08 Traffic flow aggregation for traffic engineering
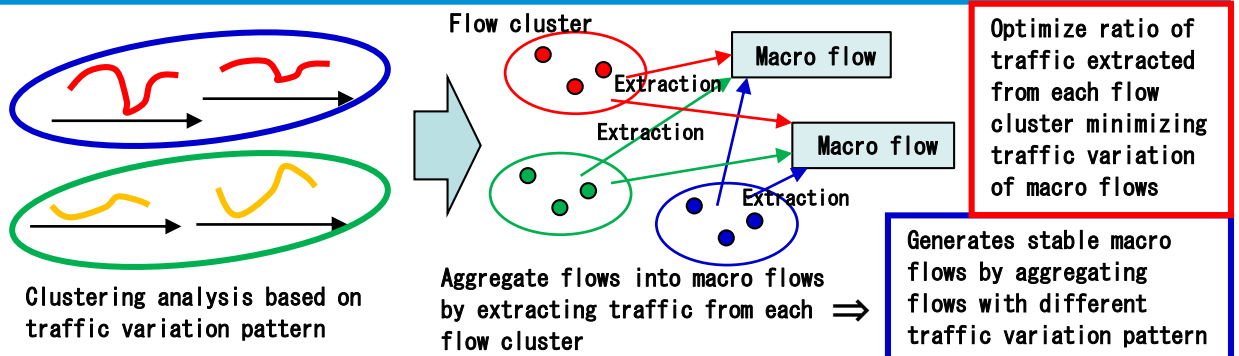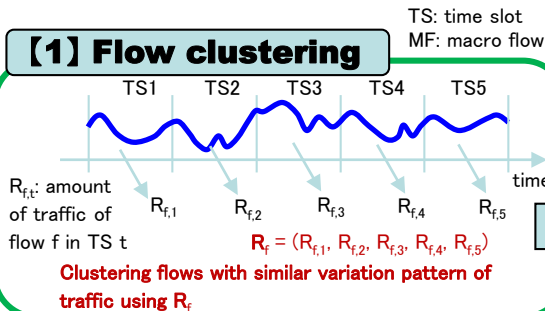## ～Classifying flows based on traffic variation pattern～
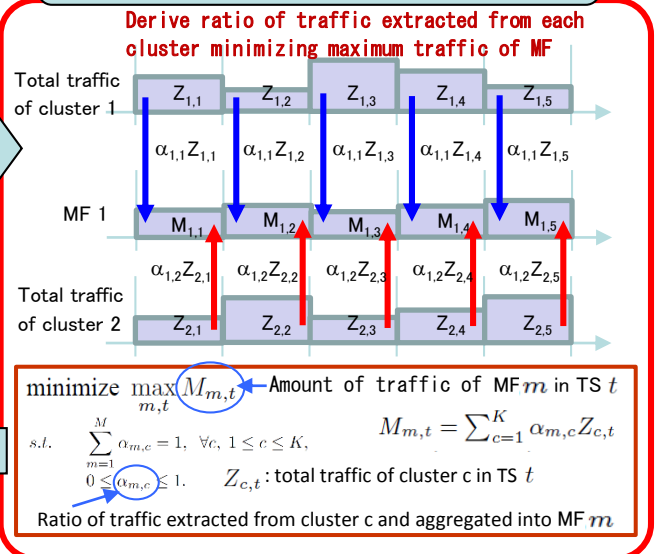
Abstract

Although the use of software-defined networking (SDN) enables routes of packets to be controlled with finer granularity by using traffic engineering (TE), the corresponding increase in the number of states that need to be managed at routers and controller is problematic in large-scale networks. Aggregating flows into macro flows and assigning routes by macro flow should be an effective approach to solving this problem. However, when macro flows are constructed as TE targets, variations of traffic rates in each macro flow should be minimized to improve route stability. We propose to cluster micro flows with similar traffic variation patterns into groups and optimizes the traffic ratio of extracted from each cluster to aggregate into each macro flow.

