

Scalable QoS routing in MPLS networks using mobile code

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Motivation / Why?

Current Internet faces increasing challenges:

- **Scalability**
- **Complexity:** support all types of traffic (Data, Video, Audio)
- **Increasing requirements:** for service quality, reliability, and efficiency

How?

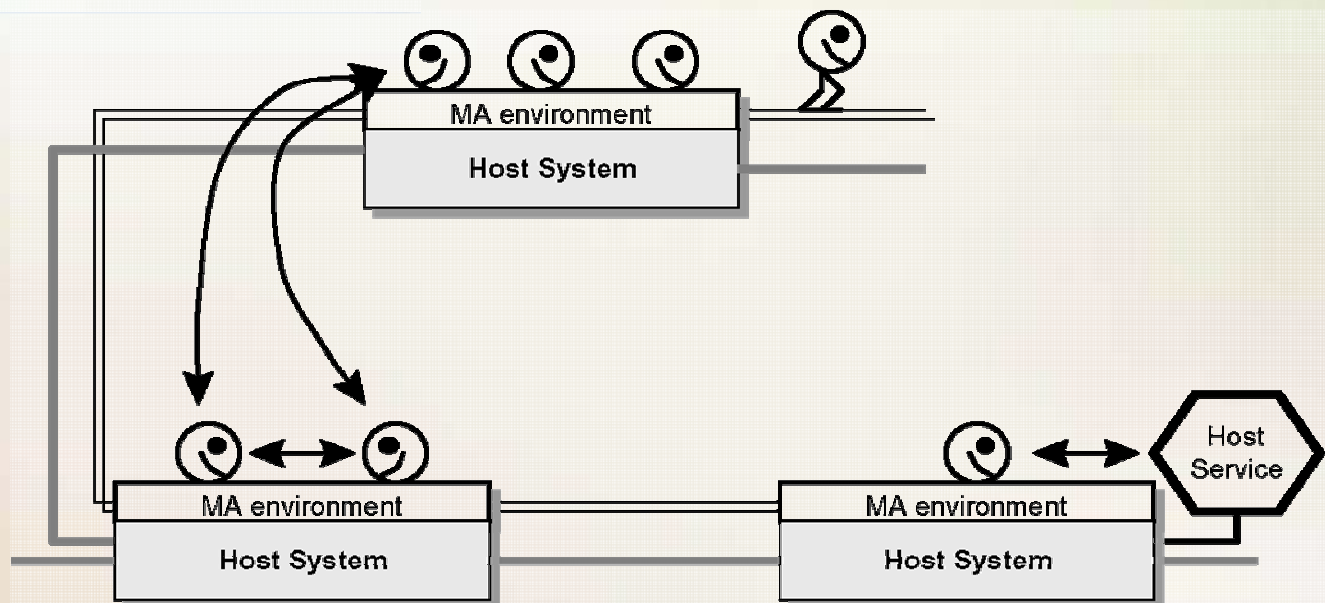
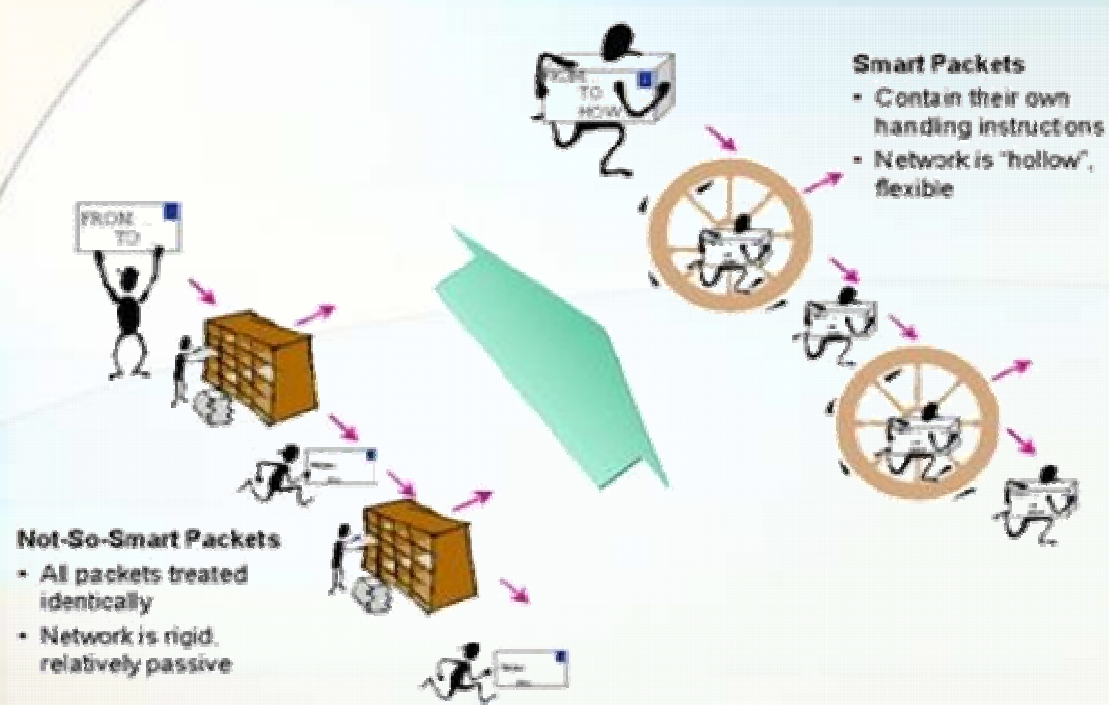
- **QoS routing**
- **Topology aggregation**
- **Distributed routing using**
 - **Active networks**
 - **Mobile agents**
- **MPLS**

Goals

The focus of the current thesis is to find optimal solutions for implementing efficient QoS routing strategies for large networks.

- Minimizing the overhead introduced by QoS in the routing process**
- Identifying improved approaches to the multi-constrained routing problem**

Active Networks vs. Mobile Agents



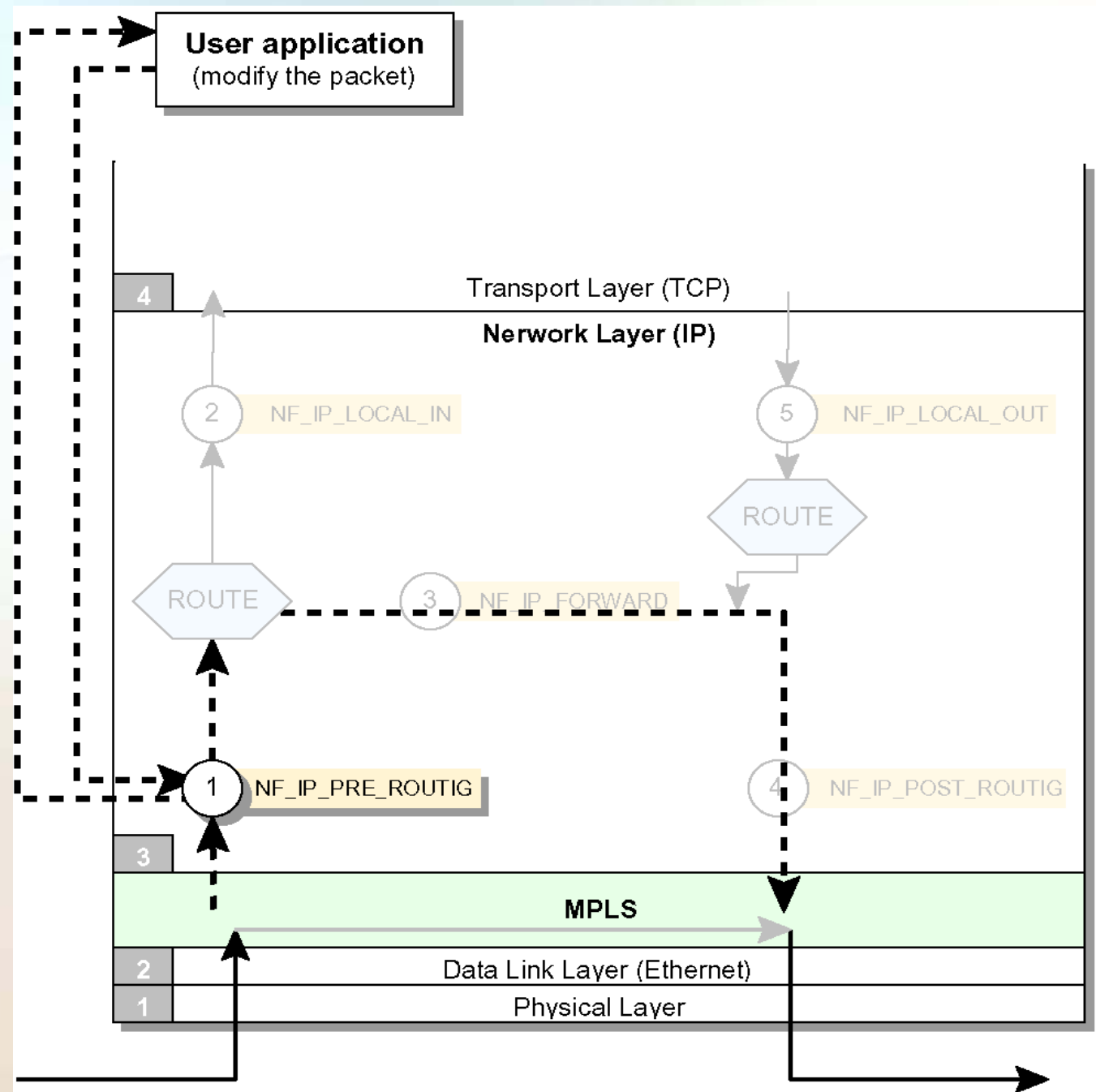
Active Networks in Access Areas

WHY?

