Traffic Engineering with Contour Channel Shift

Bhavneet Kaur†, Karanjeet Singh Kahlon and Sandeep Sharama

Guru Nanak Dev University, Amritsar, Punjab, India

Summary
To improve user performance and to make efficient use of network resources, conventional traffic engineering alters the routing of traffic to the prevailing demands within the network. This paper proposes a new way of traffic engineering which not only alters the intra-domain routing anatomy but also alter the traffic matrix. This way of traffic engineering does not disturb the traffic arrangement contrary to conventional traffic engineering where changes in BGP policies lead to change in traffic arrangement. A new framework is proposed contour channel shift (CCS) that decides which contour channel should be shifted and where.

Key words:
Routing, traffic engineering, netflow, Internet, BGP.

1. Introduction

Traffic engineering deals with the problem of smoothly assigning resources in the network so that user demands can be met and operator benefit is maximized. Conventional traffic engineering adjusts the different parameters of routing protocols to in-order to control traffic on network. Moreover conventional traffic engineering considered that topology is static and cannot be altered. But one of the recent researches confronts the above approach. A recently proposed mechanism ---"router grafting" [1] allows the ISP to dynamically alter its ends of links to neighbouring networks. This gives power to ISP to alter traffic matrix i.e. it allows operator to change entering and exiting points for traffic in real time without troubling its neighbours.

2. Configuration of Traffic Engineering

2.1 Conventional Traffic Engineering

In conventional traffic engineering, the network is represented by a directed graph G= (V,E) where vertex set V represents routers and the edge set E represents the links. Every edge a ε E has magnitude M^a. Traffic matrix TM=$\{TM_{ij}\}_{ij\ \varepsilon\ V}$. Tha goal is to be allocate traffic across the routes from i to j to minimize utilization channel ACU (Absolute channel utilization). The cost function ϕ_a [3] specifies the cost as the function of total traffic flow (TF_a) and edge magnitude (M^a). Every $\phi_a$is a piecewise linear convex function:-

$$\phi_a(TF_a, M^a)\begin{cases} TF_a & 0 \le TF_a/M^a < 0.33 \\ 3TF_a\text{-}0.66M^a & 0.33 \le TF_a/M^a < 0.66 \\ 10TF_a\text{-}5.33M^a & 0.66 \le TF_a/M^a < 0.9 \\ 70TF_a\text{-}59.3M^a & 0.9 \le TF_a/M^a < 1 \\ 500TF_a\text{-}489.3M^a & 1 \le TF_a/M^a < 1.1 \\ 5000TF_a\text{-}5439.33M^a & 1.1 \le TF_a/M^a < \infty \end{cases}$$

The task is to allocate the entries requests between every pair of vertices so that sum of all link costs can be minimized.

2.2 Shift based Traffic Engineering

This section discusses the traffic engineering model based on contour shifting which is the extension of the conventional traffic engineering.

2.2.1 Symbols used in Shift based Traffic Engineering

G= network graph G= (V, E)
V= network vertices i.e V=C U P
E= network edge i.e E= E_C U E_P
C= set of customers
P= set of providers
E_C= subset of edges that link customers c ε C to network providers in P, $E_C \subseteq C\ X\ P$.
E_P= subset of edges that link network provider p ε P to network providers in N, $E_P \subseteq P\ X\ P$.
M_a= magnitude of edge a ε E
LC_C= latest channel, $LC_C \subseteq E_C$
RQ= request matrix RQ= $\{rq_{k,l}\}_{k,l\ \varepsilon\ C}$
$rq_{k,l}$= quantity of traffic flow that customer k wishes to send customer l_{ACU}
ϕ_a = cost function used in minimization function of TF_a/M^a
TF_a= Total flow on edge 'a'.

