

A Theory of Stability for Communication Networks

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BNL
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- ORNL Collaborator: Dr. Nageswara Rao
- BU collaborators: Dr. Reuven Cohen, Niloofar Fazlollahi, Andres Guedez, Edy Tan



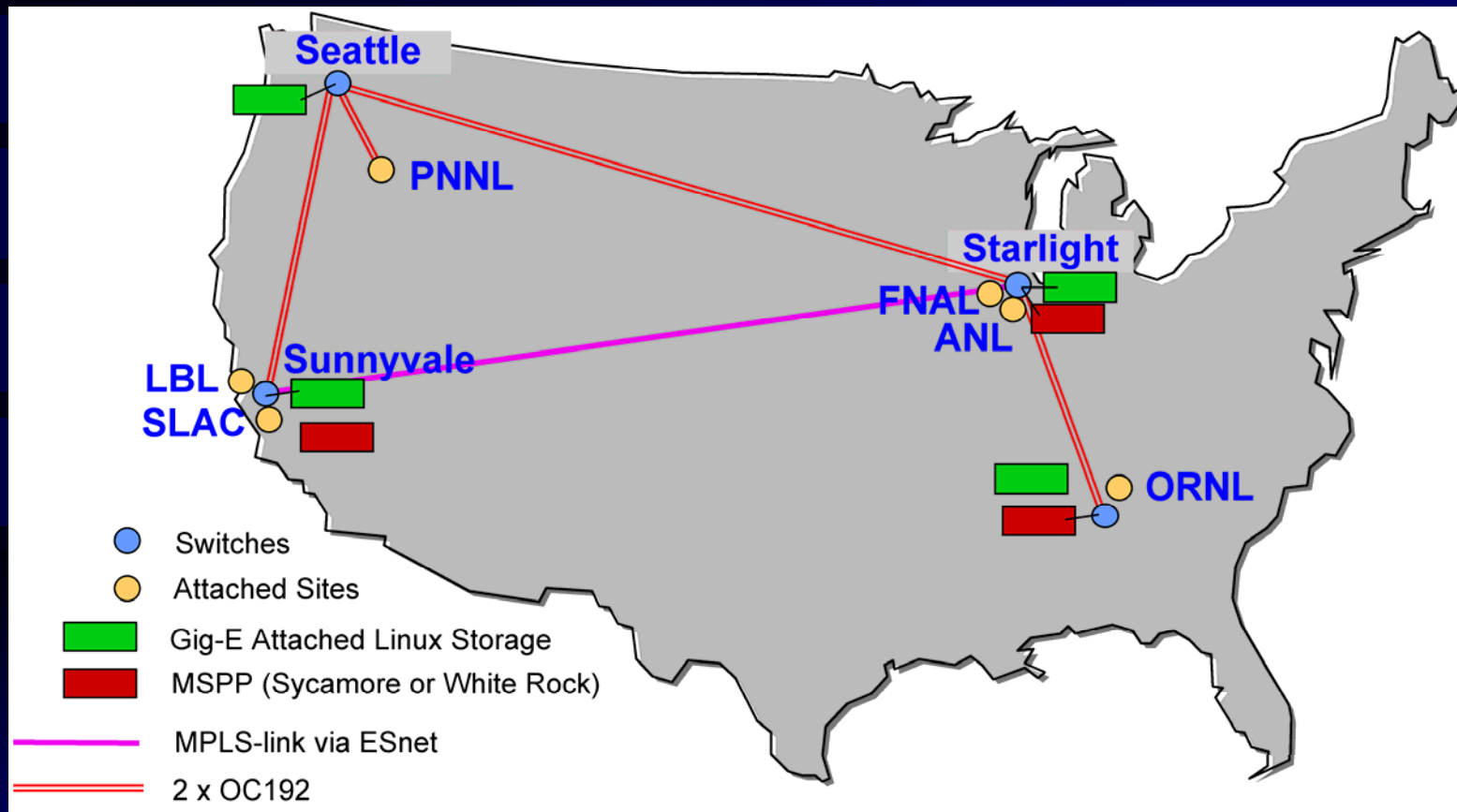
Research Thrusts

- **Thrust 1:** Formal methods and algorithms to ensure stability of control-plane protocols
- **Thrust 2:** Design and modeling of resource allocation mechanisms for Ultra Science Net
 - Algorithmic design
 - Simulation and visualization tools

Today



DOE Ultra Science Net



Ultra Science Net: Unique Features

- Channels (bandwidth) dedicated to users on demand
- Fine-grained bandwidth allocation (100's MB/s to 20 Gb/s) using SONET or 10GigE



Ultra Science Net: User Request Format



Ultra Science Net: User Request Format



Src s and dest d ...ORNL and PNNL



Ultra Science Net: User Request Format



Src s and dest d ...ORNL and PNNL
Bandwidth B ... 1 Gb/s



Ultra Science Net: User Request Format



Src s and dest d ...ORNL and PNNL
Bandwidth B ... 1 Gb/s
Time interval T ...2 Hours