- **MPLS**
 - Present in access areas
 - Suitable for QoS and TE
 - Unable to perform switching above layer 2
- **Active Networks**
 - Supports dynamic control and modification of network behavior

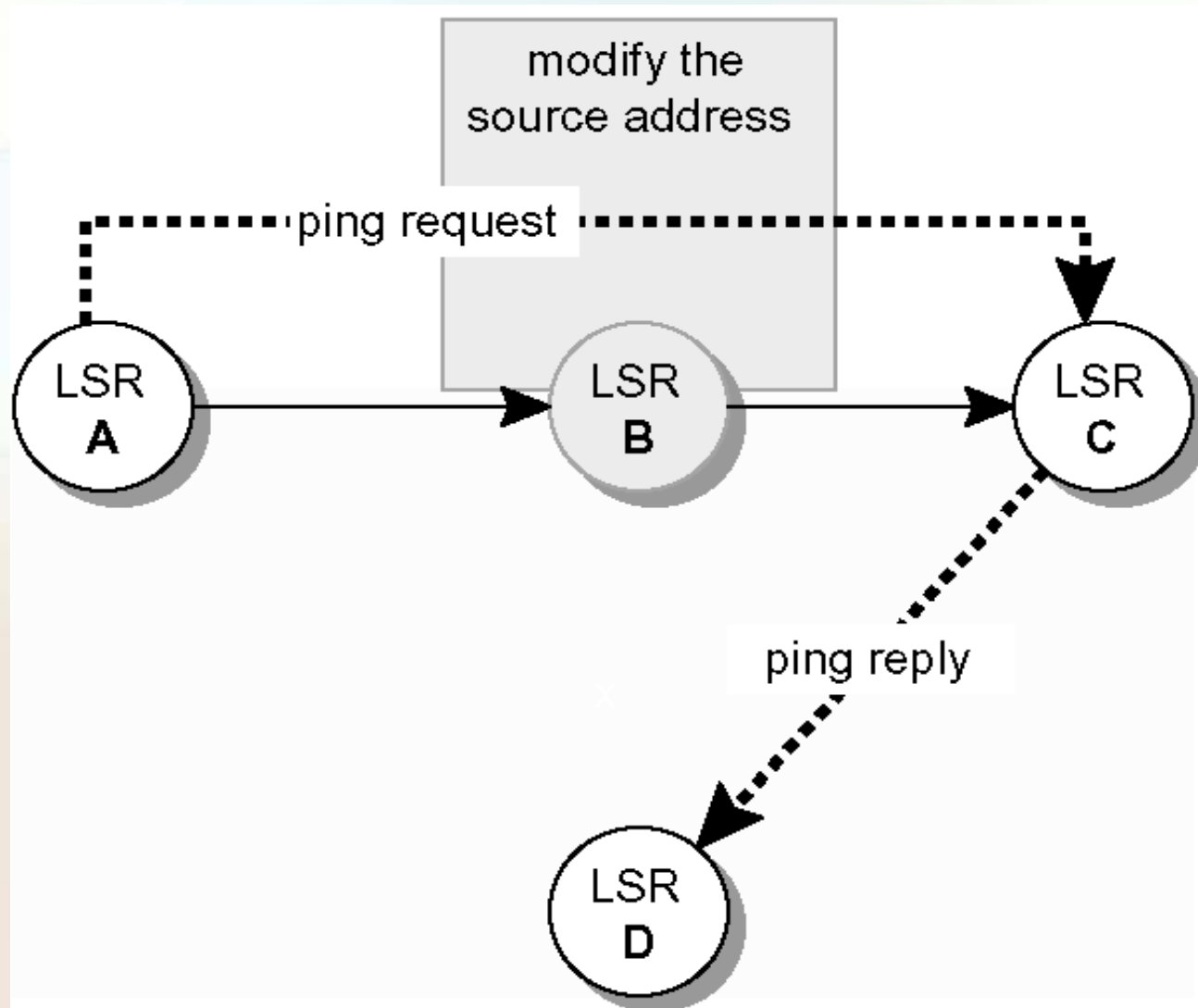
Active Networks in Access Areas

HOW?



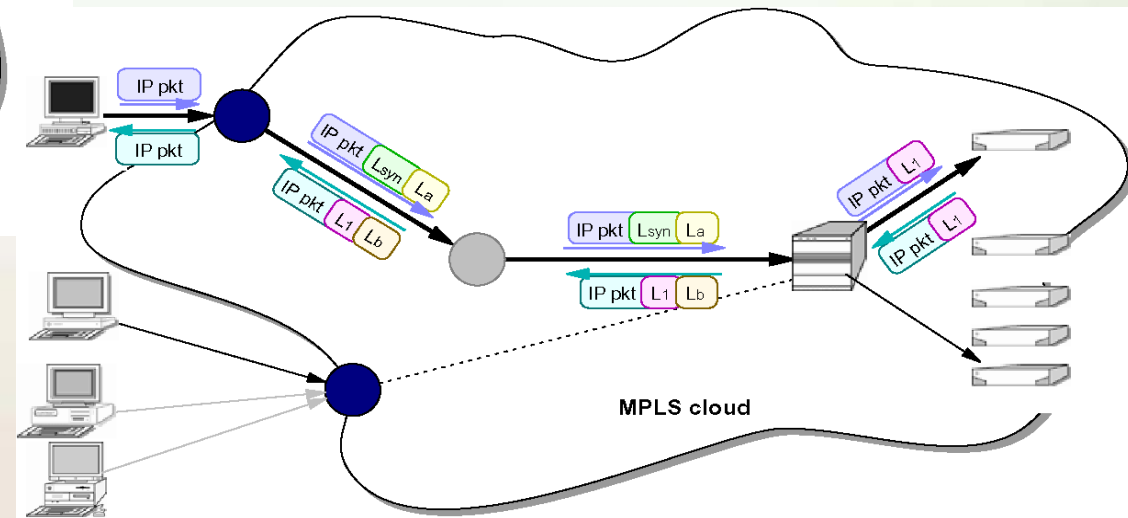
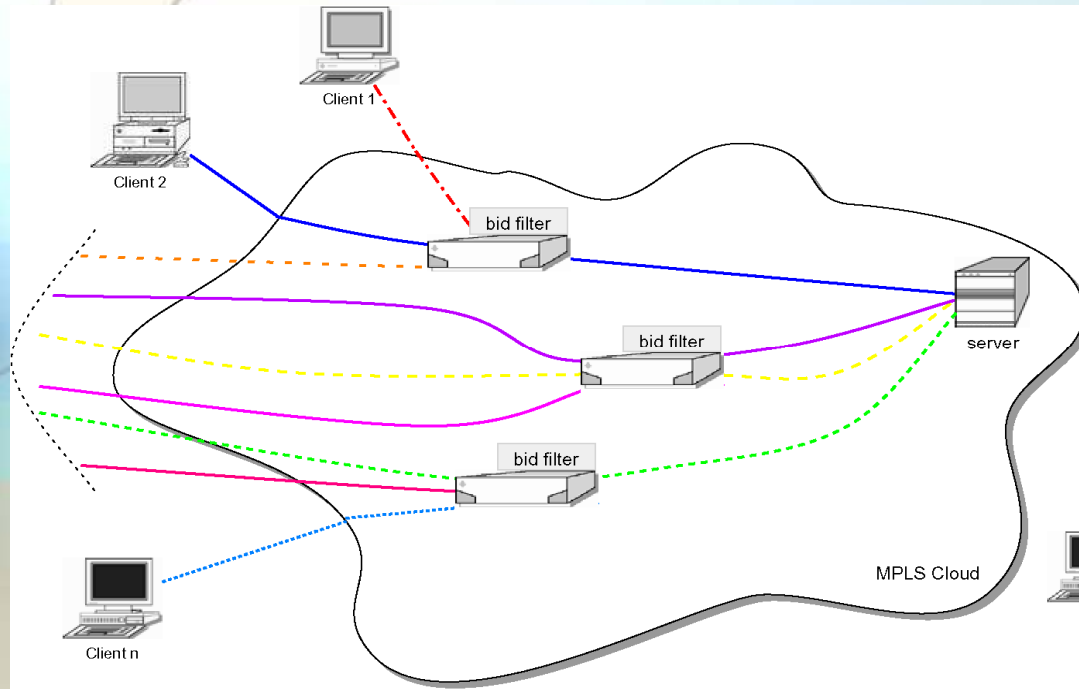
Active Networks in Access Areas

Proof-of-concept example



Active Networks in Access Areas

Applicability examples



Macro-routing

hierarchical routing protocol designed for *MPLS* networks that uses for the routing process mobile agents called *waves*