2.2.2 Shift based Traffic Engineering Model

a) Network is represented by a directed graph G= (V,E) where vertex V is union of customers (c) & provider (p)

Manuscript received June 5, 2013
Manuscript revised June 20, 2013

where C sends & receives the traffic and P is the router in the network which provides the traffic to C.

b) The concept of latent channel (LC_c) is introduced which correspond to different positions where the customer can possibly attach to the network. This allows capturing the ability of shifting. Network edge E is union of E_C & E_P where $E_C \subseteq C\ X\ P$ and $E_P \subseteq P\ X\ P$. Each edge a ε E_P has a magnitudeM_a ≥0, which calculates the quantity of traffic that can travel across edge a.

c) Each customer use a single latent channel i.e. for every customer c ε C, traffic flowing from that customer to other customer and vice versa can only travel on single edge in LC_c ; traffic along all other edges in LC_c must be zero.

d) The new shift based traffic engineering model supports the concept of multi-homing and router grafting. This model does not put check on the magnitude of latent channel bur during simulation when actual traffic patterns are used, certain restriction is introduced on how much traffic can be send and receive along each latent channel.

3. Speculative Edge Channel Shift

Although ACU minimizing solution in which each customer sends/receives traffic along a single latent channel can be computed in adequate way but finding an optimal solution is NP-hard and that even estimating the optimal solution within a steady determinant is difficult. The following sections discusses the 2 implications based on above analysis: a) Max-Channel implication b) Cluster-Customer implication

These implications are evaluated experimentally in next section.

3.1 Max-channel Implication

The max-channel implication evaluates the maximum multi-commodity flow in the input network that consists of all latent channels. Then accordingly to implication, it uses this fully-fractional flow to select a single latent channel for each customer which leads to construction of feasible solution. To achieve this max-channel implication push away, for each customer, all latent channels but the single latent channel along which the customer sends and receives the maximum traffic.

3.2 Cluster-Customer Implication

The cluster-customer implication recognizes the customers in groups and not as a single customer. According to this implication:

a) Split the set of customers into group/ clusters.

b) The cluster includes the number of customers which all can associate to the network at the accurate same locations.

c) Formulate a new network where each cluster of customers is restored by a single customer along with a set of latent channels that associate to the network at the accurate same locations.

d) Now resolve the multi-commodity flow for this network to acquire the fraction of traffic flowing over each latent channel.

e) Utilize the solution achieved from step-d to map customers to latent channels with the intention of matching the bifurcation of traffic over latent channels as closely as possible.

4. Estimation of Shift based Traffic Engineering

This section will establish the advantages of shift based traffic engineering. It will be demonstrated that max-channel implication helps in the performance improvement of network. Further it will be shown that how frequently do channels require to be shifted and what number of channels is to be shifted.

4.1 Experimental Setup

Data required for simulation is collected from Internet2 [2] which contains 10 core routers which act as providers and 200 external routers which act as customers. Data is collected for one week. For each router, Netflow data is downloaded which give concise information of sampled flows in 5-min interval. Traffic matrix was generated using routing tables which allows determining egress router for each flow along with particular interface. The selection of latent channels (LC_c) was based on geographical distance. The first latent channel for a given customer is to the router to which customer is attached in the actual topology. The second latent channel is to a router arbitrarily chosen from the routers closest to the actual topology.

4.2 Shifting boost Network Utilization

In section 4.2.1 the metric improvement is defined and it is demonstrated that the improvement alters depending upon the traffic patterns and in section 4.2.2 it is proposed that max-channel is better.

4.2.1Detail of improvement metric

Consider Absolute channel utilization (ACU) for 5-min period. The fig1 shows the results for actual topology and for shift based traffic engineering using max-channel with two channels per customer. To attain the graph shown in fig1, traffic requests were separated by escalating all entries in request matrix by a multiplicative factor, plotted on the x-axis and optimized for ACU for each. ACU minimization picks up the intention to circumvent congestion and comprises of an exponentially increasing cost for utilizing a channel. Due to the exponentially increasing cost, the network operator hopes to be at the point in the curve that comes before the exponential rise. From graph it can be determined that with shift based traffic engineering, network can handle 20% more traffic with same level of congestion. Thus improvement metric can be defined as the measure of traffic the network can transfer in the altered topology at the same level of congestion as in actual topology where ACU serve as the level of congestion.

