

An Approach For Intelligent Traffic Splitting For Sudden Changes Of Traffic Dynamics.

GanaSindu. K. S¹,SmithaShekar. B²,Harish. G²

¹Department Of Computer Science, IV Sem, M.Tech
Dr. Ambedkar Institute of Technology
Bangalore, Karnataka, India.

²Department Of Computer Science, Asst. Professor
Dr. Ambedkar Institute of Technology
Bangalore, Karnataka, India.

Abstract—In the network management process, dynamically changing traffic is a very difficult task to manage and it leads to many problems which will decrease the network performance and increase delay. Mechanisms are needed that can handle traffic load dynamics in scenarios with sudden changes in traffic demand and dynamically distribute traffic to benefit from available resources.

In the previous work [1], AMPLE (Adaptive Multi-toPoLogy traffic Engineering) is introduced which consists of two distinct phases to achieve TE objectives. First is offline network dimensioning through link weight optimization for achieving maximum intra-domain path diversity across multiple routing topologies and second is adaptive traffic splitting ratio adjustment across these routing topologies for achieving dynamic load balancing in case of unexpected traffic dynamics.

In this paper another module which is *traffic analyzer*, which help in managing the traffic and study its nature and flow, and it reduces the burden from adaptive traffic controller. The traffic analyzer will help in sending the traffic in same order as it was received, and study its behavior so that it is easy to predict to some extent the possible future traffic flow. This will increase the performance of adaptive traffic controller and help to manage unexpected traffic flow.

Keywords—Multi Topology, dynamic traffic, routing Topology, load balancing, Traffic analyzer.

1. INTRODUCTION

Research in the Traffic Engineering (TE) field has been carried out for years. Solutions exist, but few of these are actually used by operators to manage their network and one reason is that these methods are implemented for research and simulation purposes. It is considered difficult to integrate these

methods in an operational environment. Intra-domain Traffic Engineering (TE) based on IGP's such as OSPF and IS-IS has recently been receiving numerous attentions in the Internet research community. In order to achieve near-optimal or even optimal network performance, it is suggested that both IGP link weights and traffic splitting ratio need to be optimized simultaneously based on the Traffic Matrix (TM) [1], and the network topology as input. However, this is only applicable to offline TE where knowledge of the estimated TM is assumed a priori. Unfortunately, this assumption is usually not valid in real operational networks given frequent presence of traffic dynamics such as unexpected traffic spikes that are difficult to anticipate.

As a result, the absence of accurate traffic matrix estimation may lead the offline TE approaches to perform poorly. The most straightforward approach for handling this is to reassign IGP link weights dynamically in reaction to the monitored dynamics. However, re-assigning link weights on the fly may cause transient forwarding loops during the convergence phase, which often leads to service disruptions and traffic instability.

In previous work [1], AMPLE (Adaptive Multi-toPoLogy traffic Engineering), a novel IGP TE approach that is capable of adaptively handling traffic dynamics in operational IP networks. Instead of re-assigning IGP link weights in response to traffic fluctuations, we adopt multi-topology IGP's (MT-IGP's) such as MT-OSPF and M-ISIS as the underlying routing platform to enable path diversity, based on which adaptive traffic splitting across multiple routing topologies is performed for dynamic load balancing. AMPLE consists of two distinct phases to achieve our TE objectives. First, the offline phase (e.g., at a weekly or monthly timescale) focuses on the static dimensioning of the underlying network, with MT-IGP link weights computed for maximizing intra-domain path diversity across multiple routing topologies. Since the objective is to

obtain diverse IGP paths between each source/destination pair, the computation of MT-IGP link weights is actually agnostic to any traffic matrix. Once the optimized link weights have been deployed in the network, an adaptive TE performs traffic splitting ratio adjustment for load balancing across diverse IGP paths in multiple routing topologies, according to the up-to-date monitored traffic conditions.

This adaptive TE aims to efficiently handle traffic dynamics at short time-scale such as hourly or even in minutes. Given the fact that traffic dynamics are common in operational IP networks, our proposed approach provides a promising and practical solution that allows network operators to efficiently cope with these dynamics that normally cannot be anticipated in advance. The contributions of our work can be summarized as follows. First of all, AMPLE does not require frequent and on-demand re-assignment of IGP link weights, thus minimizing the undesired transient loops and traffic instability. Second, the optimization of the MT-IGP link weights does not rely on the availability of traffic matrix a priori, which plagues existing IGP TE solutions due to inaccuracy of traffic matrix estimations. Third is that another module called Traffic Analyzer is used to improve the efficiency and manage the traffic flow. Finally, our experiments based on real network topologies and traffic matrices have shown that AMPLE has a very high chance of achieving near-optimal performance with only a small number of routing topologies.

