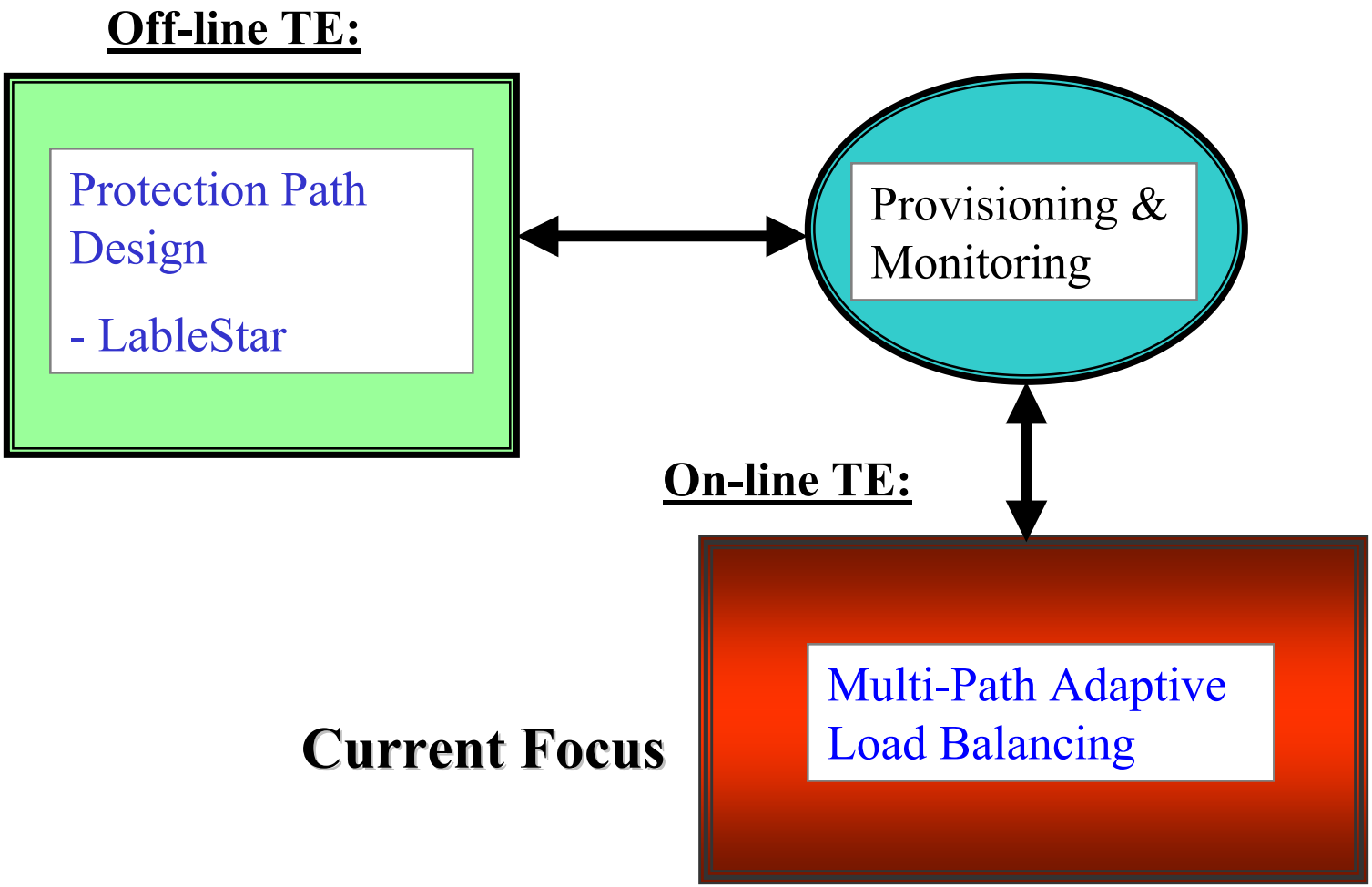
MPLS Traffic Engineering

Anwar Walid, Debasis Mitra, Nachi Nithi

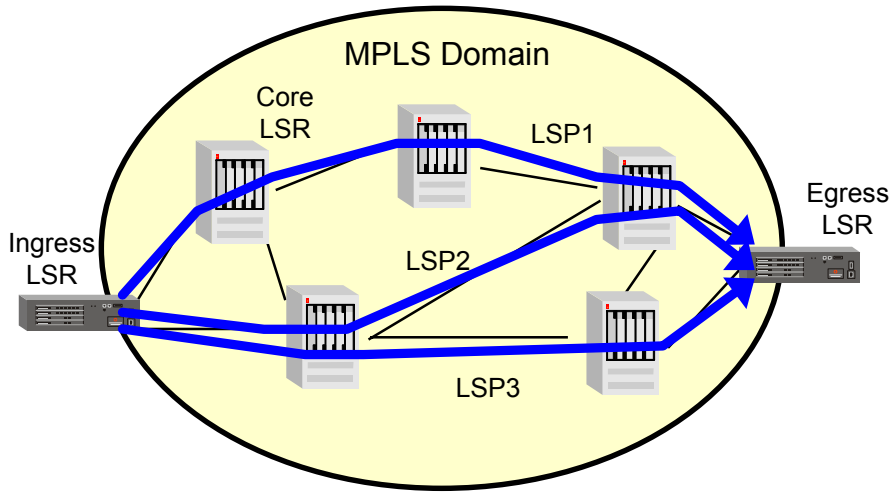
Bell Labs, Lucent Technologies

Poster Presented at DARPA NMS PI Meeting, Miami, January 21-23, 2004.

