A New Bandwidth Guaranteed Routing Algorithm for MPLS Traffic Engineering

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IEEE ICC 2002

Outline

- Introduction
- Problem Formulation
- Existing Routing Algorithms
- Proposed Algorithm
- Performance Studies
- Concluding Remarks

Introduction

- Traffic Engineering
  - Optimize the utilization of network resources
  - Provide for Quality of Service
- MPLS vs. IP Routing
  - Explicit routing vs. Static routing
  - Link state information
  - Constraint-based routing vs. Dynamic routing
  - Connection-oriented vs. Connectionless

Problem Formulation

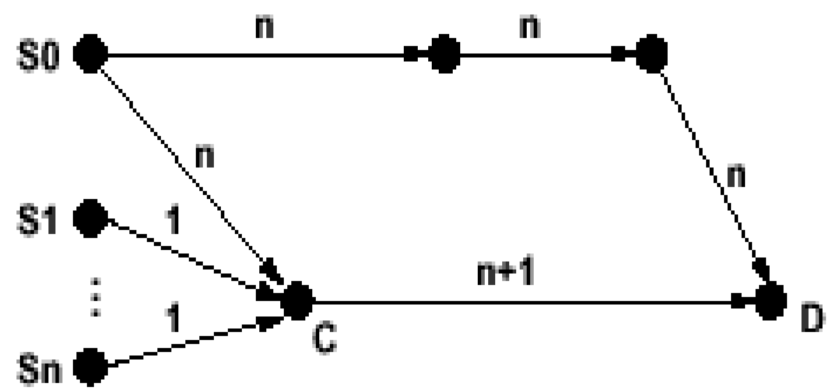
- System Model
  - A network of n routers, G=(V, E) |V|=n
  - LSP location information is known as a set of ingress-egress router pairs, denoted by L
  - Residual bandwidth of link l, denoted by $R(l)$, is accessible
  - Request r_i for LSP setup is represented by a triple (s_i, d_i, b_i) where $(s_i, d_i) \in L$
- Objective: find an LSP routing algorithm to satisfy the demands and make efficient use of network resources

Existing Routing Algorithms

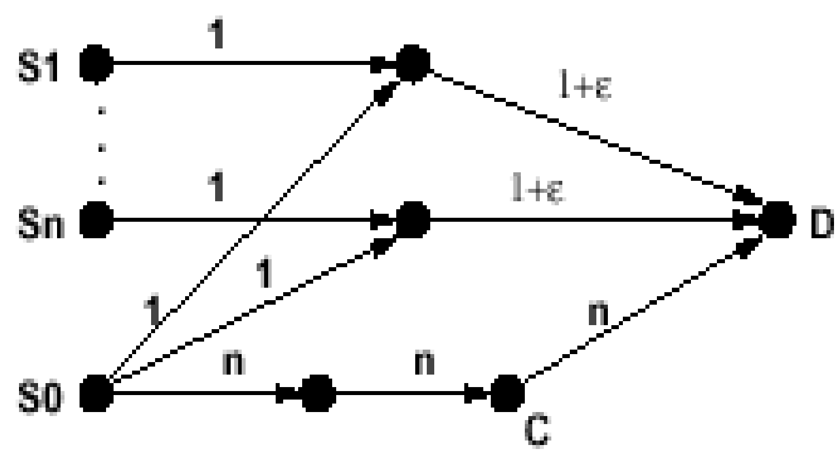
- Routing decision based on
  - Only current network status
    - MHA: Minimum hop routing algorithm
    - WSP: Widest(residual capacity) shortest path
    - SWP: Shortest widest path
  - Traffic profile
    - PBR (Profile-based routing): use measurement based profile to predict future distribution
    - MATE (Multipath Adaptive Traffic Engineering)
  - Interference to potential unknown future requests
    - MIRA (Minimum Interference Routing)

Shortcomings of MIRA (1/2)

- Concentrator graph
  - *n+1* requests (S_0,D,n), $(S_1,D,1)$, …, $(S_n,D,1)$ arrive in sequence
  - MIRA will route (S_0,D,n) along the path $\{S_0,C,D\}$