Ultra Science Net: User Request Format



Src s and dest d ...ORNL and PNNL
Bandwidth B ... 1 Gb/s
Time interval T ...2 Hours
Starting time (optional)? 09/29/2005
12PM



All-Slots Algorithm

- Return all the time slots for a path of bandwidth B and duration of at least t between a source s and destination d



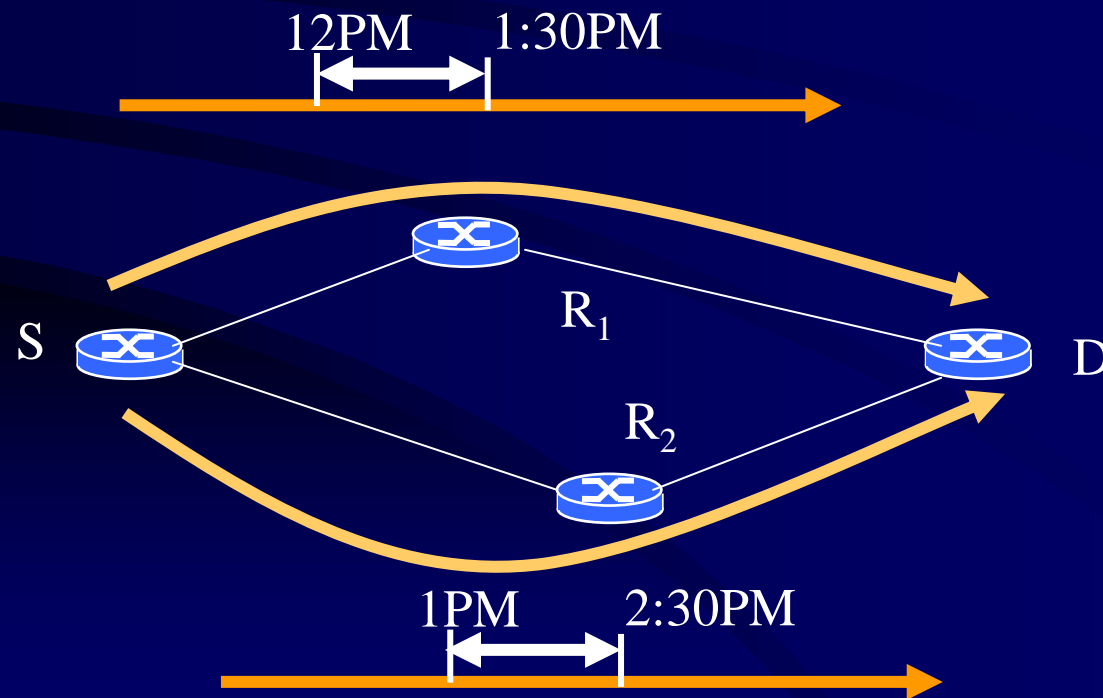
All-Slots Algorithm: Properties

- Use the same path over the entire connection
- Returns a feasible path, if several are available



Observation #1

- Possible to achieve significant performance improvement if **path switching** is allowed during a connection



Contribution #1:

All-Slots/Path-Switching Algorithm

- Return all available time-slots where it is possible to establish a connection (possibly switching between different paths) between a source s and destination d with bandwidth B and duration at least t .
- Complexity: $O(|V|^2R)$
 - $|V|$ is the number of vertices in the graph
 - R is the number of pending connections already scheduled
- Number of path switching during a connection upper bounded by $2R$



Contribution #2:

Optimized Path Selection Algorithm

- When several different paths are available in a given time slot, compute the “best” one according to some heuristics
 - Shortest path
 - Widest path
 -
- Can be implemented in conjunction with either variants of All-Slots algorithms
- Polynomial complexity



Simulator (Work-in-progress)

- Tool to compare performance of different bandwidth allocation mechanisms
- Key performance metrics are:
 - Average delay
 - Throughput