Project Overview

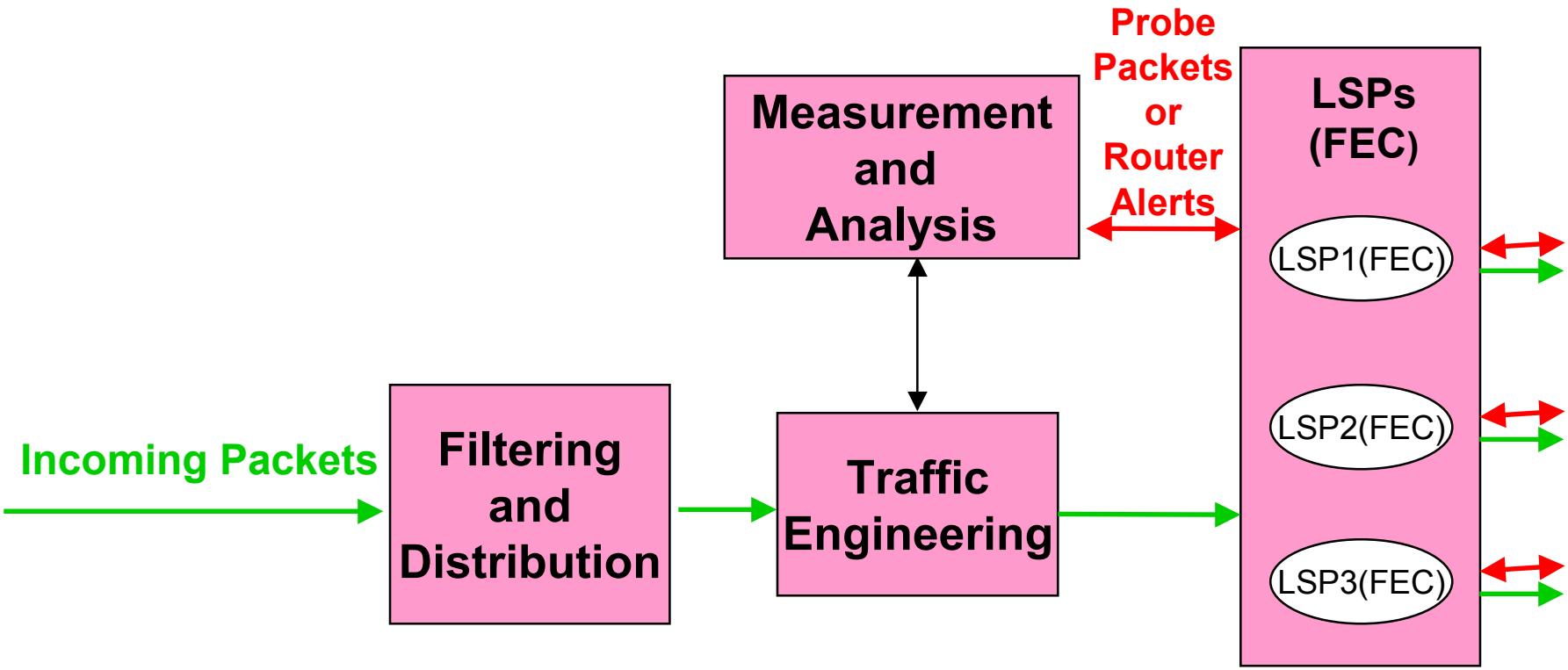


Multi-Path Adaptive Load Balancing: Overview

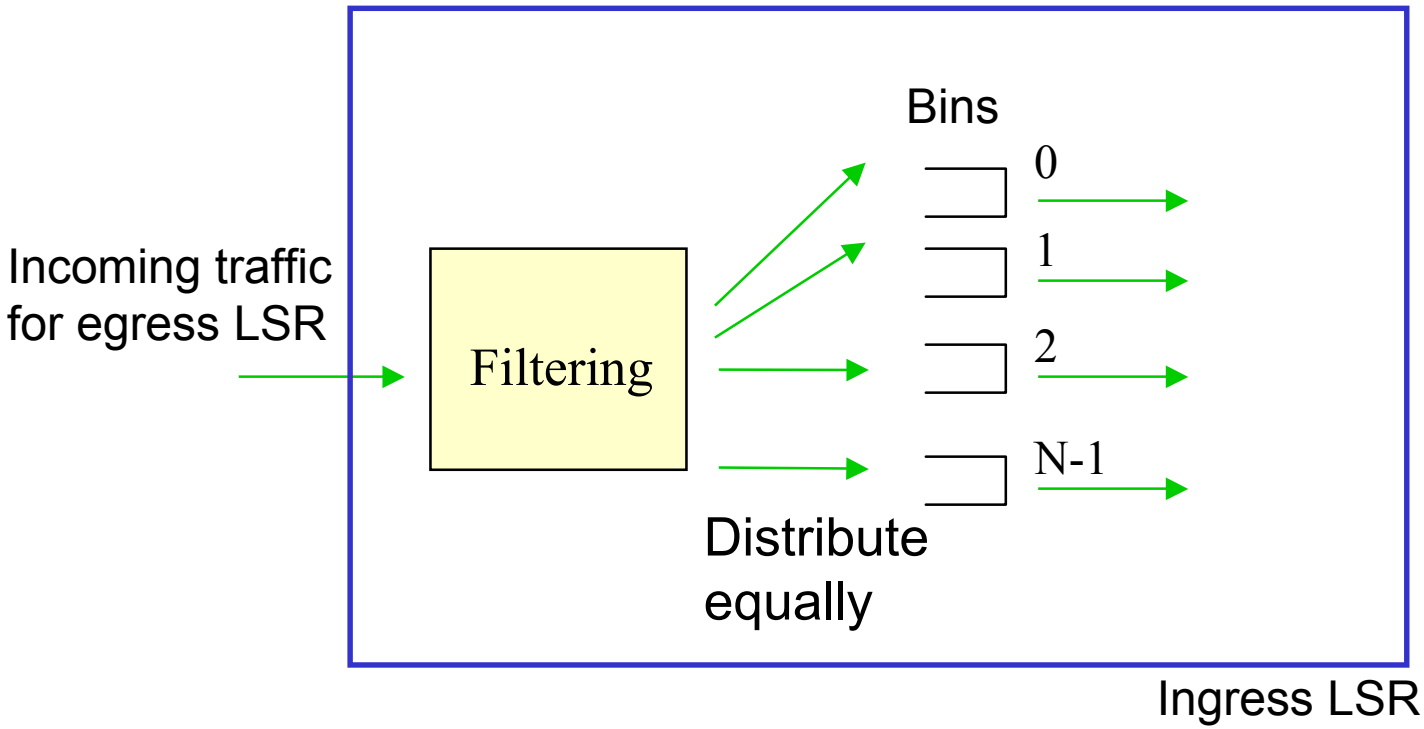


- **Online, automated enhancement of throughput in MPLS-based IP networks**
- **Ability to react to dynamic traffic patterns**
- **Load balancing using path measurements:**
  - end-to-end protocol based on real-time probes
  - node-to-node protocol based on router alerts
- **Maintain packet sequence within a flow**