Flow cluster

Macro flow

Extraction

Extraction

Extraction

Clustering analysis based on traffic variation pattern

Aggregate flows into macro flows by extracting traffic from each flow cluster ⇒

Optimize ratio of traffic extracted from each flow cluster minimizing traffic variation of macro flows

Generates stable macro flows by aggregating flows with different traffic variation pattern

TS: time slot
MF: macro flow

【1】 Flow clustering

TS1 TS2 TS3 TS4 TS5

$R_{f,t}$: amount of traffic of flow f in TS t

$R_{f,1}$, $R_{f,2}$, $R_{f,3}$, $R_{f,4}$, $R_{f,5}$

time

$R_f = (R_{f,1}, R_{f,2}, R_{f,3}, R_{f,4}, R_{f,5})$

Clustering flows with similar variation pattern of traffic using R_f

【3】 Aggregating flows into MF

Assign flows realizing optimum extraction ratio

$$\min \quad (1-\beta)Q + \beta S$$
$$s.t. \quad Q = \max_{m,t} \sum_f R_{f,t} x_{f,m},$$
$$S = \max_c \sum_{t=1} \left\| \sum_{f \in G_c} R_{f,t} x_{f,m} - \alpha_{m,c} Z_{c,t} \right\|,$$
$$\sum_{m=1}^M x_{f,m} = 1, \ \forall f, \ 1 \le f \le F.$$
$$x_{f,m} \in \{0, 1\}.$$

Q: max. traffic of MF m
S: deviation from optimum

$x_{f,m}$: binary variable taking unity when assigning f to MF m

【2】 Optimizing ratio of traffic extracted from each cluster

Derive ratio of traffic extracted from each cluster minimizing maximum traffic of MF

Total traffic of cluster 1

$Z_{1,1}$ $Z_{1,2}$ $Z_{1,3}$ $Z_{1,4}$ $Z_{1,5}$

$\alpha_{1,1}Z_{1,1}$ $\alpha_{1,1}Z_{1,2}$ $\alpha_{1,1}Z_{1,3}$ $\alpha_{1,1}Z_{1,4}$ $\alpha_{1,1}Z_{1,5}$

MF 1

$M_{1,1}$ $M_{1,2}$ $M_{1,3}$ $M_{1,4}$ $M_{1,5}$

$\alpha_{1,2}Z_{2,1}$ $\alpha_{1,2}Z_{2,2}$ $\alpha_{1,2}Z_{2,3}$ $\alpha_{1,2}Z_{2,4}$ $\alpha_{1,2}Z_{2,5}$

Total traffic of cluster 2

$Z_{2,1}$ $Z_{2,2}$ $Z_{2,3}$ $Z_{2,4}$ $Z_{2,5}$

$$\text{minimize} \quad \max_{m,t} (M_{m,t}) \leftarrow \text{Amount of traffic of MF } m \text{ in TS } t$$
$$s.t. \quad \sum_{m=1}^M \alpha_{m,c} = 1, \ \forall c, \ 1 \le c \le K, \qquad M_{m,t} = \sum_{c=1}^K \alpha_{m,c} Z_{c,t}$$
$$0 \le \alpha_{m,c} \le 1. \qquad Z_{c,t}: \text{total traffic of cluster c in TS } t$$

Ratio of traffic extracted from cluster c and aggregated into MF m

Related works

[1] N. Kamiyama, Y. Takahashi, K. Ishibashi, K. Shiomoto, T. Otoshi, Y. Ohsita, M. Murata, "Flow aggreagation for traffic engineering", in Proc. IEEE GLOBECOM 2014, 2014.

[2] Y. Takahashi, K. Ishibashi, N. Kamiyama, K. Shiomoto, T. Otoshi, Y. Ohsita, M. Murata, "Macroflow-based traffic engineering in SDN-controlled network," in Proc. 11th International Conference on IP+Optical Network (iPOP2015), 2015.

Contact

Noriaki Kamiyama   NTT Network Technology Laboratories
E-mail：kamiyama.noriaki(at)lab.ntt.co.jp