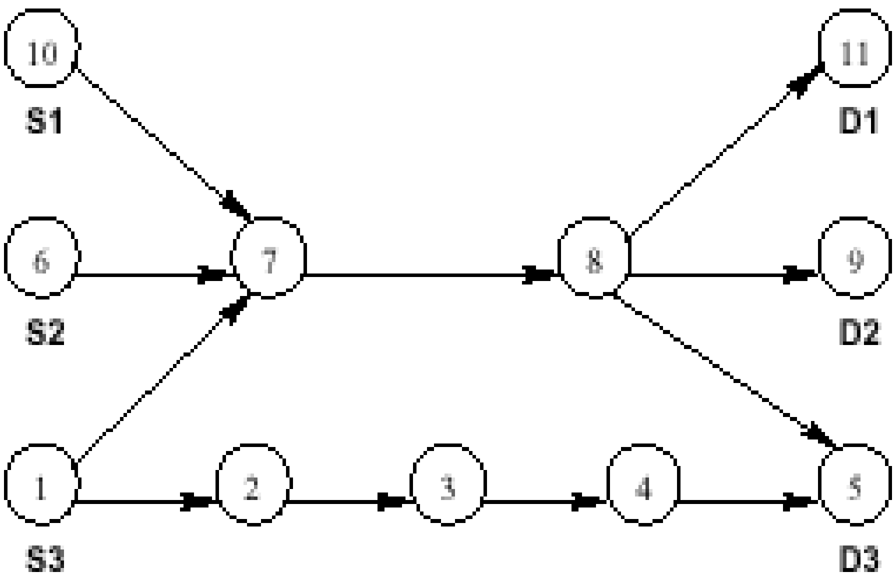


- Distributor graph
  - *n* requests of $(S_0,D,1)$, followed by n more requests $(S_1,D,1)$, $(S_2,D,1)$,…,$(S_0,D,1)$ in sequence
  - MIRA will not route $(S_0,D,1)$ along the path $\{S_0,C,D\}$



Shortcomings of MIRA (2/2)

- Bottleneck-link graph
  - 3 requests $(S_3,D_3,1)$, $(S_2,D_2,1)$, $(S_1,D_1,1)$ arrive in sequence
  - According to MIRA, if link {7,8} has 1 unit residual bandwidth, it is a critical link, then $(S_3,D_3,1)$ will be routed along the path {1,2,3,4,5}
  - If link {7,8} has 2 unit residual bandwidth, it is not a critical link, $(S_3,D_3,1)$ will be routed along {1,7,8,5}



Proposed Algorithm (1/2)

- Idea
  - Similar to MIRA, take into account the importance of critical links
  - Also consider link residual bandwidth and path hop counts
  - Given an LSP request *(s,d,b)*, the impact of routing this LSP on future LSP setup requests is characterized by assigning weights on links

$$w(l) = \sum_{(s',d') \in L} \frac{f_l^{s'd'}}{\theta^{s'd'} \cdot R(l)}, \quad l \in E,$$

Proposed Algorithm (2/2)

INPUT: $G(V, E, B)$**,** L**, an LSP request (**s**,** d**,** b**).**

OUTPUT: A route between s **and** d **having a capacity of** b **units of bandwidth.**

Procedure *LSP_Online_Routing* (**G(V, E, B), r(s, d, b)**)