Functional Modules



Traffic Filtering and Distribution



- Hashing: h(address)=mod (f(address) , N)
- Each bin receives approximately an equal amount of traffic
- Packet order for a given flow is maintained
- Bins facilitate traffic shifting

Implementation Procedures

- **Lookup engine produces multiple results per IP lookup and selects one of the them to be mapped to an LSP**
- **Hash function (based on CRC polynomial) of the IP source and destination addresses is applied to produce 5-bit hashed outputs (equivalent to 32 bins)**
- **The hashed outputs (i.e., bins) is mapped to the associated LSPs in accordance with the load balancing objective**
  - –The load balancing information is stored in a table and is software configurable via the load balancing algorithm

One-way Path Measurements Using Probing

I. End-to-end Path Probing

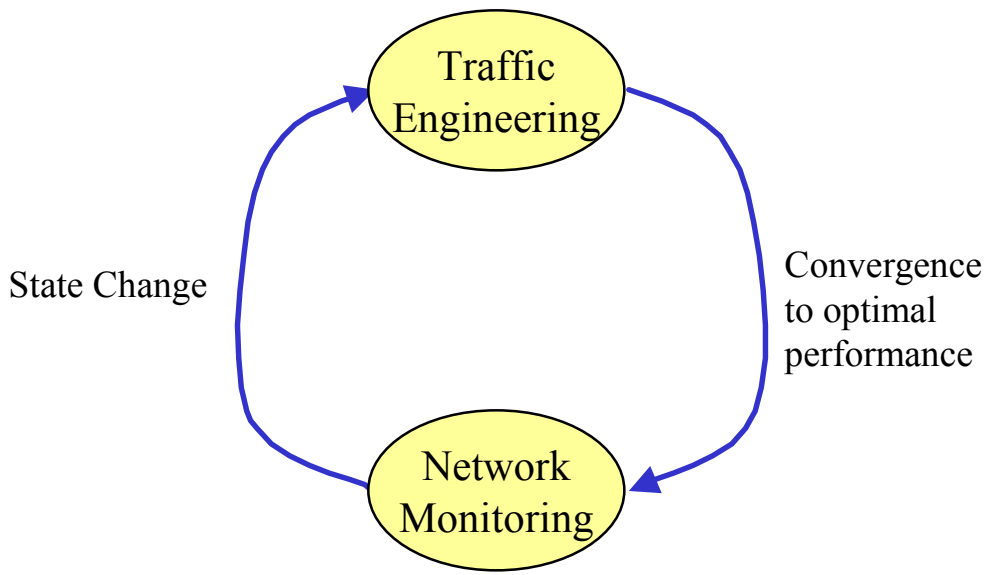
- Intermediate routers do not participate.
- Measures ***relative*** delay (loss) of multiple paths.

II. Path Measurement Based on Router Alert

- To measure LSP congestion, an ingress LSR sends a “Router Alert” packet along the LSP.
- Each intermediate LSR intercepts the “Router Alert” packet and passes it to a local software module for further processing.
- Local software module copies the outgoing link utilization to the “Router-Alert” packet which then gets forwarded to the next LSR.
- Egress LSR returns the Router-Alert packet back to the ingress LSR which uses the information for determining path congestion.

Adaptive Load Balancing

- Alternate between Two Phases:
  - Traffic Engineering Phase
  - Network State Monitoring Phase



- Different Time Scales

Statistical Analysis

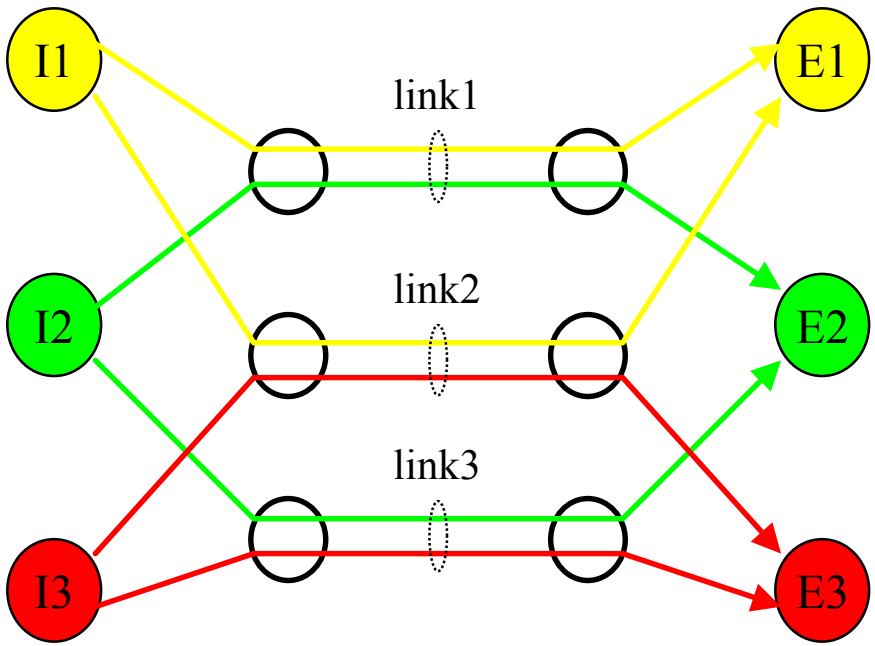
Objectives:

- Obtain reliable estimates of congestion measures
- Minimize effect of probe traffic on the LSPs
  - issue: loaded paths are more sensitive

Solution:

- Loss on loaded paths can be estimated more reliably
- Statistical Techniques:
  - Sequential Sampling and Estimation
  - **Bootstrap** Re-sampling

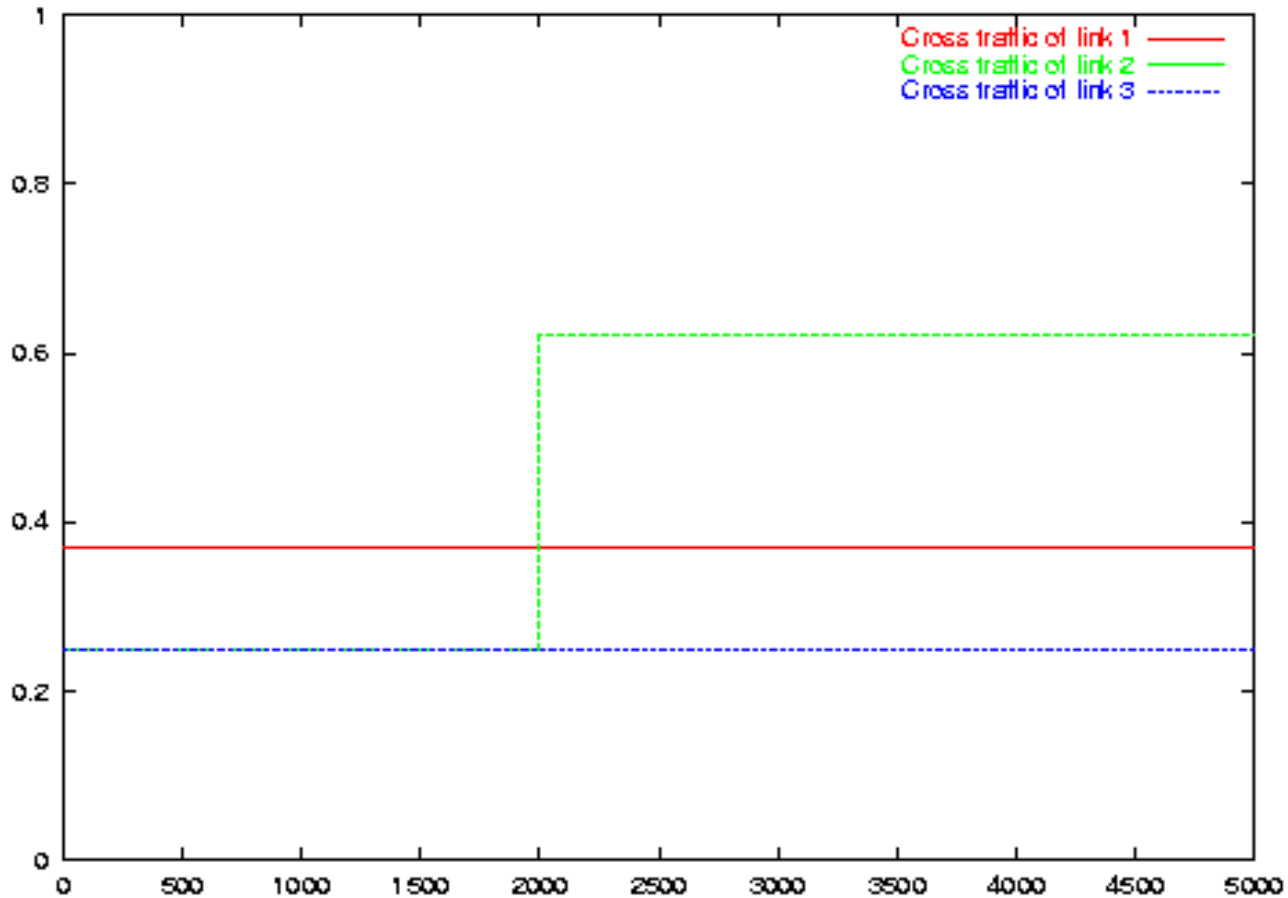
Simulation Experiment



Topology Example

- Link speed is 10 Gbps
- 3 Ingress/Egress pairs
- 2 LSPs per pair
- Link1, Link2, Link3 each support 2 LSPs from different pairs plus additional “cross traffic”

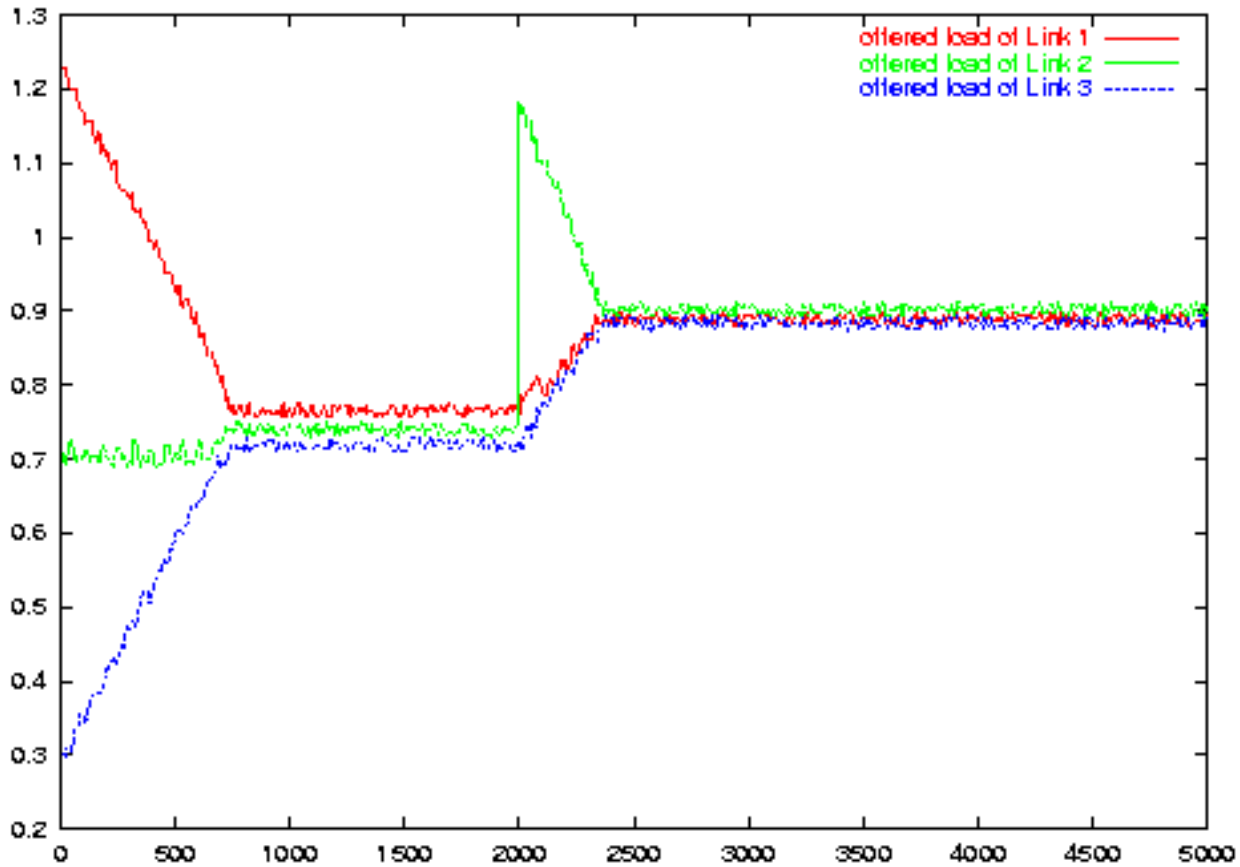
Input (Cross) Traffic Profile



Time (ms)