2. TRAFFIC ENGINEERING

For a network operator it is important to analyse and tune the performance of the network in order to make the best use of it [12]. The process of performance evaluation and optimization of operational IP-networks is often referred to as traffic engineering. One of the major objectives is to avoid congestion by controlling and optimizing the routing function. The traffic engineering process can be divided in three parts as illustrated in Figure 1.

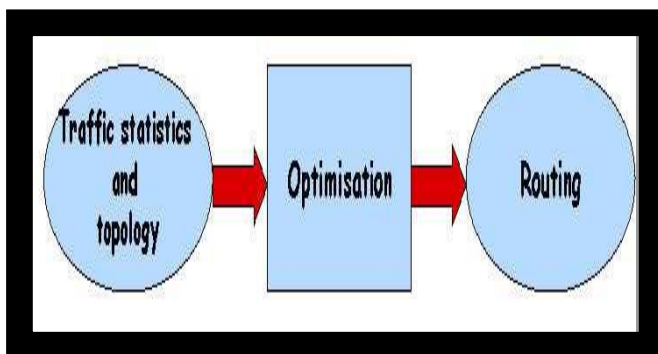


Figure 1.

The first step is the collection of necessary information about network state. To be specific, the current traffic situation and network topology. The second step is the optimisation calculations. And finally, the third step is the mapping from optimization to routing parameters. Current routing protocols are designed to be simple and robust rather than to optimize the resource usage.

The two most common intra-domain routing protocols today are OSPF (Open Shortest Path First) and IS-IS (Intermediate System to Intermediate System). They are both link-state protocols and the routing decisions are typically based on link costs and a shortest (least-cost) path calculation. While this approach is simple, highly distributed and scalable these protocols do not consider network utilization and do not always make good use of network resources. The traffic is routed on the shortest path through the network even if the shortest path is overloaded and there exist alternative paths. With an extension to the routing protocols like equal-cost multi-path (ECMP) the traffic can be distributed over several paths but the basic problems remain. An underutilized longer path cannot be used and every equal cost path will have an equal share of load.

3. CLASSIFICATION OF TRAFFIC ENGINEERING METHODS

A classification of traffic engineering [12], schemes is possible along numerous axes. Our framework is intended to facilitate the analysis and help us identify the requirements for traffic engineering.

1. Optimize Legacy routing vs. Novel routing mechanisms. One approach is to optimize legacy routing protocols. The advantage is easy deployment of the traffic engineering mechanism. However, the disadvantage is the constraints imposed by legacy routing.
2. Centralized vs. Distributed solutions. A centralized solution is often simpler and less complex than a distributed, but is more vulnerable than a distributed solution.
3. Local vs. Global information. Global information of the current traffic situation enables the traffic engineering mechanism to find a global optimum for the load balancing. The downside is the signalling required to collect the information. In addition, in a dynamic environment, the information quickly becomes obsolete.
4. Off-line vs. On-line traffic engineering. Off-line traffic engineering is intended to support the operator in the management and planning of the network. On-line traffic engineering on the other hand, reacts to a signal from the network and perform some action to remedy the problem.

4. COMPONENT SPECIFICATION

As already mentioned, AMPLE encompasses four distinct tasks, namely (1) offline network dimensioning through link weight optimization for achieving maximum intra-domain path diversity across multiple MT-IGP routing topologies, and (2) adaptive traffic splitting ratio adjustment across these routing topologies for achieving dynamic load balancing in case of unexpected traffic dynamics.

(3) Network monitoring is used to get the volume of the traffic flow in the network and it constantly monitor the network and the amount of the traffic flow.

(4) Another module is proposed which is the Traffic Analyzer which is used to manage the traffic flow and maintain the correct order, which is shown in figure 2.

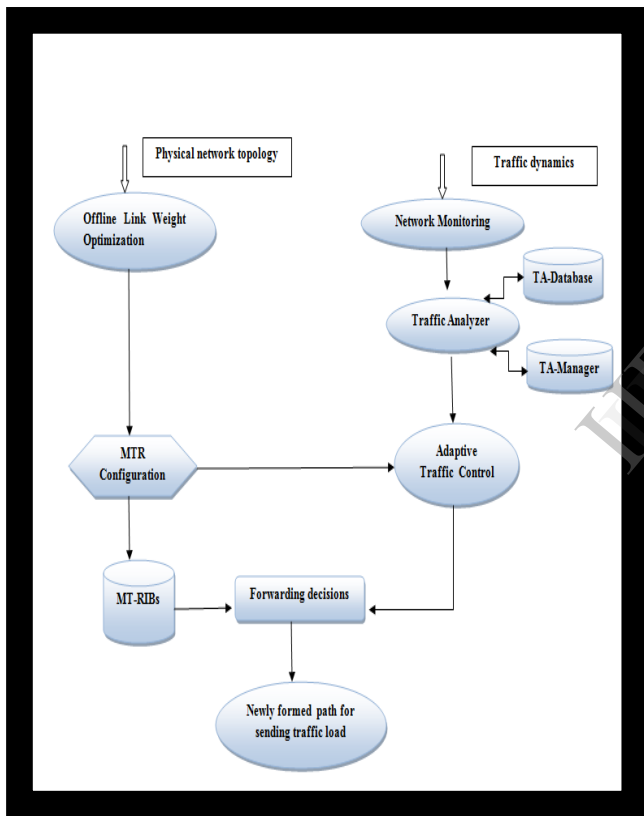


Figure 2.