1. Determination of participant domains

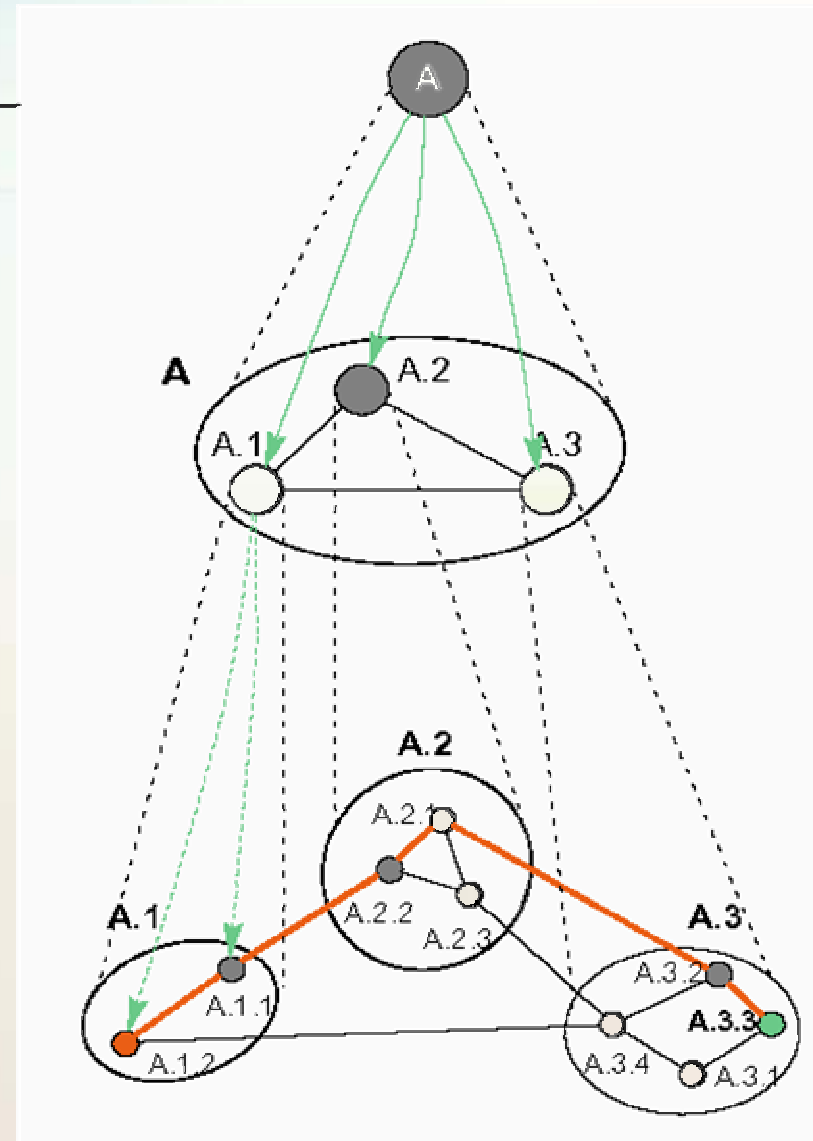
- upwards search for the root
- downwards search for the participant domains

2. Path computation

- create the aggregate representation for every domain
- build the next hierarchical level
- repeat the process until having one domain

3. Path reservation and set-up

- reserve the resources
- set the Label Switched Paths (LSPs)



Macro-routing

Advantages

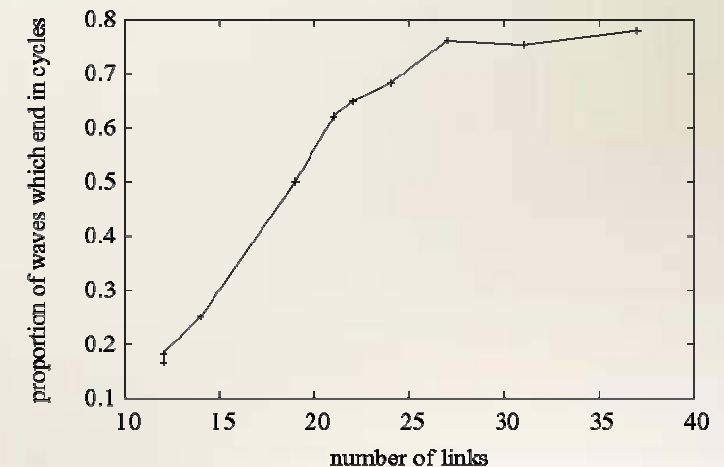
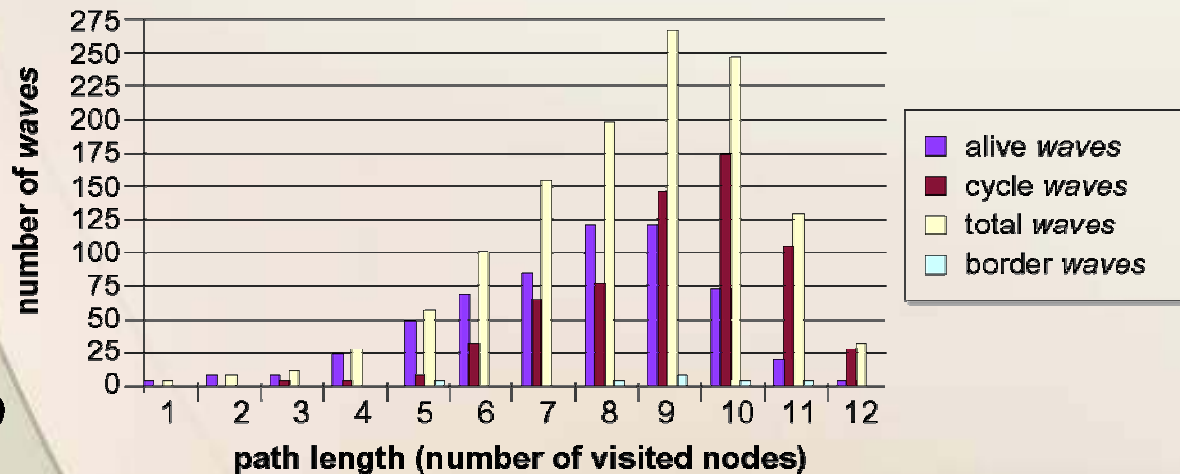
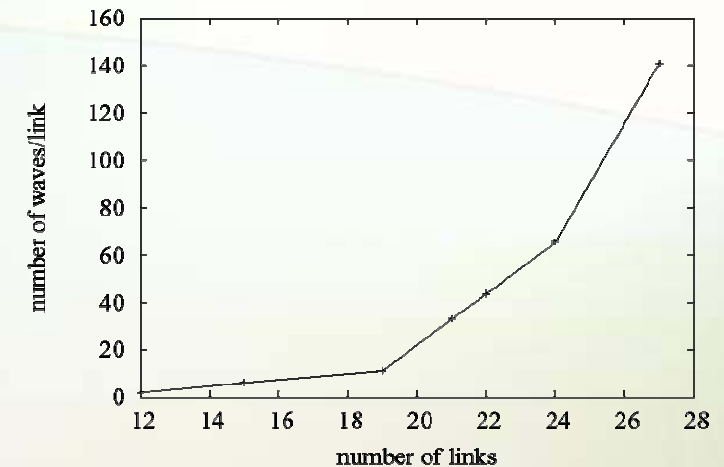
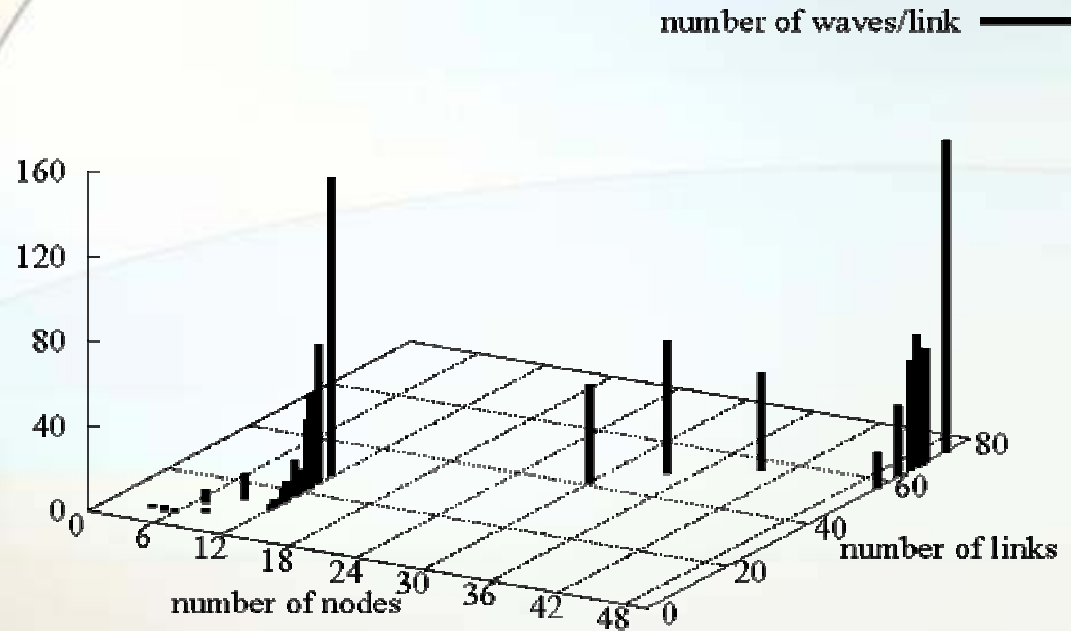
- ✓ No routing information dissemination
- ✓ Overcomes inaccurate aggregation
- ✓ Parallel processing
- ✓ Distributed processing with multiple simple tasks
- ✓ Finds the best path
- ✓ Finds multiple paths

Issue: It might generate too much traffic!

- How much traffic?
- How to limit the traffic?

