Estimation of Traffic Amounts on All Links
by Using the Information from a Subset of Nodes

Yuya Tarutani*, Yuichi Ohsita**,
Shin'ichi Arakawa*, and Masayuki Murata*

*Graduate School of Information Science and Technology,
Osaka University, Osaka, Japan
* * Graduate School of Economics,
Osaka University, Osaka, Japan*

2010/10/28   1

Osaka University

Research background

- Traffic engineering
  - Reconfigure the routing so as to suit the current traffic
    - Trigger: Traffic changes (day time / night)
    - Objective: Optimize network performance
    - Given: Traffic Matrix (Traffic volume between each node)
    - Variable : Routing
  - Require the traffic matrix

2010/10/28   2

Osaka University

Difficulties in Traffic Engineering

- Traffic Matrix is difficult to collect directly

- Traffic engineering methods using link loads have been proposed
  - Traffic engineering using estimated traffic matrices

  Routing
  Traffic matrix
  $$X = AT$$
  Traffic volume on each link (Link load)

- Overhead for collecting all link loads is still large in a large network
  - Querying all nodes is required

2010/10/28   3

Osaka University

Research Purpose

- Our Purpose
  - Reduce collecting overhead of link loads
- Our Approach
  - Develop a method to estimate all link loads from the link loads collected from subset of nodes (monitoring nodes)
  - Propose a method to select monitoring nodes
    - Estimation errors depend on selection of monitoring nodes
    - Large estimation errors cause incorrect detection of congestions

2010/10/28   4

Osaka University

Our method

Step.1 Select the nodes to collect the link loads
- So as to avoid the large estimation errors

Step.2 Estimate the link loads from the collected information
- By using the relation between the link loads and the number of edge-to-edge traffic

Step.3 Adjust the link loads so as to satisfy the following equation

Traffic volume on each link (Link load)
Routing
Traffic matrix
$$X = AT$$

2010/10/28   5

Osaka University

Step.1 Selecting monitoring nodes

The edge-to-edge traffic cannot be monitored any other
Select the nodes
The number of edge-to-edge traffic is large
Select the nodes

1. Select nodes passing the edge-to-edge traffic cannot be monitored by any other nodes
   - To avoid lack of traffic information related to some edge-to-edge traffic

2. Select nodes passed by a large number of edge-to-edge traffic
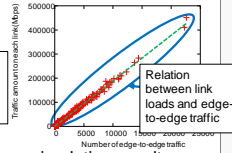   - To obtain information related to more edge-to-edge traffic

2010/10/28   6

Step.2 Estimating the link loads

- Relation between the link loads and the number of edge-to-edge traffic
  - Simulation to clarify the relation

Simulation environment
Topology : AT&T topology (523 nodes 1304 links)
Traffic matrix: Follow Gravity model and lognormal distribution ($\sigma = 4.3$, $\mu = 1.04$)

Relation between link loads and edge-to-edge traffic

  - Model of the relation according to our simulation results

$$U_i = \alpha Z_i + \beta$$

U_i: Estimated link loads roughly on link i
Z_i: The number of edge-to-edge traffic on link i

- Estimation steps
  - Calculate α and β by using the collected link loads
  - Estimate the link loads roughly

2010/10/28   7

Step.3 Adjusting link load

- Link loads should satisfy the following equation

Routing

Traffic volume on each link (Link load)

$$X = AT$$ Traffic matrix

- Adjustment steps
  - Estimate traffic matrix from roughly estimated link loads
    - Obtain $\hat{T}$ so as to minimize $\|X' - A\hat{T}\|$
      - X': link loads estimated at Step. 2
  - Calculate link loads from estimated traffic matrix and routing

$$A\hat{T} \rightarrow \hat{X}$$ Estimated link loads

2010/10/28   8

Simulation settings

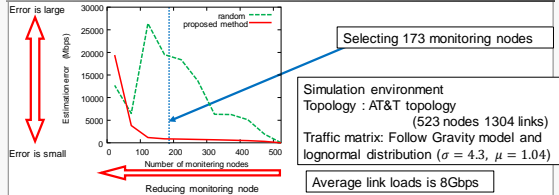- Simulation environment
  - Topology
    - AT&T Topology: Measured router-level topology of AT&T (523 nodes and 1304 links)
  - Traffic matrix T^{grav} : genererated randomly so as follow the Gravity model
    $T^{grav} + \Delta$ Δ : The white Gaussian noise
  - Number of monitoring nodes: Changed from 23 to 523
- Performance Metric
  - Estimation error of link loads (RMSE)

$$X_{RMSE} = \sqrt{\frac{1}{L}\sum_{k=1}^{L}(\hat{X}_k - X_k)^2}$$

2010/10/28   9

Simulation Result

Selecting 173 monitoring nodes

Simulation environment
Topology : AT&T topology
(523 nodes 1304 links)
Traffic matrix: Follow Gravity model and lognormal distribution ($\sigma = 4.3$, $\mu = 1.04$)

Average link loads is 8Gbps

- Our method achieves estimation errors less than 8 % of average link load (600 Mbps) with 30% of monitoring nodes

Our method reduces the collecting overhead by 70%

2010/10/28   10

Conclusion and Future Work

- Conclusion
  - We propose a method to select the monitoring node and estimate the link loads
  - Simulation results show that our method reduces the collecting overhead by 70%
- Future work
  - Evaluation of the performance of traffic engineering using the link loads estimated by our method
  - Obtained results: Maximum link loads achieved by the traffic engineering
    - Our method with 30 % of monitoring nodes achieves the similar maximum link loads as the case of using the actual link loads

2010/10/28   11