5. OFFLINE LINK WEIGHT OPTIMIZATION

In Offline link weight optimization, the binary metric of Full Degree of Involvement (FDoI) [1] [2], to evaluate the overall path diversity for a given MT-IGP link weight configuration. More specifically, the FDoI value for a link with respect to an S-D pair is set to 1 if this link is shared by the shortest IGP paths across all VRTs for that S-D pair, otherwise it is set to

0. The fundamental idea behind this scheme follows the strategy of offline provisioning of multiple diverse paths in the routing plane and online spreading of the traffic load for dynamic load balancing in the forwarding plane. The approach can be briefly described as follows. MT-IGPs are used as the underlying routing protocol for providing traffic-agnostic intradomain path diversity between all source-destination pairs. With MT-IGP routing, customer traffic assigned to different virtual routing topologies (VRTs) follows distinct IGP paths according to the dedicated IGP link weight configurations within each VRT.

Our ultimate objective is to minimize the chance that a single link is shared by all routing topologies between each source-destination pair. The objective is to avoid introducing critical links with potential congestion where the associated source destination pairs cannot avoid using it no matter which routing topology is used. The Full Degree of Involvement (FDoI), which indicates whether a critical link l is included in the IGP paths between source-destination pair

(u, v) in all routing topologies:

$$FDOI_l^{u,v} = \begin{cases} 1 & \text{if } DoI = |R| \\ 0 & \text{Otherwise} \end{cases}$$

The optimization objective of OLWO is to minimize the sum of FDoI values across all network links with regard to all S-D pairs. If this sum is equal to 0, then no critical link is formed given the underlying MT-IGP link weights, which means that at least one source in the network will always be able to find alternative path(s) to bypass the over-loaded link given any single link congestion scenario.

6. NETWORK MONITORING

Network monitoring [1], is responsible for collecting up-to-date traffic conditions in real-time and plays an important role for supporting the ATC operations and it forms input for the traffic analyzer. AMPLE adopts a hop-by-hop based monitoring mechanism. The basic idea is that a dedicated monitoring agent deployed at every PoP node is responsible for monitoring:

- The volume of the traffic originated by the local customers toward other PoPs (intra-PoP traffic is ignored).
- The utilization of the directly attached inter-PoP links.

7. TRAFFIC ANALYZER

Traffic monitoring and analysis is essential in order to more effectively troubleshoot and resolve issues when they occur, so as to not bring network services to a stand still for extended periods of time. Numerous tools are available to help administrators with the monitoring and analysis of network traffic.

Network traffic analysis which provide a clear overview of the structure of traffic and enable the efficient detection of potential problems and irregularities. Network traffic analysis is the process of capturing network traffic and inspecting it closely to determine what is happening on the network. A number of technologies have been developed to increase our understanding of the behavior of network traffic. It enables an overview of the statistics of the traffic passing through our network and is recommended for environments where the network devices can support this technology.

In the previous module only the volume and the amount of the traffic flow can be known and if this raw data is given to the Adaptive Traffic Controller means it will reduce the efficiency of ATC. So it is very necessary for the traffic analyzer to view all the traffic and manage it and then give that input to the ATC.

It consists of two parts to manage the traffic

1. Traffic Analyzer Manager- which do the function of collecting the incoming traffic and maintain the proper order of the incoming traffic so that whichever traffic link comes first will be the first one to be sent to the ATC for efficient traffic splitting.

2. Traffic Analyzer Database- which is the central storage of the incoming traffic at that interval of time, and this database are mainly used for the prediction of the next incoming traffic and so can provide efficient steps for it.

The results of this analysis provide us with the following information:

1. Information on the total amount of traffic between individual subnets (bytes, packets, connections);
2. Information on the total amount of local traffic (protocols, servers and hosts);
3. Information about external access to our network (protocol, service, host);
4. A prediction of future traffic behavior;
5. The existence of a virus in the network (a large amount of incoming or outgoing traffic is being generated);
6. Generated);

7. Dos attacks (a large amount of traffic is being generated towards dns or email servers);
8. Bandwidth abuse (such as, YouTube, face book, or torrent);
9. Access to forbidden websites;
10. Attempts to attack/access protected network devices;

Advantages:

1. Centralized data collection.
2. The existing equipment may be used.
3. Easy configuration.
4. The possibility of collecting other parameters during communication, such as, delays, variation of delays or lost packets.