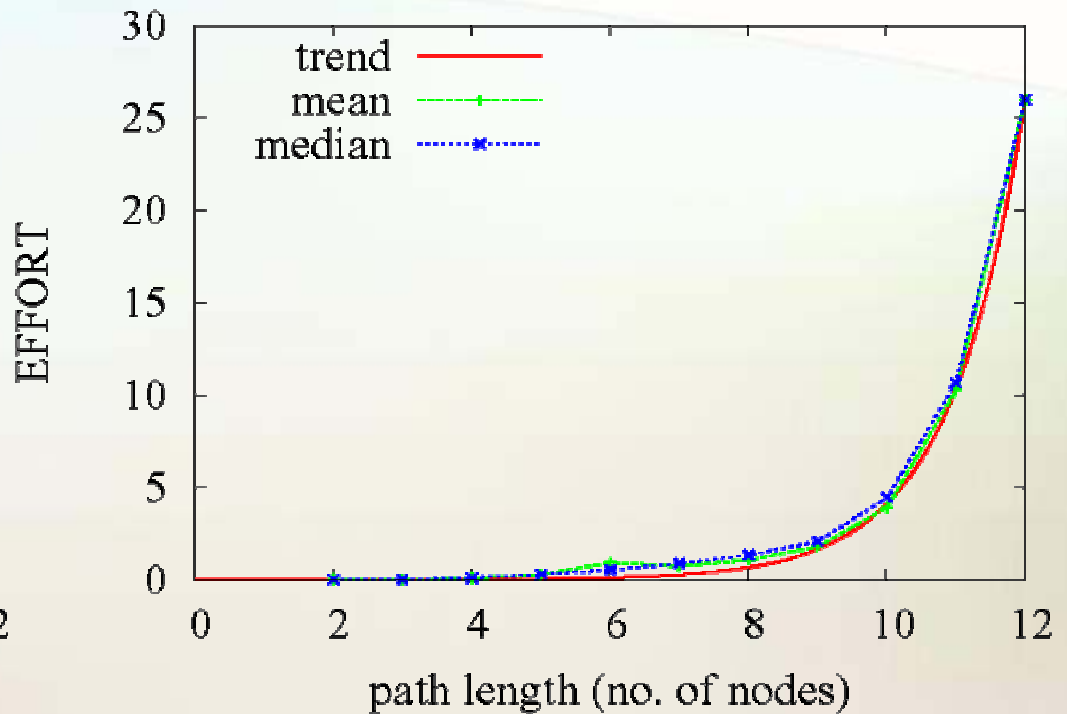
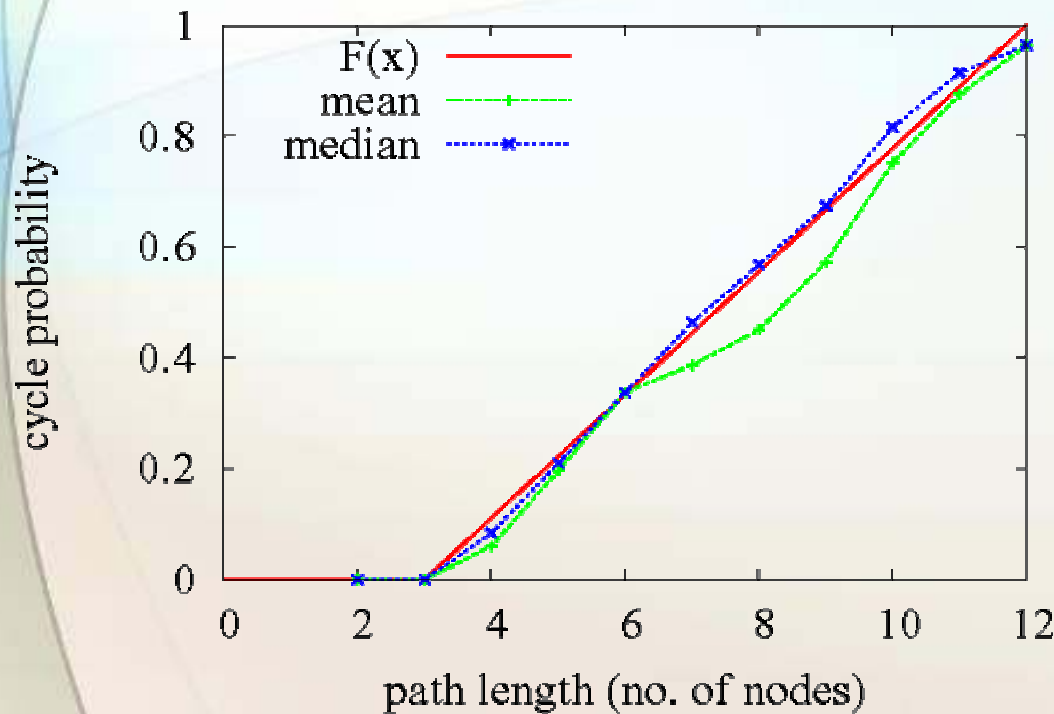
Macro-routing. How much traffic?

In a single, flat domain



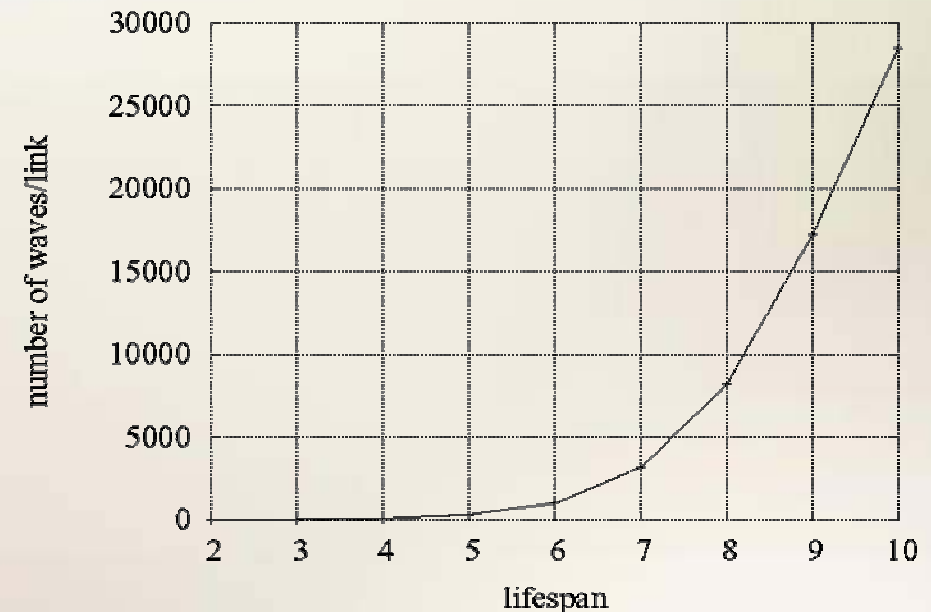
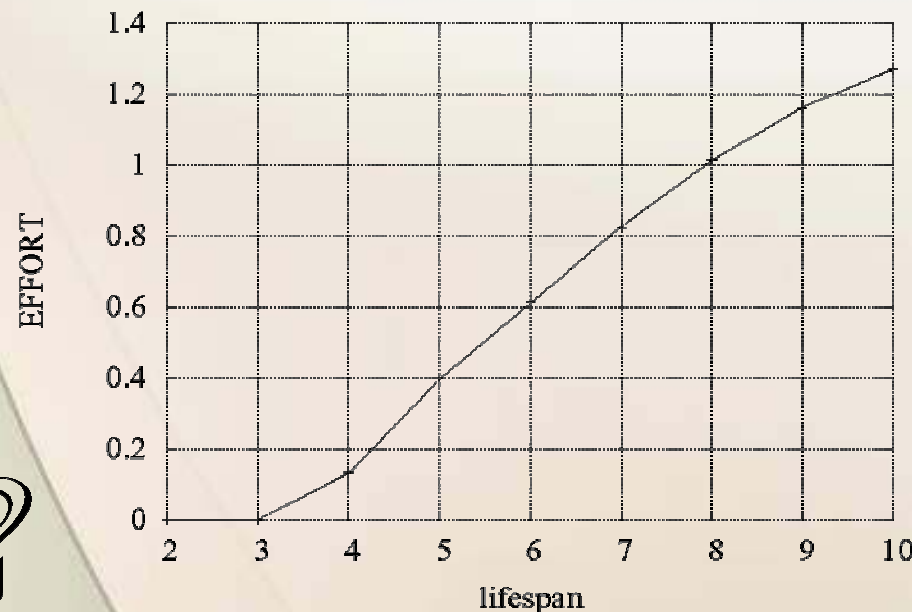
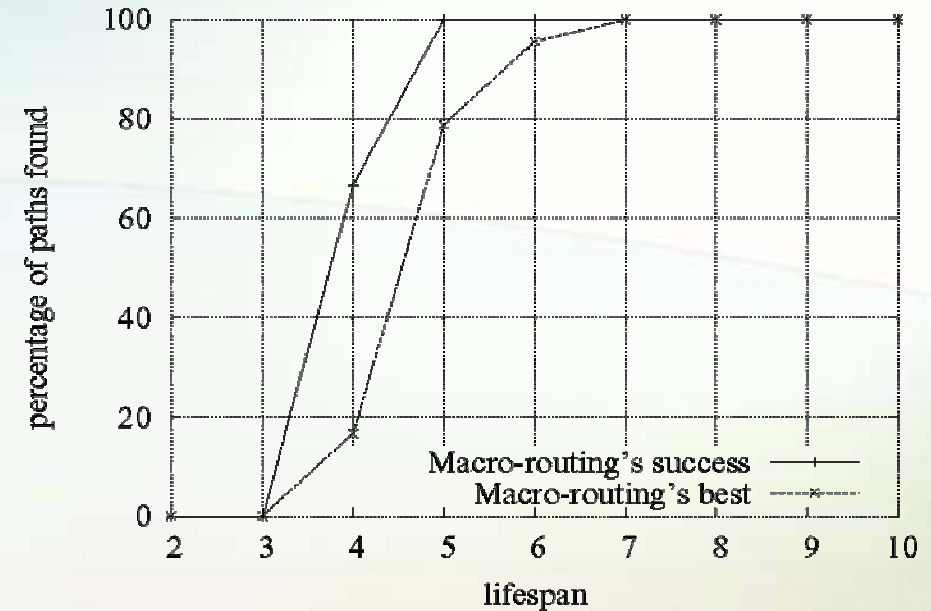
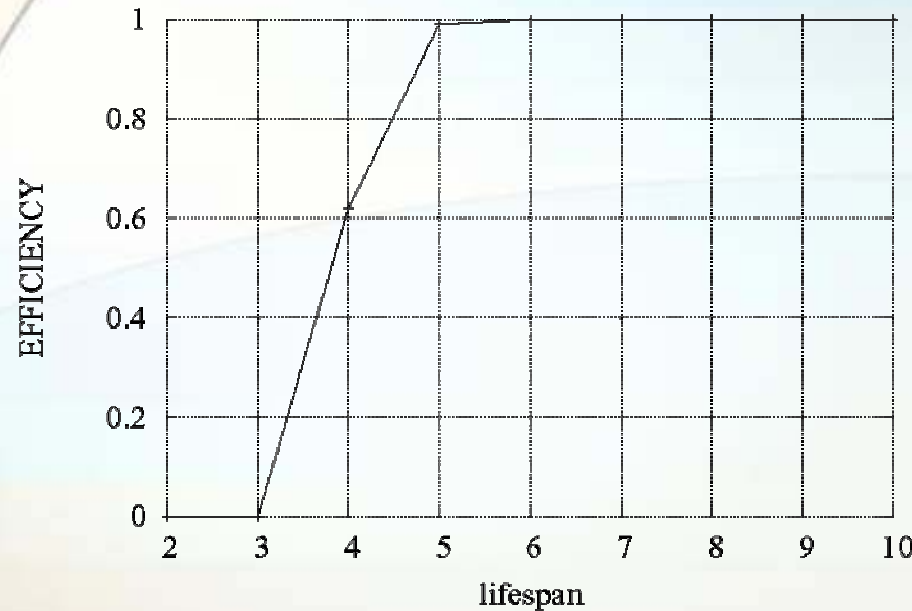
Macro-routing. How much traffic?