Result: Load Balancing Performance

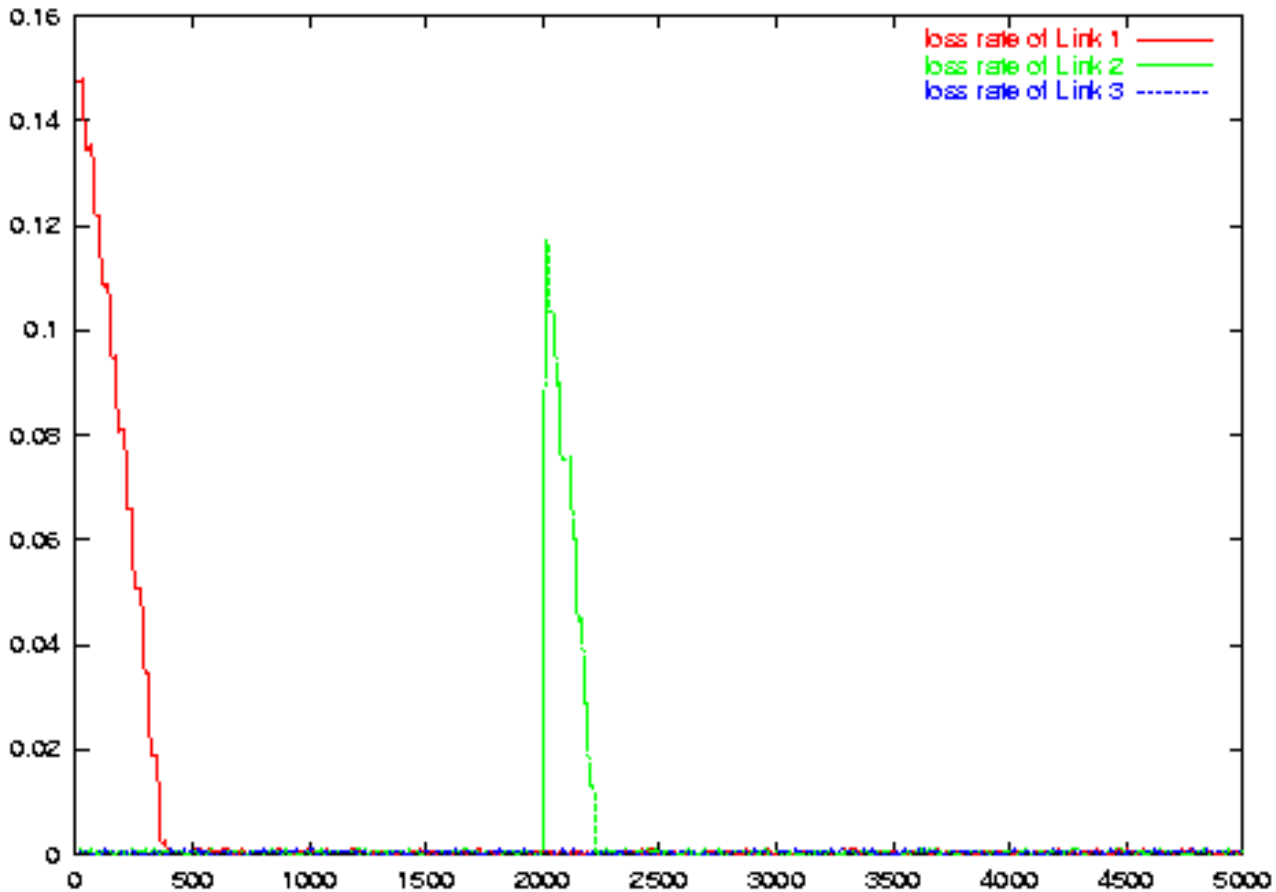
offered load



Time (ms)

Result: Packet Loss Performance

loss rate



Time (ms)

Future Extensions

- Larger Topologies
- Simulation Speed-up
- Multi-Path Routing and Load-Balancing in Ad-hoc Networks

Ingress LSR Behavior (? For background only)