The total action is given below figure 3.

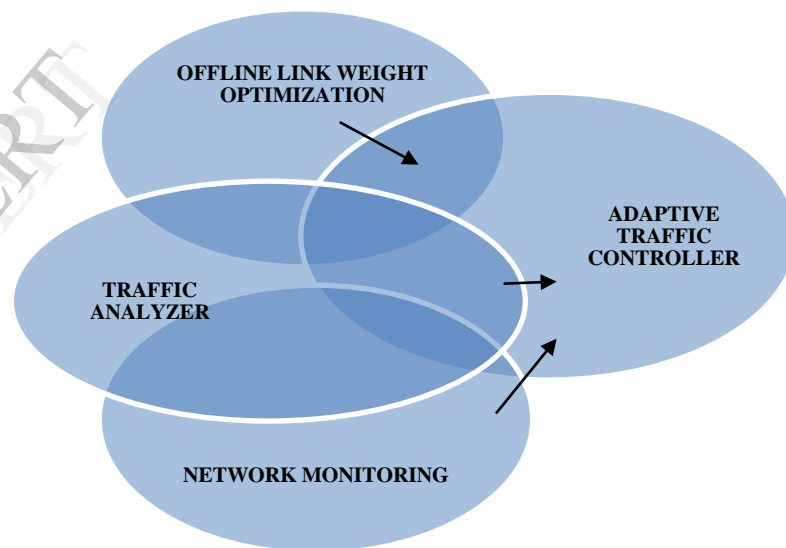


Figure 3.

8. ADAPTIVE TRAFFIC CONTROL

In this section [1] [2], adaptive adjustment of traffic splitting ratio at individual PoP source nodes. In a periodic fashion at a relatively short-time interval (e.g., hourly), by getting input from the Traffic Analyzer, the central TE manager needs to perform the following three operations:

1. Measure the incoming traffic volume and the network load for the current interval.

2. Compute new traffic splitting ratios for all PoP nodes based on the measured traffic demand and the network load for dynamic load balancing.
3. Instruct individual PoP nodes to enforce the new traffic splitting ratio over their locally originated traffic.

Given the optimized MT-IGP link weights produced by OLWO, Adaptive Traffic Control (ATC) can be invoked at short-time intervals during operation in order to re-optimize the utilization of network resources in reaction to traffic dynamics.

The optimization objective of ATC is to minimize the Maximum Link Utilization (MLU), which is defined as the highest utilization among all the links in the network. The rationale behind ATC is to perform periodic and incremental traffic splitting ratio re-adjustments across VRTs based on traffic pattern "continuity" at short a timescale, but without necessarily performing a global routing re-optimization process from scratch every time. To fulfill the second task, a Traffic Engineering Information base (TIB) is needed by the TE manager to maintain necessary network state based on which new traffic splitting ratios are computed.

The structure TIB [1], which consists of two inter-related repositories, namely the Link List (LL) and S-D Pair List (SDPL). The LL maintains a list of entries for individual network links. Each LL entry records the latest monitored utilization of a link and the involvement of this link in the IGP paths between associated S-D pairs in individual VRTs. More specifically, for each VRT, if the IGP path between an S-D pair includes this link, then the ID of this S-D pair is recorded in the LL entry. On the other hand, the SDPL consists of a list of entries, each for a specific S-D pair with the most recently measured traffic volume from S to D.

Each SDPL entry also maintains a list of subentries for different VRTs, with each recording the splitting ratio of the traffic from S to D, as well as the ID of the bottleneck link along the IGP path for that S-D pair in the corresponding topology.

During each ATC interval, the TIB is updated upon the occurrence of two events. First, upon receiving the link utilization report from the network monitoring component, the TE manager updates the link utilization entry in the LL and the ID of the bottleneck link for each S-D pair under each VRT in SDPL. Second, when the adaptive traffic control phase is completed and the new traffic splitting ratios are computed, the splitting ratio field in SDPL is updated accordingly for each S-D pair under each VRT.

CONCLUSION

In this paper AMPLE, a novel TE approach that enables dynamic load balancing in operational IP networks. Instead of frequently changing IGP link weights, we use multi-topology IGP routing protocols that allow adaptively splitting traffic across multiple routing topologies. Offline link weight optimization is performed in order to enable path diversity, followed by the adaptive control of traffic splitting across individual routing topologies according to the monitored traffic and also along with the network monitoring another module is used which is Traffic Analyzer for Traffic Management.

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