The cycle probability & the path effort in 12 node domains

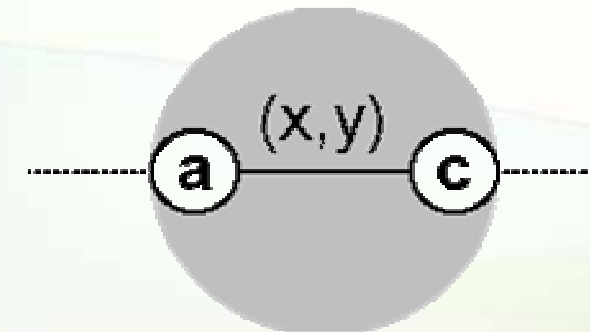
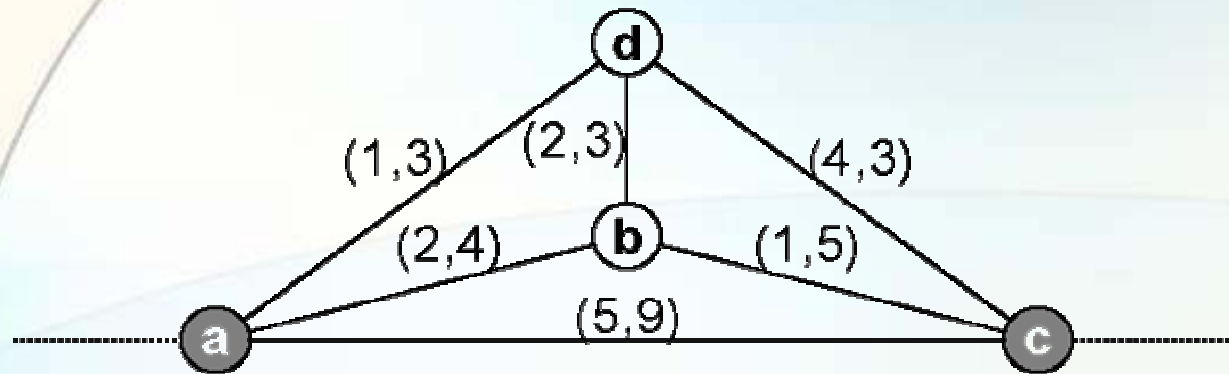


Macro-routing. How to limit the traffic?

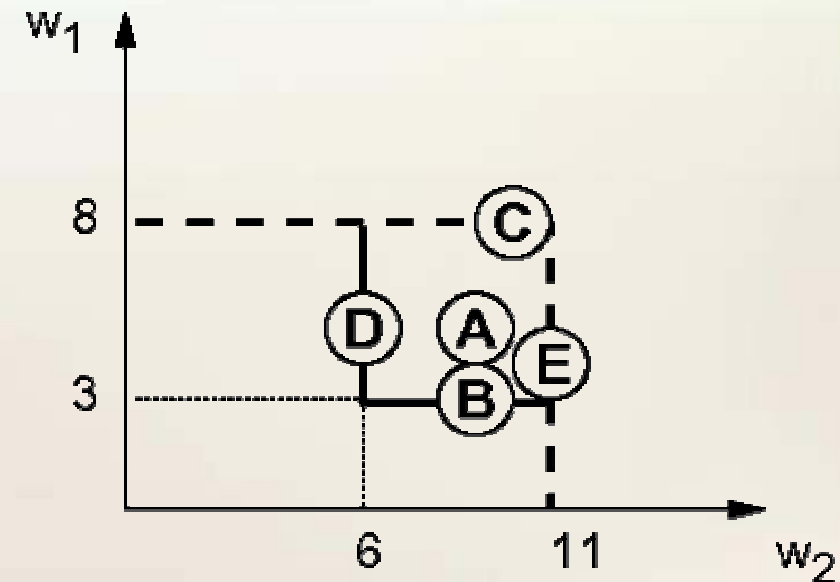
Results for a 12x12 node topology



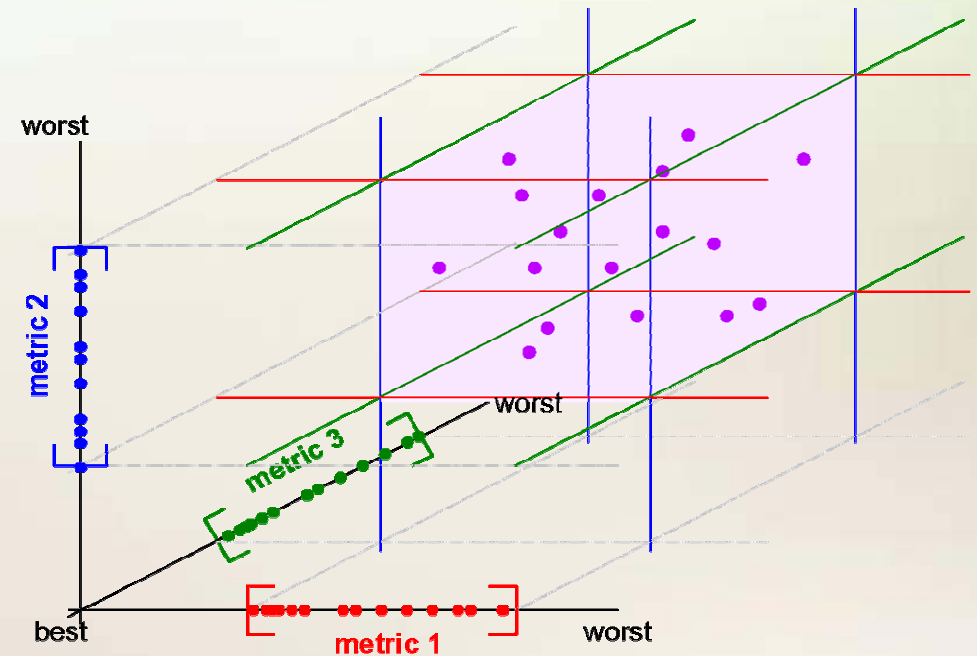
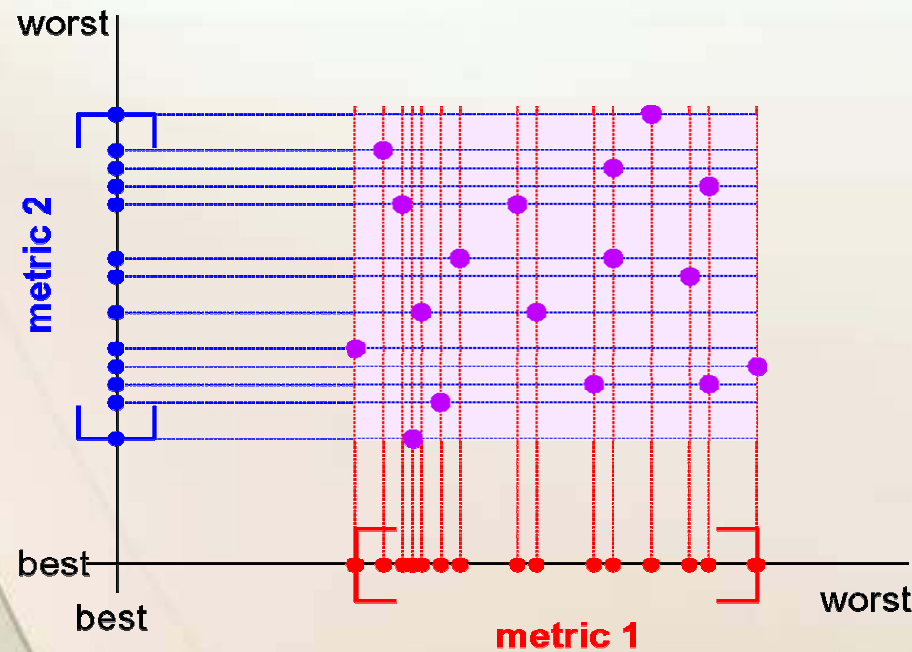
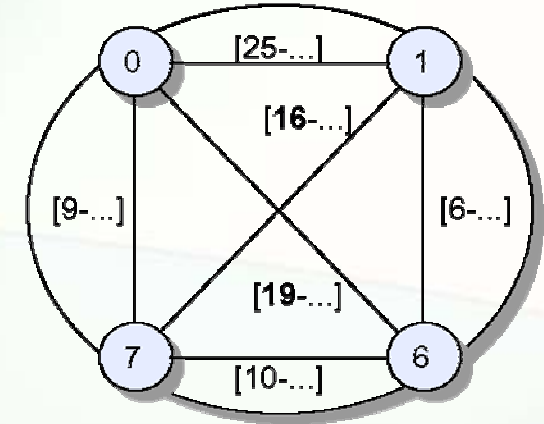
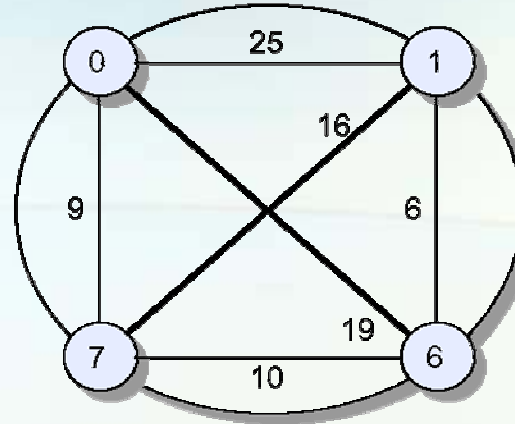
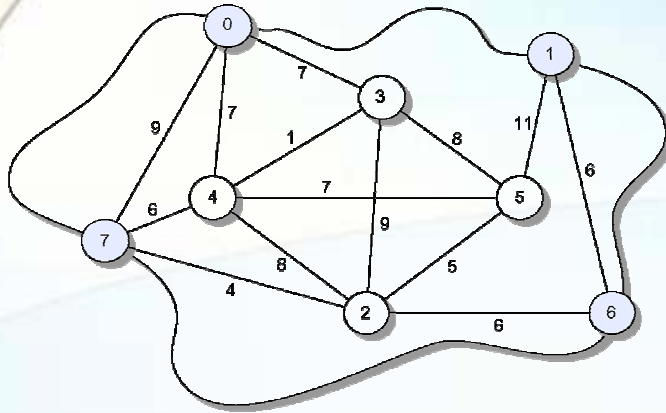
Multi-constrained Macro-routing