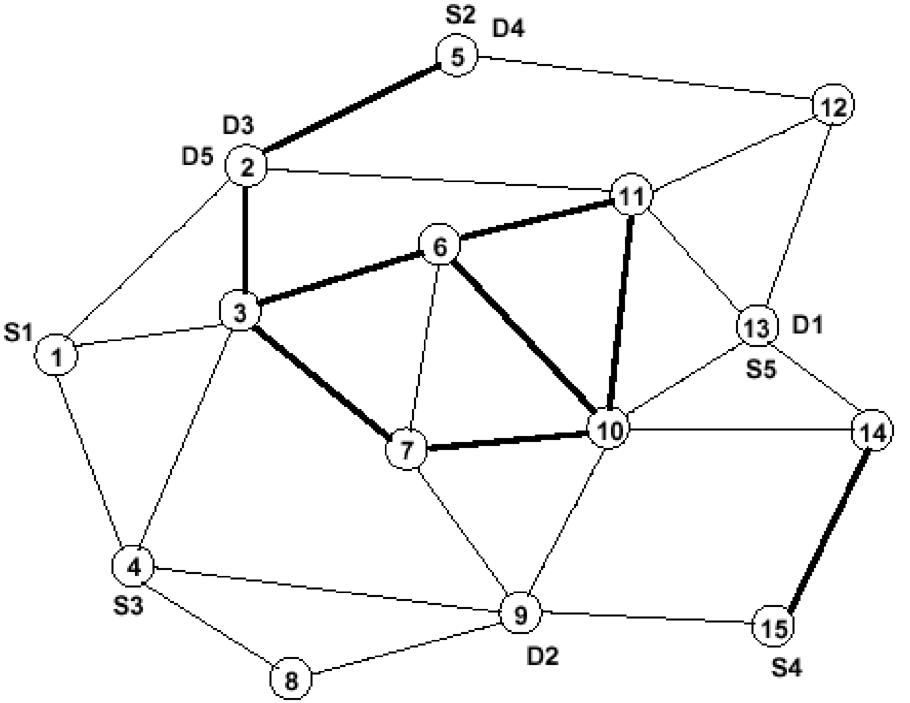
{

1. Compute the maximum network flow values for all $(s', d') \in L$;
2. Compute the weight $w(l)$ for all $l \in E$ according to Eq. (2);
3. Eliminate all links that have residual bandwidth less than b and form a reduced network topology with remaining links and nodes;
4. Using Dijkstra's algorithm to compute the shortest path in the reduced network using $w(l)$ as the weight on link l;
5. Route the bandwidth requirement of b units from s to d along this shortest path and update the residual link capacities;

}

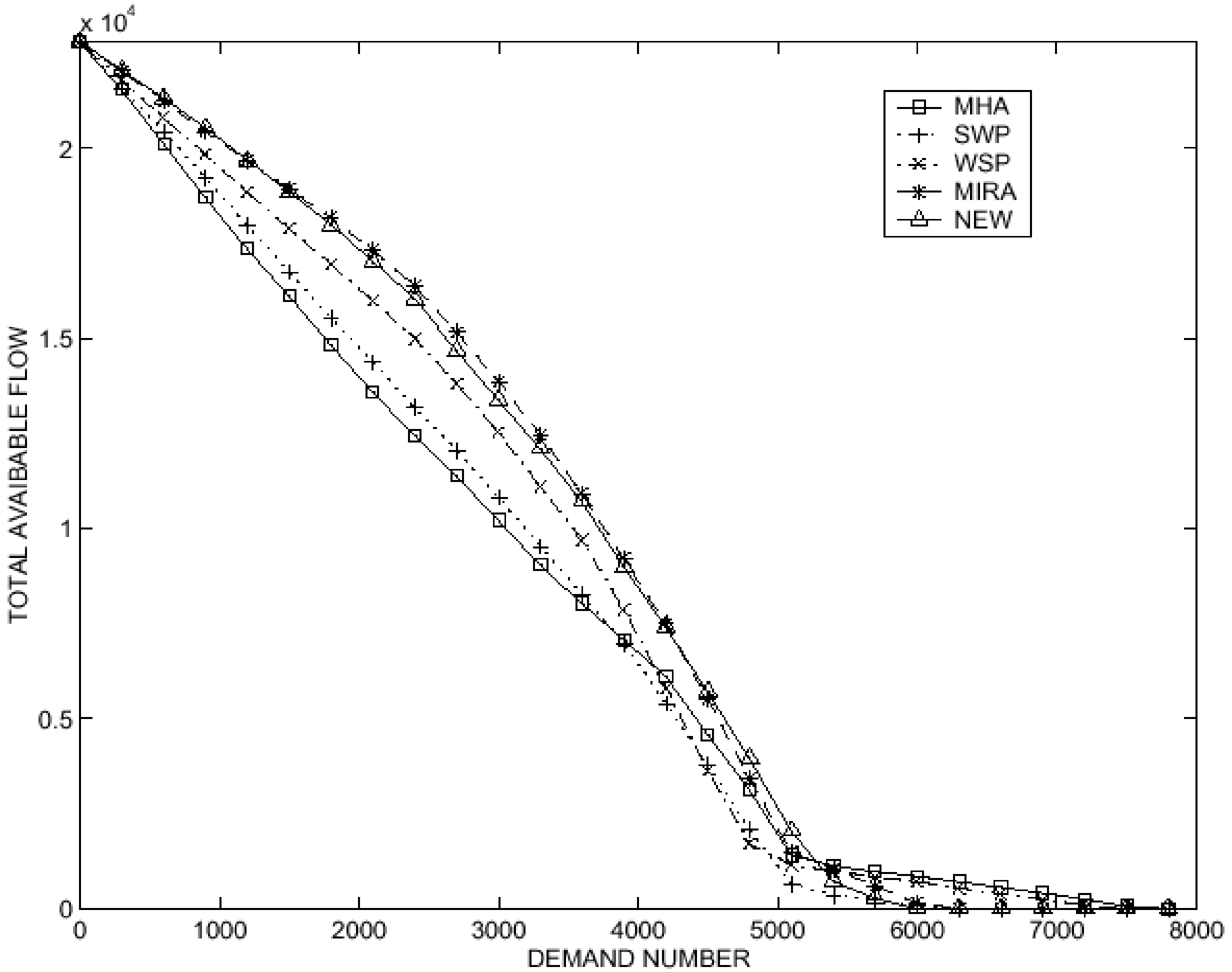
Performance Studies (1/4)

