Multi-domain WDM Network Resource Provisioning for Dynamic Traffic Demands

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Motivation

- Emerging short duration high-bandwidth streaming applications

- Dynamic optical layer can support well

- Multiple autonomous domains
  - key to reliability and business model
  - Can hurt efficiency
Simple Example of Joint Routing Problems

Path 1 total cost 5 (src domain bears 3)

Path 2 total cost 5 (dst domain bears 3)

Several issues are introduced in joint provisioning...
Issues in Multi-Domain Provisioning

- Balance performance and cost
  - Dimensioning
  - Routing

- Need to study the interaction between domains
  - Design quantitative models
  - Provide metrics that quantify resource utilization/fairness
  - Guidance for building business/peering models

- Decisions made in one domain can affect performance of other domains.
  - Cooperation on provisioning
  - Information exchange/sharing
Scope of the Paper

- Study the limitation of current routing approaches
- Propose improved routing algorithms
- Propose dimensioning techniques
- Propose penalty metric
  - Measure the resource cost on each domain to support external traffic.
- Performance study
  - Effectiveness/fairness of each dimensioning and routing schemes
  - Interaction among domains
Existing Routing Schemes

- least number of hops
  - Other cost model also apply

- Concatenated shortest path routing (CSR)
  - source picks shortest path to border ("hot potato")
  - no sharing of cost information

- End-to-end shortest path routing (E2E)
  - Shortest global path
  - implies sharing of path cost information
Potential Problem w/ Global SPF

- Larger domains can have advantage over smaller domains while using E2E

Global SPF prefers larger domain!
Normalized Global SPF Routing (nE2E)

- Find the shortest path using link cost $1/TSL$
  - $TSL$ is the average topological shortest path length in the domain

- Each link cost is normalized by the size of the network
- Only share the path cost across borders.
Network dimensioning

- Allocate working wavelengths on each link
  - Per-wavelength equipment & management cost
  - Assume OEO networks for simplicity

- Extension on *Basic dimensioning* technique (prev. work for single domain)
  - capacity provisioned based on
    - expected traffic volume
    - *and* routing algorithm
  - load definition
    - scale factor in offered traffic
    - (relative to provisioned volume)
Resource dimensioning algorithms for external traffic

- Independent stitched path dimensioning (ISA)
  - Each domain dimension independently
  - Assuming external traffic flows equally from all border nodes
  - No cost information is shared

- Global shortest path dimensioning (GSA)
  - Joint dimensioning external traffic using E2E routing
  - Path cost information is shared

- Normalized shortest path dimensioning (NSA)
  - Joint dimensioning external traffic using nE2E routing
  - Path cost information is shared
Sample networks

NSFNET

ARPANET
Shared Dimensioning Reduces Blocking

External traffic blocking prob.

External offered load

- IS-CSR
- IS-E2E
- GS-E2E
- NS-nE2E

independent

shared
Benefit of nE2E Routing

Improvement on NSF
Other important results – cont.

- **Under-provisioned domain**
  - affect the performance of well-provisioned domains
  - specially, they are independently provisioned.

- **Unlimited inter-domain link capacity**
  - improve the performance on both networks using shared schemes (GS- and NS-).
Conclusion

- Proposed dimensioning and routing algorithms to support external traffic
- Proposed dimensioning penalty metric
- Dimensioning must be coordinated to achieve optimal performance.
  - Independent dimensioning can hurt coordinated routing
  - Insufficiently provisioned domain can affect other domains.
- Smaller domains can have disadvantages.
- Further study is needed to guide
  - Design of control planes
  - Operation/management policies
Thank you and Questions?