- A. $a-c = (5,9)$
- B. $a-b-c = (3,9)$
- C. $a-b-d-c = (8,10)$
- D. $a-d-c = (5,6)$
- E. $a-d-b-c = (4,11)$

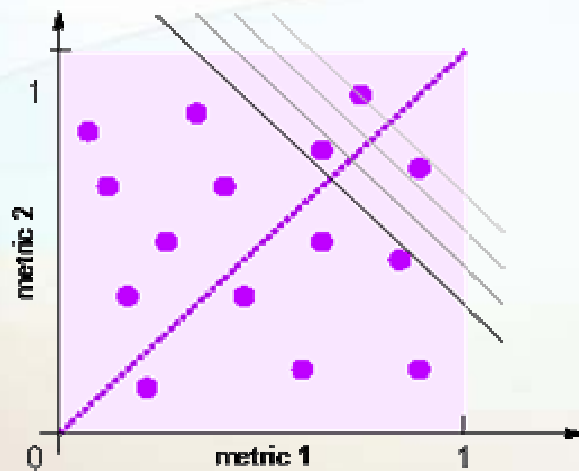


The Extended Full-Mesh Aggregation

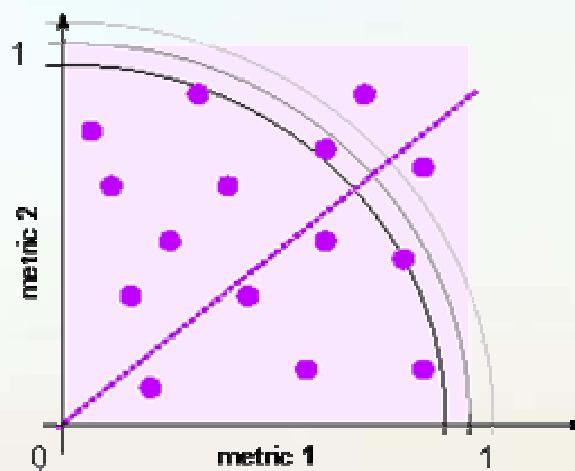


Determining the EFM interval

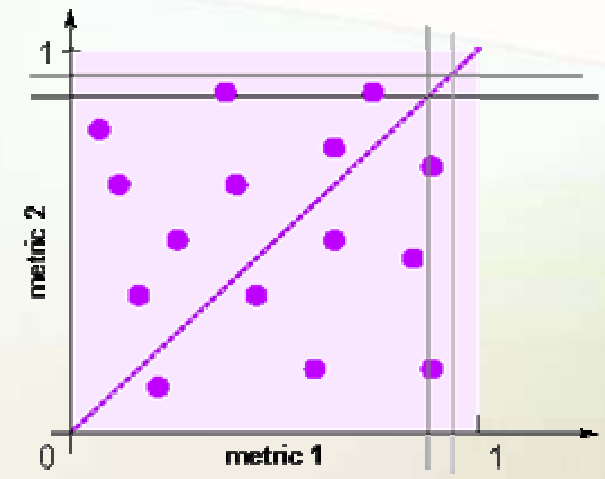
- Truncation methods



(a) *normal* method