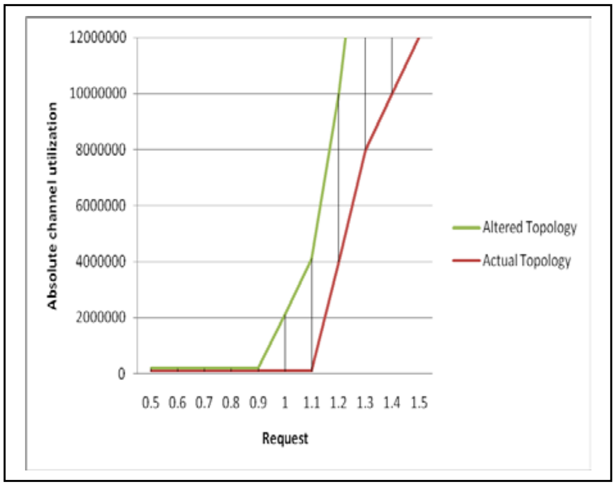

Fig.1 Max-channel analysis

4.2.2 Max-channel Vs Cluster-customer

The graph in fig2 shows the improvement metric achieved with max-channel as well as cluster-customer implications. It can be determined that shift-based traffic engineering upgrades the network utilization by 18.9% when max-channel is utilized. Actually this improvement is based on two factors:

a) By optimizing the homing location based on the request matrix, customers that interact will likely to get closer together. With channel-shift, topology can be changed so that customers that interact can come close together.

b) If topology is re-optimized it can have important impact on congested channels. Congestion can be decreased by allowing some traffic to drop the congested channel through shift based traffic engineering.

4.3Repeated Shifting not required

To estimate the frequency of shifting, analyze the traffic at different times- every 5-min, 30-min, 1hour, 6-hours, 12-hours and 24-hours as shown in fig 3. The request matrix employed when estimating the multi-commodity flow in max-channel implication was the mean request matrix for the next interval. Consider 5-min case, errors in the forecasting alter the results. But as the intervals increases, traffic pattern becomes even and it is easy to forecast. ACU is concluded for 5-min of traffic using this topology and results are compared with actual topology.