- Simulation network topology
  - 5 potential LSP location pairs
  - Link capacity
    - 1200 units (light link)
    - 4800 units (dark link)
  - LSP requests are randomly chosen from the above pairs
  - LSP bandwidth demands: Uniform(1,4)



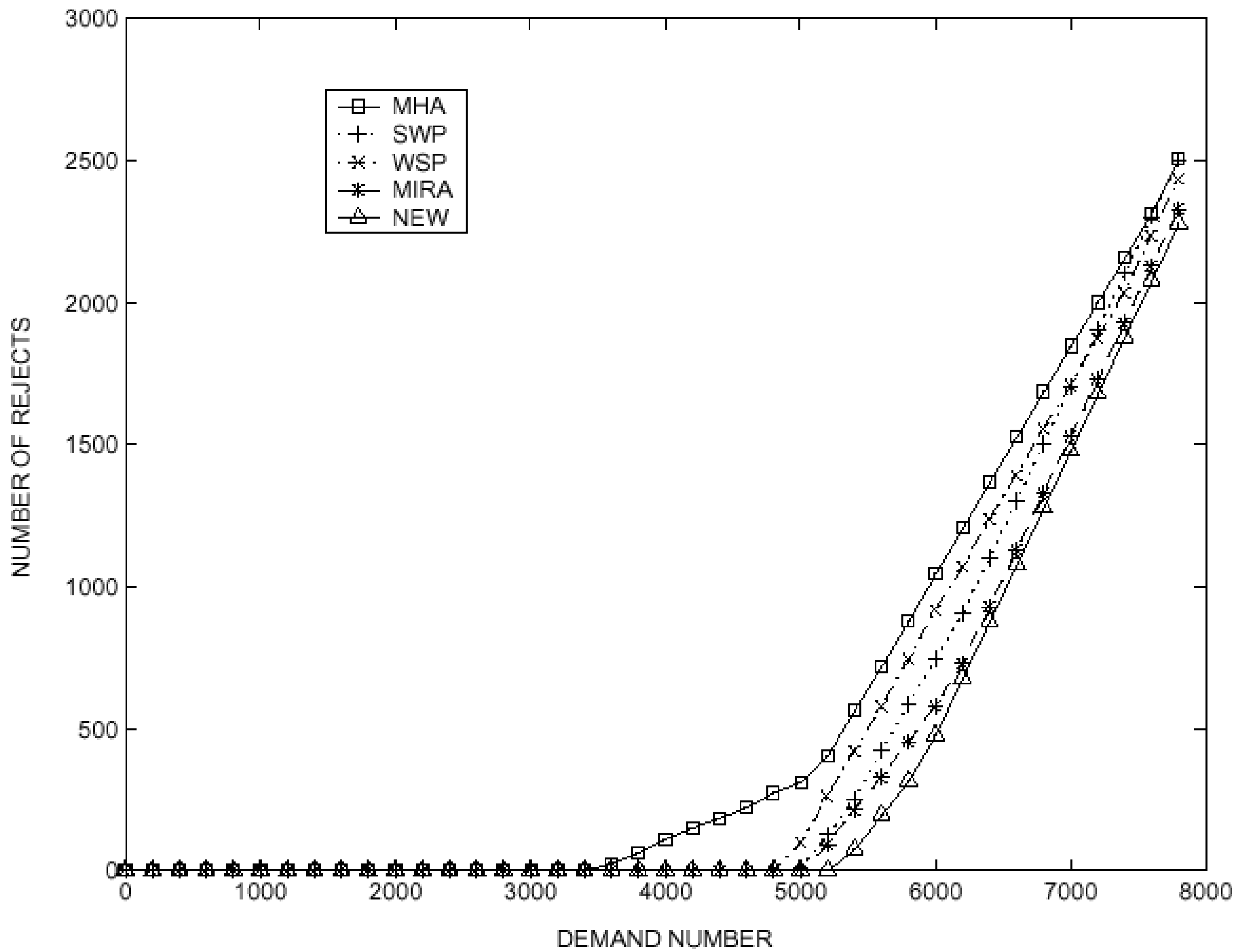
Performance Studies (2/4)