(b) *radius* method

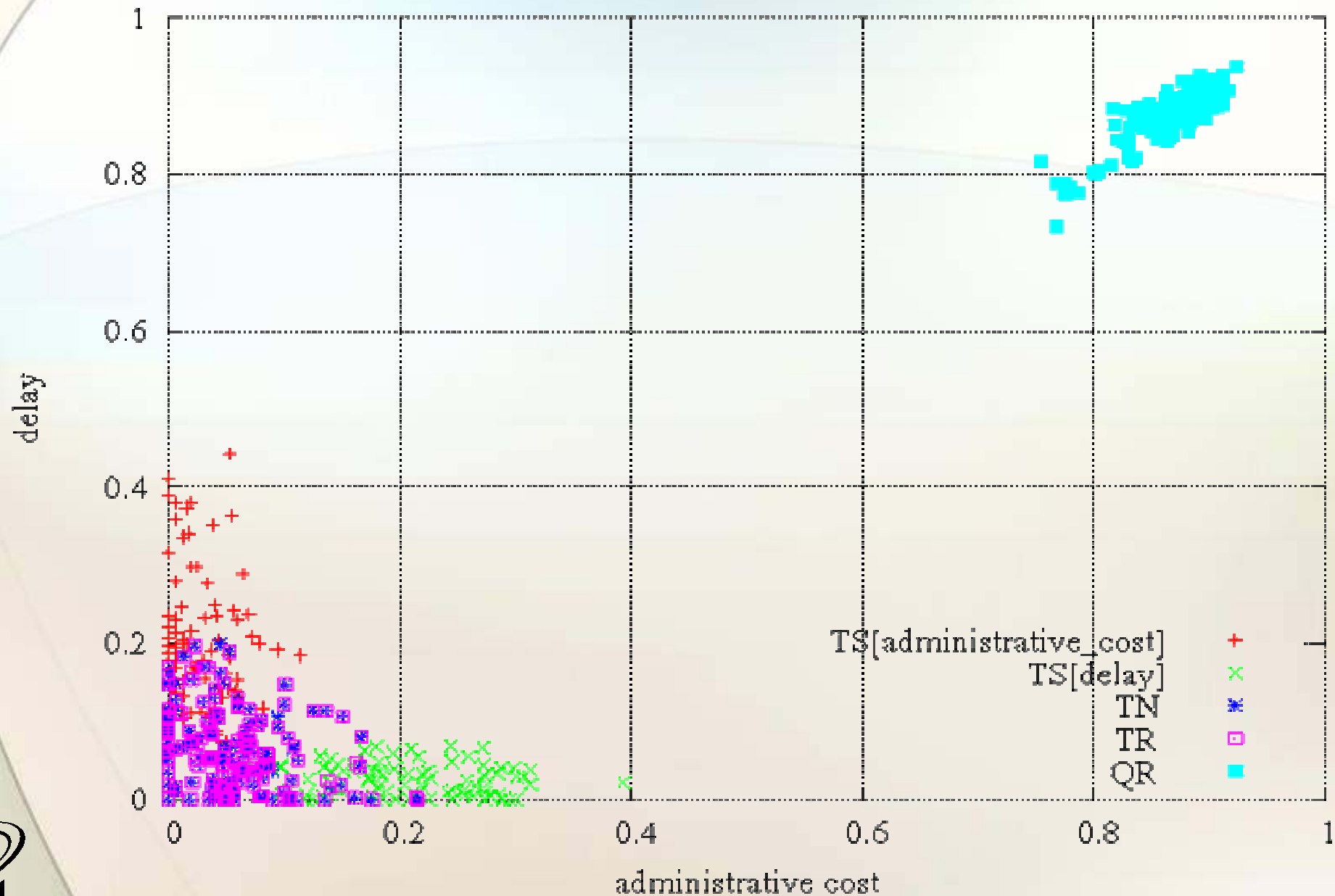


(c) *simple* method

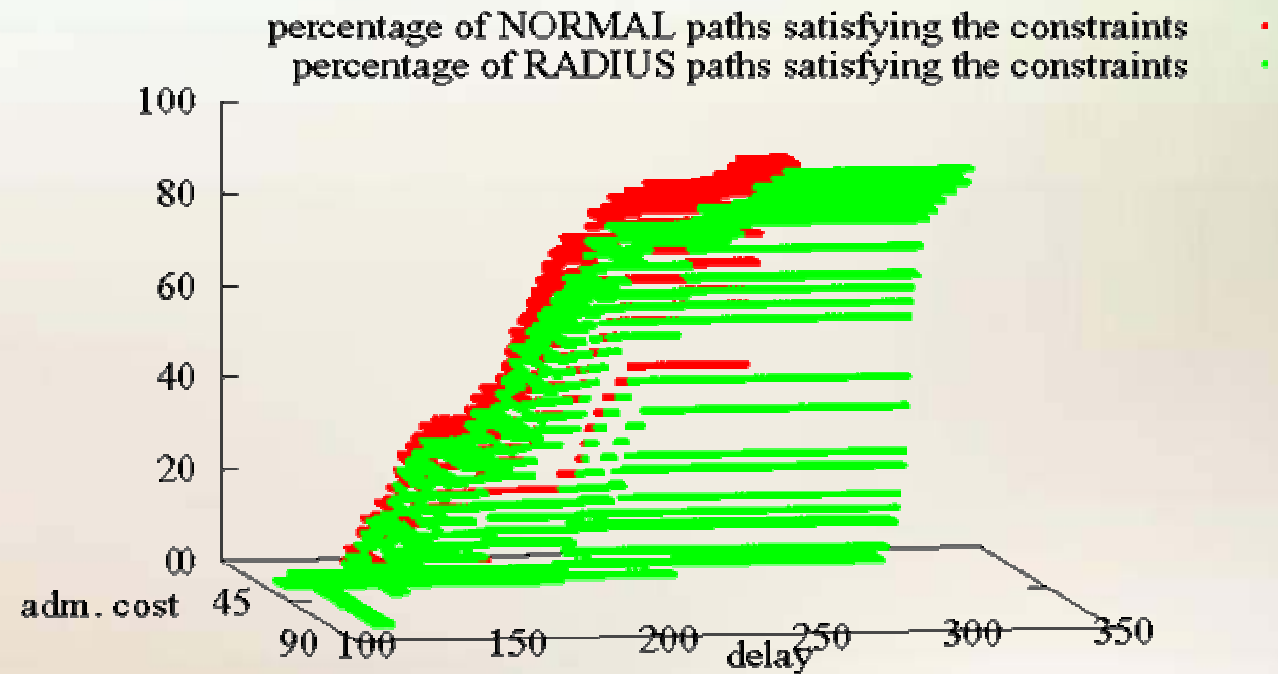
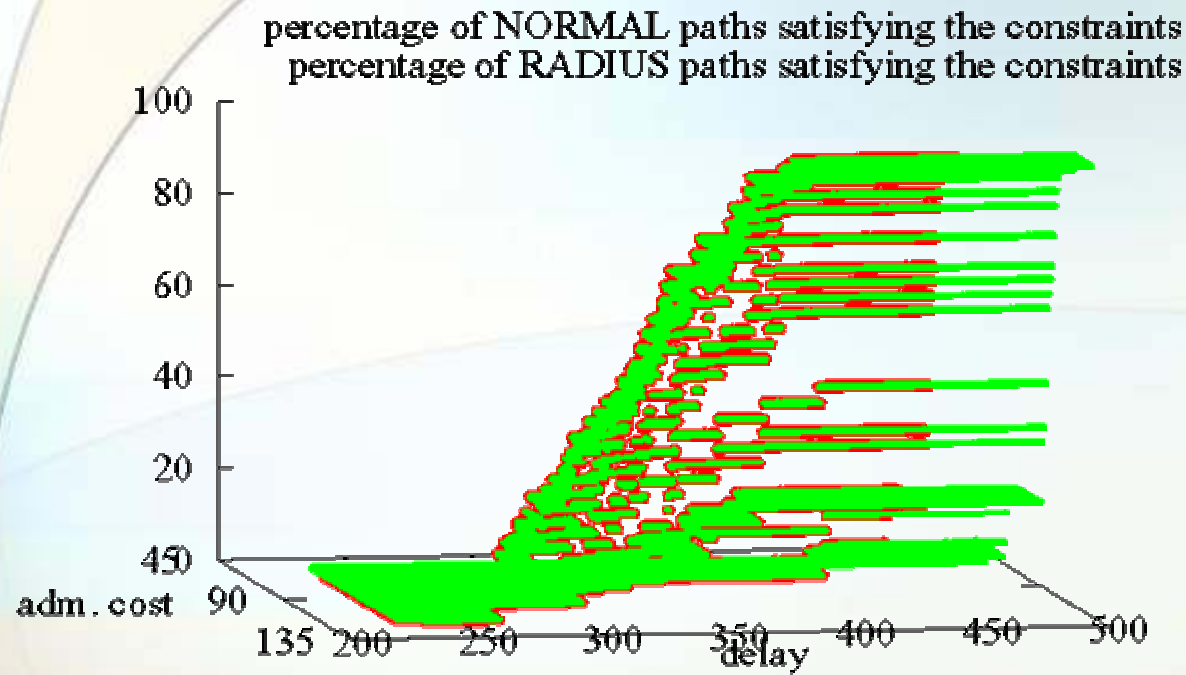
- Random selection

Compare the EFM path selection methods

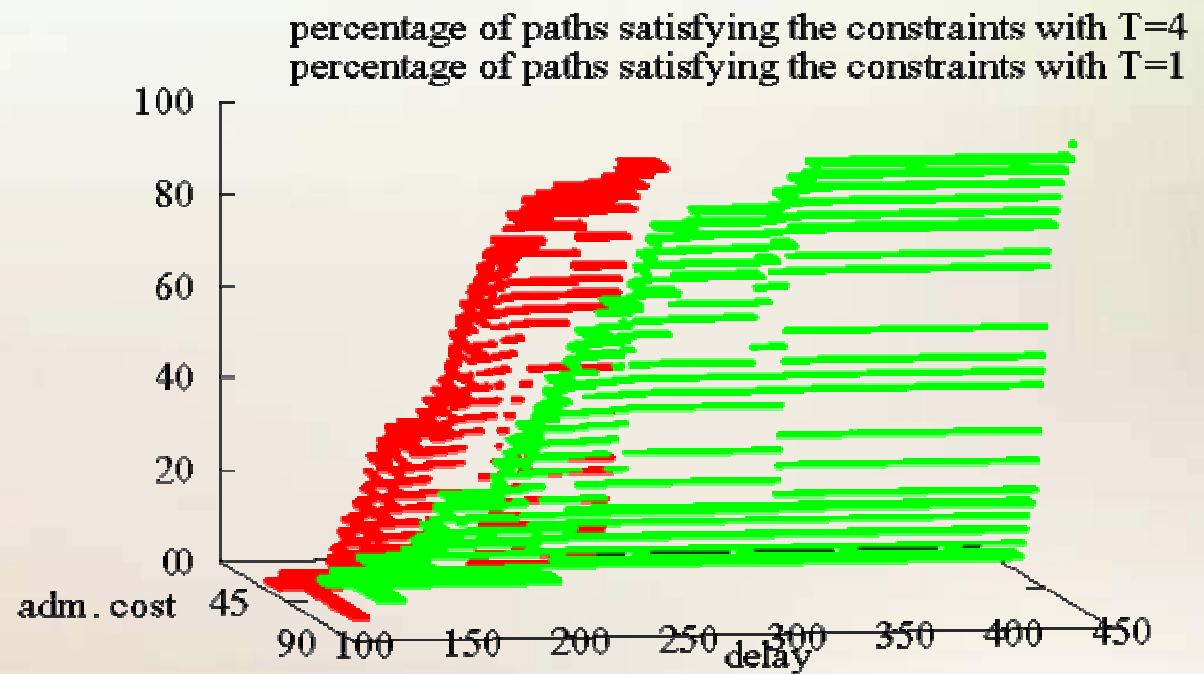
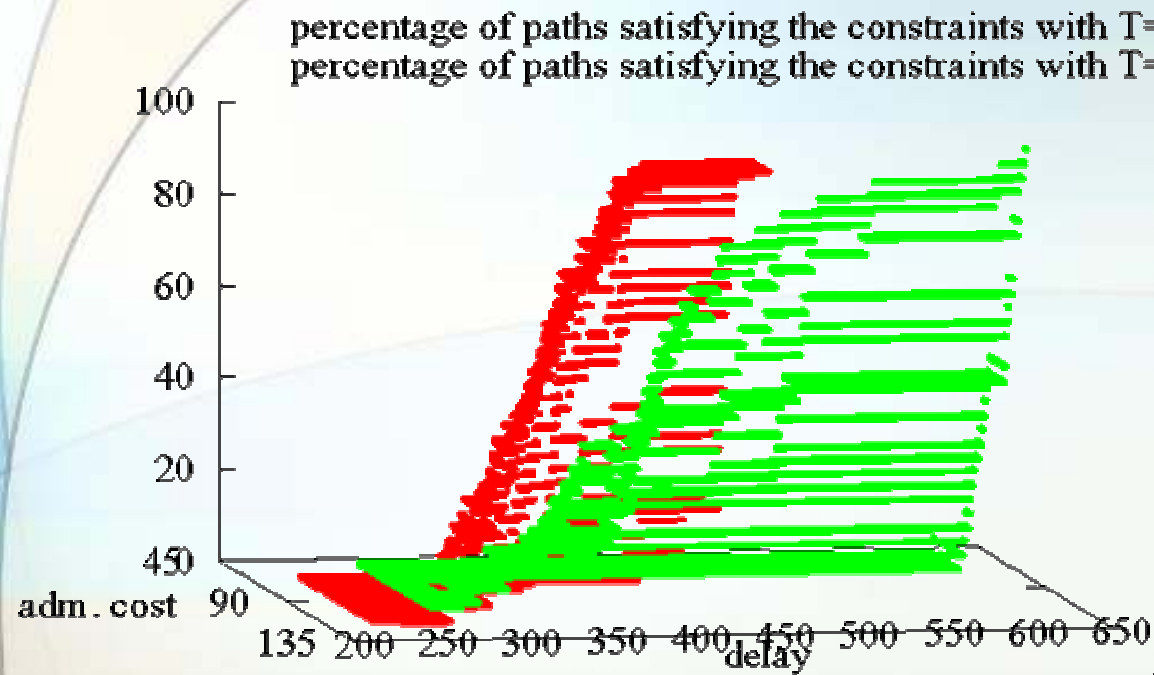
On a 20x20 node topology