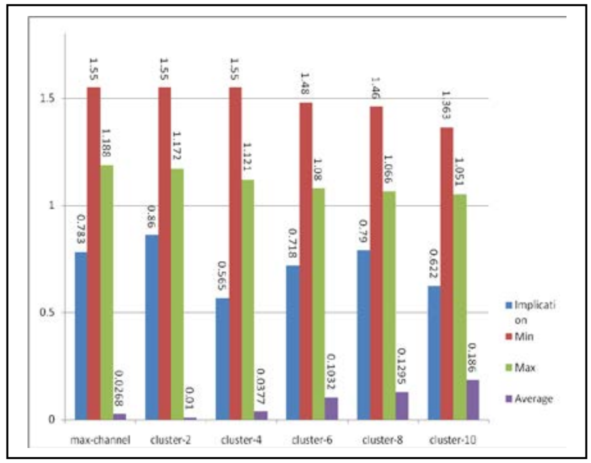

Fig. 2 Improvement analysis of altered topology

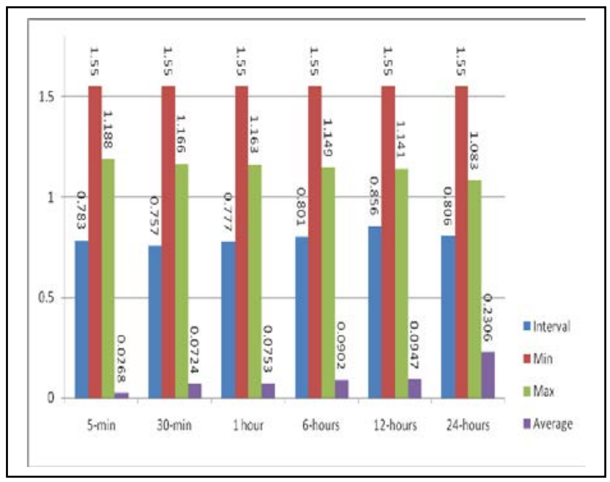

Fig. 3 Improvement analysis of altered topology a different intervals

4.4 How many Channels needed to be shifted?

The model proposed in this study i.e. Shift based traffic engineering does not presently include the cost of shifting. To establish which customers to shift, measure weigh of cost of shifting a customer across the gain from shifting that customer when affect of shifting a customer is low i.e. shifting might not be required. For this, examine the quantity of traffic each customer sends or receives in 5-min interval. It is analyzed that 85% of the traffic comes from just 42 out of 205 customers out of whom max-channel implication found that only 5 customers needed to be shifted. This shows that improvement in network performance can be increased even by shifting only small number of channels.

5. Conclusion

This study proposed a new advancement in traffic engineering where instead of only optimizing for established traffic patterns, it also had effect on traffic where it enter or exit the network. Simple implications lead to important performance gains without the need of repeated shifting or large number of channels to be shifted. More realistic aspects can be added to shift based traffic engineering. Cluster selection can be further explored in cluster-customer implication. Contour channel shift model can be further investigated under data-centre networks which can result in different patterns and practical constraints.

References

[1] E. Keller, J. Rexford, and J. van der Merwe. Seamless BGP session migration with router grafting. In Proc. Networked Systems Design and Implementation, April 2010

[2] Internet2.http://www.internet2.org

[3] B. Fortz and M. Thorup. Internet traffic engineering by optimizing OSPF weights. In Proc. IEEE INFOCOM, 2000

[4] S. Kandula, D. Katabi, B. Davie, and A. Charny. Walking the tightrope: Responsive yet stable traffic engineering. In Proc. SIGCOMM, 2005

[5] M. Roughan and Y. Zhang. GATEway: symbiotic inter-domain traffic engineering'. In The Second International Workshop on Game Theory in Communication Networks, Athens, Greece, October 2008.

[6] R. Teixeira, T. Griffin, M. G. C. Resende, and J. Rexford. TIE breaking: Tunable interdomain egress selection. IEEE/ACM Trans. Networking, August 2007.

[7] H. Wang, H. Xie, L. Qiu, Y. R. Yang, Y. Zhang, and A. Greenberg. COPE: Traffic engineering in dynamic networks. In Proc. SIGCOMM, 2006.

[8] C. Zhang, Z. Ge, J. Kurose, Y. Liu, and D. Towsley. Optimal routing with multiple traffic matrices: Tradeoff between average case and worst case performance. In Proc. International Conference on Network Protocols, Nov. 2005

Bhavneet kaur is working as an Assistant Professor in Department of Computer Science and Engineering, Guru Nanak Dev University, Amritsar (India). She is pursuing her Ph.D. in Inter-domain Routing protocol at Department of Computer Science and Engineering, Guru Nanak Dev University, Amritsar.

Karanjeet Singh Kahlon is serving as Professor at Computer Science and Engineering Department, Guru Nanak Dev University, India. He has 23 y ears of teaching and research experience. His research areas are parallel/ distributing computing and networks. He has supervised 4 doctoral theses.

Sandeep Sharma received the B.E. in Computer Engineering from Pune University, INDIA in 1994, M.E. degree in Computer Engineering from Thapar Institute of Engg. & Tech. Patiala, INDIA in 2000 and Ph.D. degree from Guru Nanak Dev University Amritsar (Punjab), INDIA in 2011.He is working as Associate professor in department of Computer Science & Engineering and he is also acting as Chief Security Information Officer of the University. His area of interest is Parallel Processing, Multistage Interconnection Network, Fault Tolerance and Cloud Computing.