- Total available bandwidth v.s. demands
  - Considering long-lived LSPs



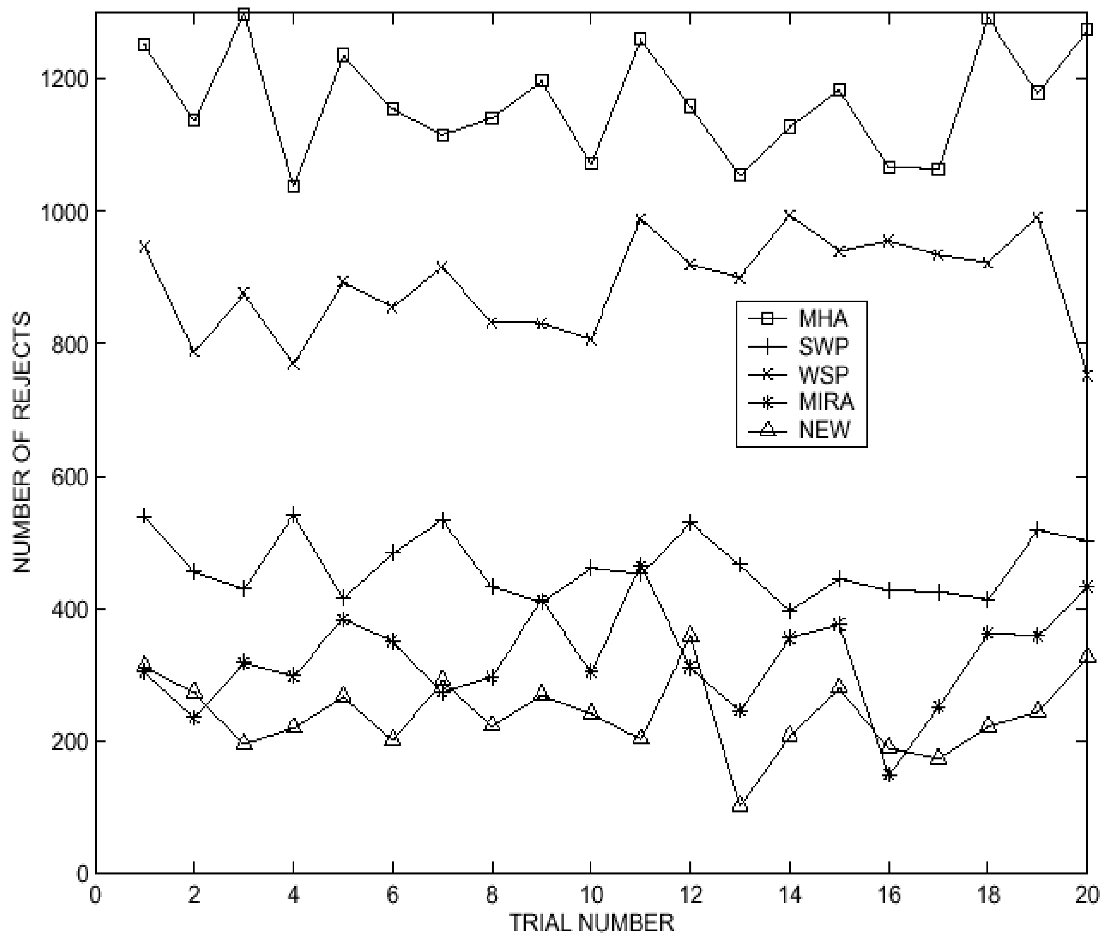
Performance Studies (3/4)

- Rejected requests v.s. demands
  - Considering long-lived LSPs



Performance Studies (4/4)

- Dynamic rejected requests
  - 4000 long-lived LSPs, and 4000 LSPs with exponential holding time



Concluding Remarks

- An online algorithm for dynamically routing bandwidth guaranteed LSP is developed.
- The proposed algorithm considers not only the importance of critical links, but also their relative importance to routing possible future LSP setup requests
- The proposed algorithm leads to improved performance and provides better network resource utilization.