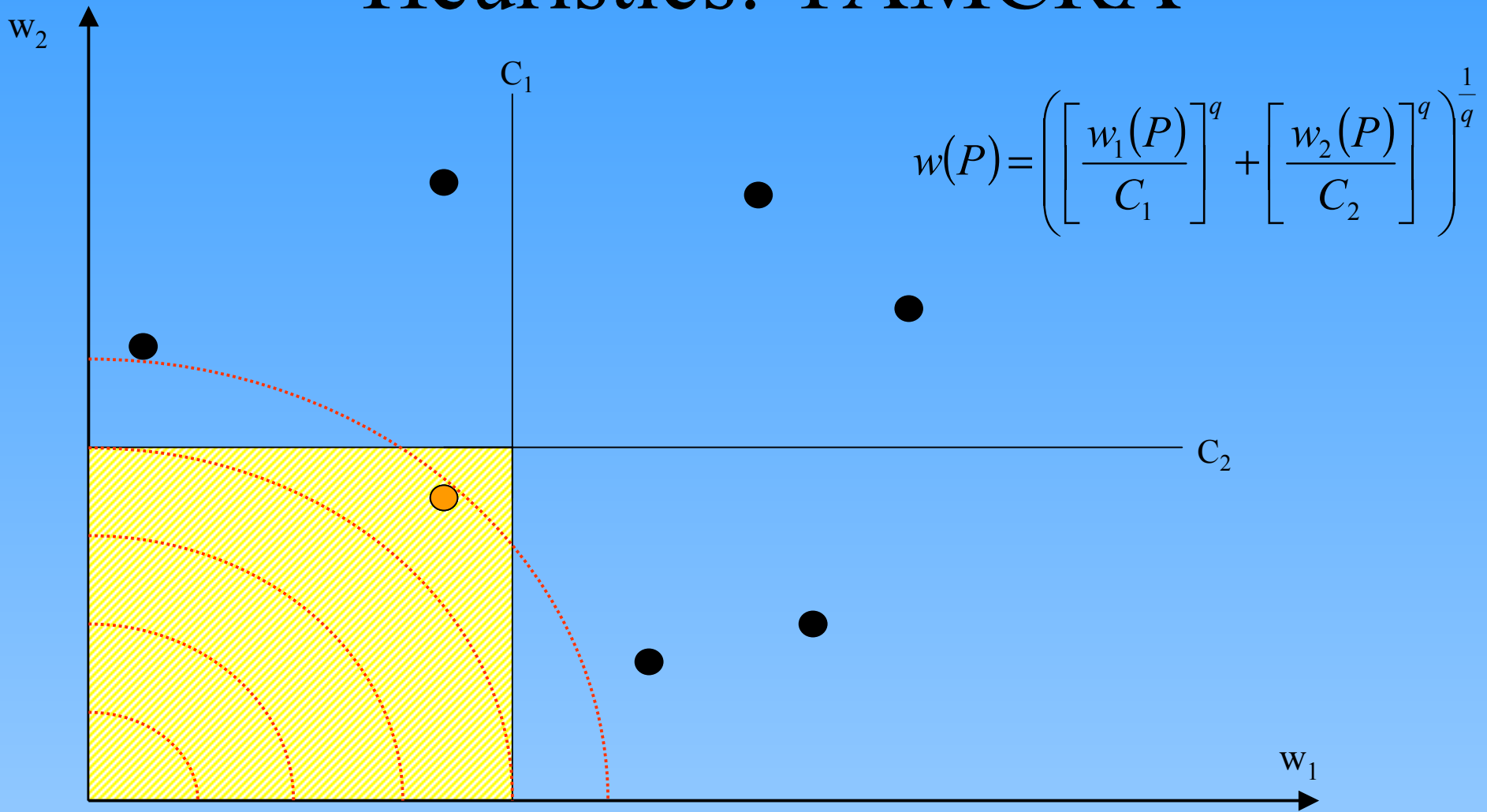
	Link-optimization	Link-constrained	Path-optimization	Path-constrained
Link-optimization	-	Link-constrained link-optimization routing problem **POLYNOMIAL**	-	Path-constrained link-optimization routing problem **POLYNOMIAL**
Link-constrained		Multi-link-constrained routing problem **POLYNOMIAL**	Link-constrained path-optimization routing problem **POLYNOMIAL**	Link-constrained path-constrained routing problem **POLYNOMIAL**
Path-optimization			-	Multi-path-constrained optimization routing problem, MCOP **NP-COMPLETE**
Path-constrained				Multi-path-constrained routing problem, MCP **NP-COMPLETE**

