Multi-constraint Macro-routing by using the extended full-mesh aggregation

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Hierarchical routing protocols

Why do we need them?

- The Internet increases in size & user demands
- The Internet Service Providers (ISP) deploy:
  - Traffic Engineering
  - Quality of Service routing

Scalability issues
- Storage overhead
- Computational overhead
- Communication overhead
Hierarchical routing protocols

Topology aggregation

The network is divided into domains. Detailed routing information is delivered only inside each domain, and only aggregated routing information is transmitted across domain boundaries.
Hierarchical routing protocols

Examples

- Open Shortest Path First (OSPF)
- Private Network-to-Network Interface (PNNI)
- Hierarchical Distributed Protocol (HDP)
- Viewserver Architecture
Multi-protocol Label Switching (MPLS)

Why?

- Quality of Service & Traffic Engineering
- hierarchical forwarding

![Diagram of MPLS label stack](image-url)
A mobile (software) agent is: a computational entity
- which acts on behalf of others,
- is autonomous, proactive, and reactive,
- exhibits capabilities to learn, cooperate, and move.

**Advantages**
- flexibility
- modularity
- scalability
- adaptability
- robustness

**Disadvantages**
- efficiency
- security
- provability
Mobile Agents

The WAVE technology

. . . is based on spatial matching of recursively defined strings in the navigational WAVE language with the network topology.

WAVE programs

- recursive code
- dynamically self-spreading
- may be injected from any agent
- propagates together with intermediate data

- very compact: (Ex: finding the shortest path three in a link-weighted network:)

@#a.F=0.RP(N~;F<N.N=F.N1=P.$.F+L)
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 by using the full-mesh aggregation
- parallel processing
- distributed processing with multiple simple tasks
- finds the best path
- finds multiple paths
Macro-routing

Disadvantages

- Might generate too much traffic  
  (see results presented at GLOBECOM 2006)

- Does not solve the multi-constrained problem
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

- **Dispersal methods**

  (a) normal method
  (b) radius method
  (c) distance method
Conclusions

- **Macro-routing**
  - a new approach for hierarchical routing
  - no information dissemination as the routing information is consulted *in situ*

- **Multi-constraint Macro-routing**
  - Macro-routing + multi-constraint routing

- **The extended full-mesh aggregation**
  - Allows more paths to be considered
  - Increases the chances of finding a viable path
  - It might generate too much traffic
  - A number of techniques for limiting the EFM representation