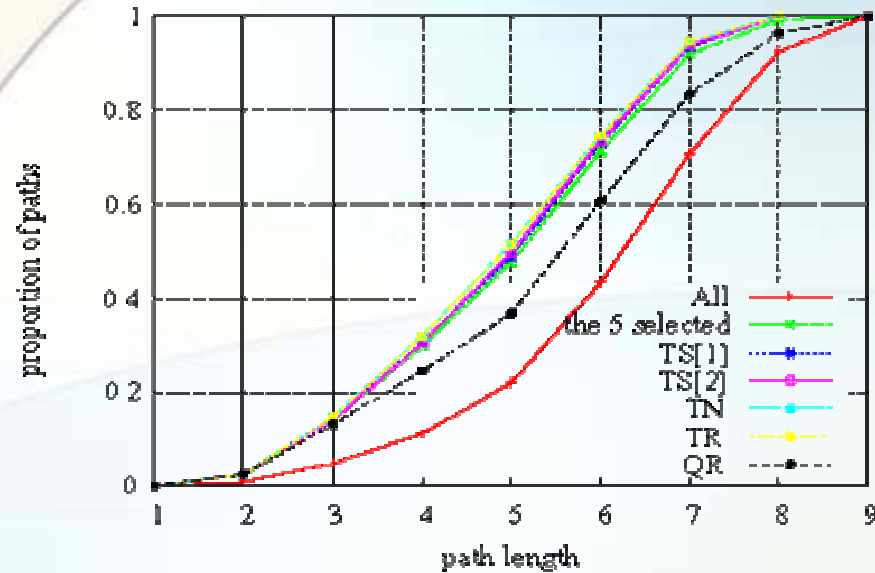
TRUNCATE NORMAL vs. TRUNCATE RADIUS



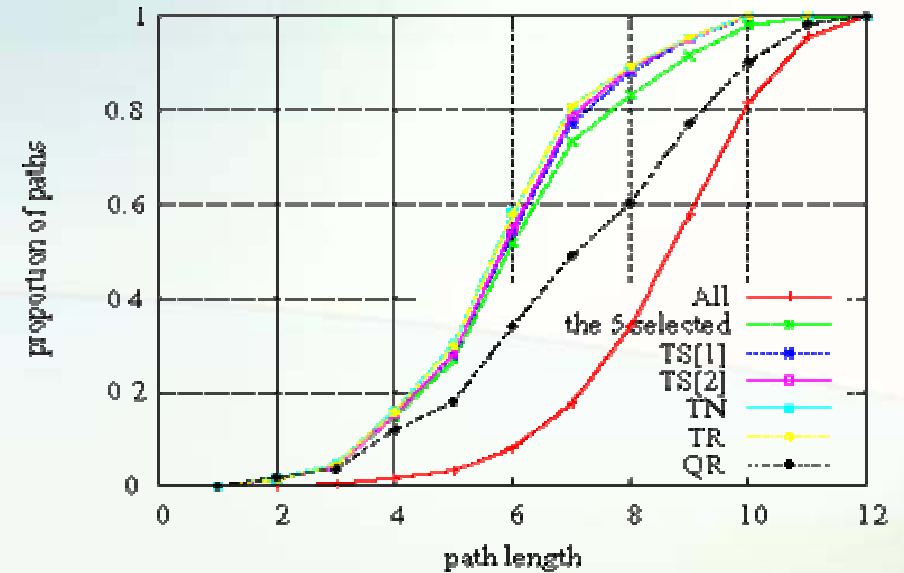
Full-Mesh vs. EFM



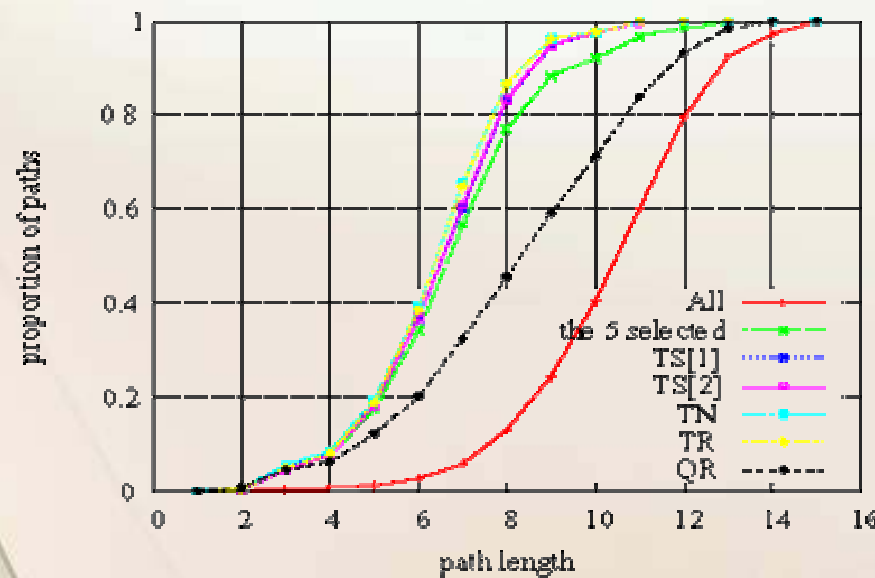
Confirmation for the *lifespan* parameter



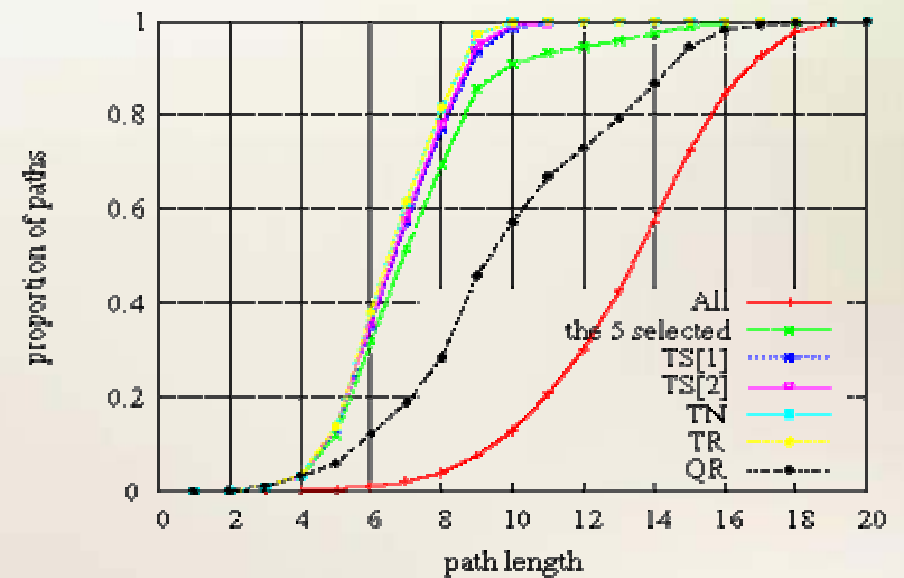
(a) on an 9×9 topology



(b) on an 12×12 topology



(c) on an 15×15 topology



(d) on an 20×20 topology

Summary of contributions

- **Active networks vs. Mobile agents**
 - A comparison from the QoS routing perspective
- **Integration of Active Networks with MPLS**
 - To overcome the inability of MPLS to perform switching above layer two
 - Applicability Examples
- **Macro-routing**
 - A new hierarchical QoS routing protocol which reduces some of the overhead introduced by QoS routing
- **The Extended Full Mesh**
 - A new aggregation technique which performs better than Full-Mesh
 - Increases the chances for finding a multi-constrained path

Future work

- **Macro-routing**
 - Make it deployable in the field
 - Quantitatively evaluate its scalability
 - Compare to rival protocols (e.g. PNNI)
 - Optimal lifespan
- **The Extended Full-Mesh**
 - Optimal number of EFM paths
 - A wider range of path selection techniques
- **Related to MR**
 - Generating the optimal hierarchy (the tradeoff between domain size and number of hierarchical levels)
 - Suitability for deployment in wireless or optical networks

Concluding remarks

- **Efficient QoS routing strategies are essential in the current Internet**
- **This thesis presents:**
 - **Specific QoS problems & solutions**
 - **Proposes a new and more efficient solutions for:**
 - **QoS routing**
 - **Resource reservation**
 - **Path setup**

Acknowledgements

- **Dr. Martin Collier**
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