Heuristics: Jaffe's algorithm



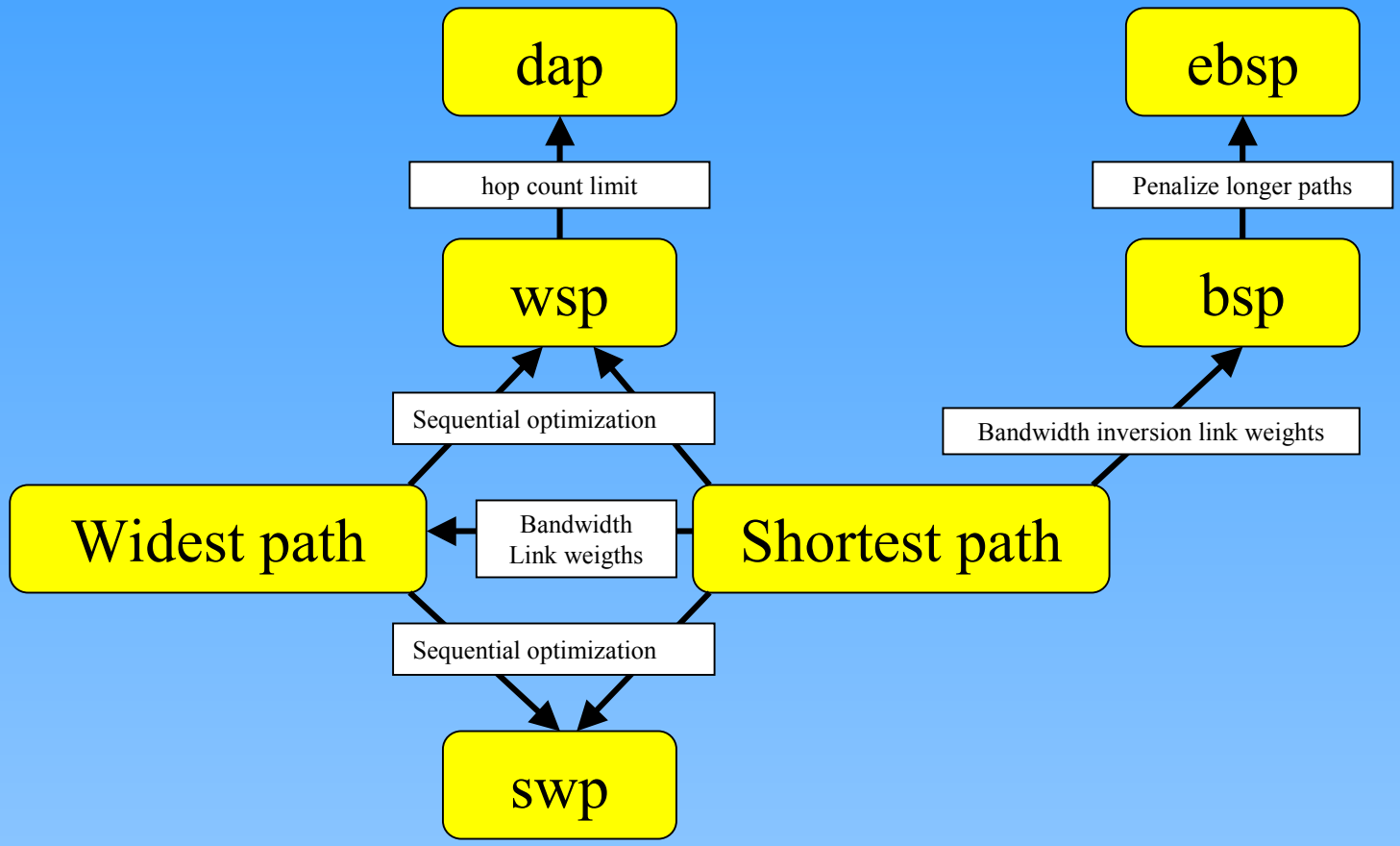
$$w(P) = d_1 \cdot w_1(P) + d_2 \cdot w_2(P)$$

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



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