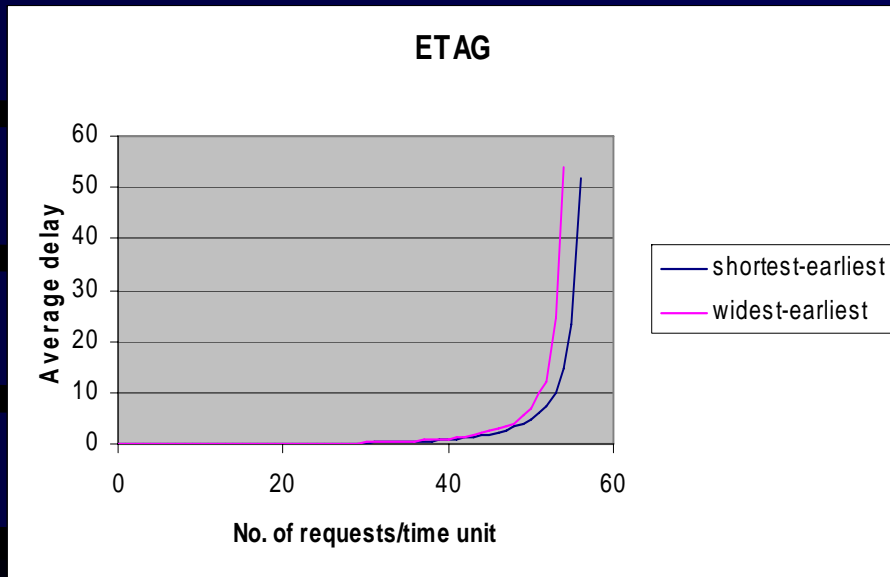


Simulation Parameters

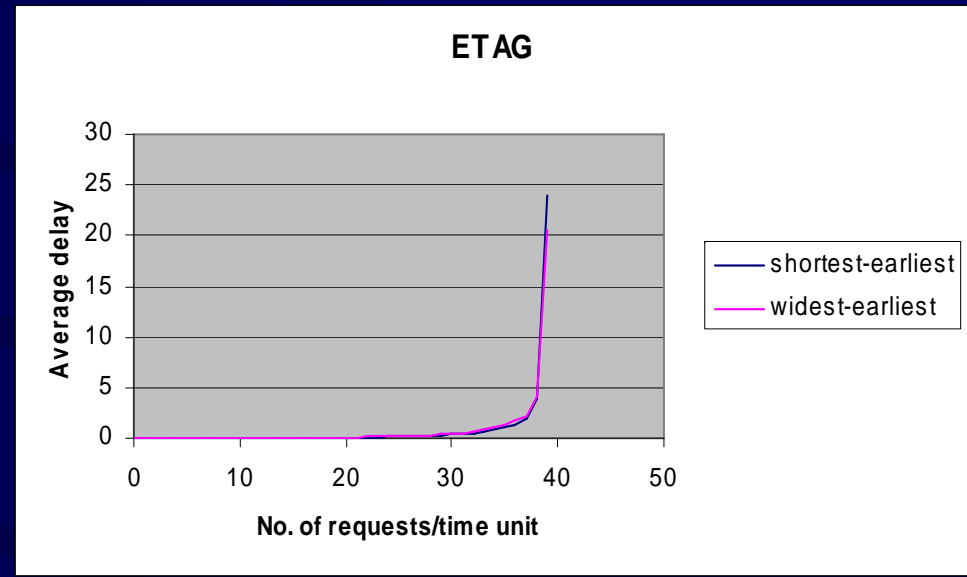
- Network topology
- Rate of arrivals λ
- Distribution of BW request
 - Uniform (1,10) Gb/s
 - 80-20: 80% request-1Gb/s, 20%-request 10Gb/s
- Destination
 - Random
 - Hot spot (50% of requests go to a certain node, rest is uniformly distributed)
- Transfer size
 - Exponential distribution
 - Heavy tailed distribution



Typical Simulation Results



Random destination model



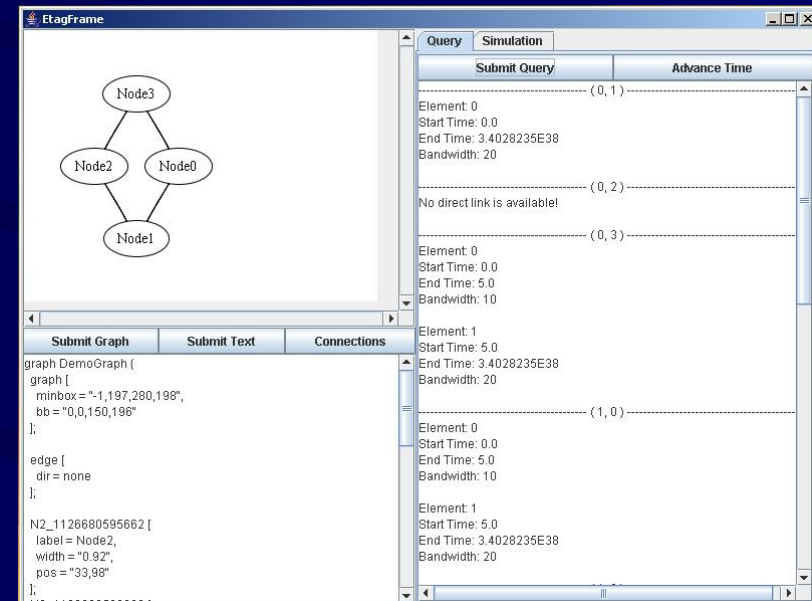
Hot spot model

Performance is sensitive to workload model!



Simulator GUI

- Designed to help understand bandwidth allocation mechanisms
- Currently allows manual requests
- Allows visualization of graph using Grappa library



Future Work

- All-Slots/Path-Switching Algorithm
 - Design and analysis
 - Simulation
 - Implementation over Ultra Science Net
- Comparison of heuristics for path selection, when multiple paths are available
- Workload characterization



Web Page

<http://nislabs.bu.edu/nislabs/projects/stability/index.html>

The end

