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DISTRIBUTED MEASUROUTING FOR TRAFFIC MONITORING

[#1] V.Nandini, [#2] M. Vamsi Kiran, [#3] K. Chaitanya Latha

Department of Computer Science and Engineering,
Vignan's Nirula Institute of Technology and Science for Women.Guntur, A.P,India

Abstract:- The technique of MeasuRouting acquires monitor deployment as an input and chooses the way to direct traffic to optimize the objectives of measurement. MeasuRouting can abstractly amend to the patterns of the changing traffic patterns and objectives of measurement. The most important challenge intended for MeasuRouting is to effort within the checks of active operations of intra domain traffic engineering that are geared for resources of powerfully utilizing bandwidth, otherwise congregation of the constraints of quality-of-service. The primary idea behind MeasuRouting is to separate traffic aggregates into subpopulations and then differentially direct the subpopulations of traffic based on the monitoring capability of obtainable routes and the comparative measurement significance of the traffic subpopulations. MeasuRouting can be used to preserve measurement resources and can improve the correctness of such structures by means of selecting the traffic that pass through the node. The performance of MeasuRouting is susceptible to the number of paths present connecting pairs of nodes. A general routing framework was proposed for MeasuRouting, assuming the incidence of mechanisms of special forwarding. There are three essential ways in which MeasuRouting improves the utility of traffic monitoring devoid of violating policy of traffic engineering.

Keywords: *MeasuRouting, Traffic engineering, Quality-of-service, Traffic patterns.*

I.INTRODUCTION

The most favourable placement and configuration of monitoring infrastructure intended for a precise measurement objective in general assumes a priori knowledge with reference to the traffic features. In view of the fact that routing is dynamic in nature Our scheme is harmonizing to the well-investigated problem of monitor placement that obtains traffic routing as an input and make a decision where to situate monitors to optimize the objective of measurement [4]. The most important challenge intended for MeasuRouting is to effort within the checks of active operations of intra domain traffic engineering that are geared for resources of powerfully utilizing bandwidth, otherwise congregation of the constraints of quality-of-service [11]. A framework was proposed for MeasuRouting that permits traffic of rerouting toward the conclusion of optimizing objectives of ISP's measurement while being amenable to constraints of traffic engineering.

A straightforward situation involves consistent sampling of routers implementation or an estimation of it, with network operators being concerned in observing a subset of the traffic [8]. MeasuRouting can possibly be used to make make the most of their overall rate of sampling. The technique of MeasuRouting acquires monitor deployment as an input and chooses the way to direct traffic to optimize the objectives of measurement. MeasuRouting can abstractly amend to the patterns of the changing traffic patterns and objectives of measurement [1] [5]. The primary idea behind MeasuRouting is to separate traffic aggregates into subpopulations and then differentially direct the subpopulations of traffic based on the monitoring capability of obtainable routes and the comparative measurement significance of the traffic subpopulations. MeasuRouting can subsequently direct traffic subpopulations that may have flows of medium-sized across such routers . Important performance gains were shown for MeasuRouting, the preference of experimental networks was

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constrained to networks with an extremely low number of paths present connecting node pairs. A network can contain dissimilar measurement communications of active and passive and deployed algorithms and MeasuRouting can express traffic across paths by means of superior measurement prospective [2] [9]. MeasuRouting can be used to preserve measurement resources and can improve the correctness of such structures by means of selecting the traffic that pass through the node. A general routing framework was proposed for MeasuRouting, assuming the incidence of mechanisms of special forwarding.

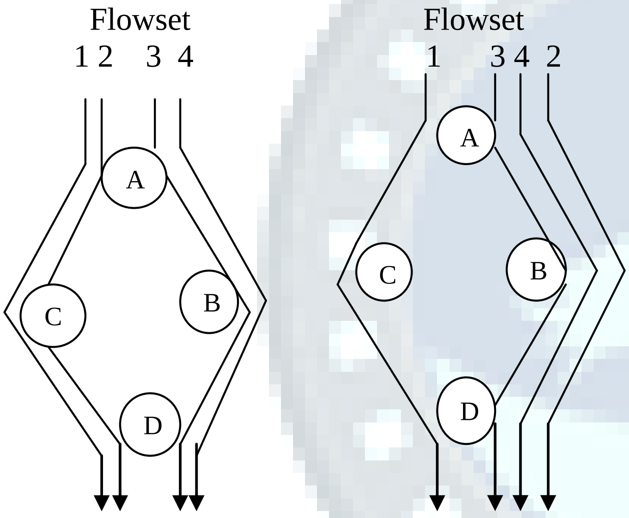

Fig1: An overview of routing use to focus on a traffic subpopulation

MeasuRouting can, consequently, direct our MeasuRouting have got to be cognizant of measurement of fine-grained traffic any inferences that rerouting traffic has on subpopulations devoid of disturbing the the policy of traffic engineering. There are aggregate routing. Fig1 depicts the unique three essential ways in which MeasuRouting routing that follows the policy of traffic improves the utility of traffic monitoring engineering and also represents a routing devoid of violating policy of traffic that contravenes the policy of traffic engineering. The policy of traffic engineering with the intention of routing all engineering is generally definite for the way through router [3] . It is aggregated flows [6]. The primary idea significant to make a note of that the aggregate traffic has to span multiple paths monitoring performance. Important successively intended for MeasuRouting to performance gains were shown for be functional in this way. If the aggregate MeasuRouting, the preference of traffic passes through a single path, then no chance exists to differentially direct traffic experimental networks was constrained to networks with an extremely low number of subsets [7]. The subsequent way in which paths present connecting node pairs. The MeasuRouting is helpful stems from the primary idea behind MeasuRouting is to description of objectives of traffic separate traffic aggregates into engineering. The objectives of traffic subpopulations and then differentially direct engineering may possibly be insensible to the accurate placement of traffic aggregate the subpopulations of traffic based on the monitoring capability of obtainable routes and only obtain cognizance of review and the comparative measurement metrics such as the utmost link utilization significance of the traffic subpopulations. across the network [10]. At last, a network The means traffic aggregates are operator can identify a convinced disintegrating into numerous subpopulations permissible level of violations of traffic has an impact on the performance of engineering policy. Such a requirement MeasuRouting. would facilitate a trade-off connecting the benefit derived from MeasuRouting and observance to the policy of traffic MeasuRouting can be used to preserve engineering.

II. RELATED WORK

Earlier work in the area of traffic monitoring has focused on:1) inferring characteristics of original traffic from sampled traffic; 2) investigating and improving the effect of oblivious sampling on monitoring certain traffic subpopulations; and 3)placing monitor agents at certain strategic network locations. Guanyao Huang, Chia-Wei Chang, Chen-Nee Chuah, and Bill Lin presented an MMPR (Measurement-aware Monitor Placement and Routing) framework that jointly optimizes monitor placement and dynamic routing strategy to achieve maximum measurement utility. The main challenge in solving MMPR is to decouple the relevant decision variables and adhere to the intra-domain traffic engineering constraints. They formulate it as an MILP (Mixed Integer Linear Programming) problem and propose several heuristical gorithms to approximate the optimal solution and reduce the computation complexity. Through experiments using real traces and topologies they showed that heuristic solutions can achieve measurement gains that are quite close to the optimal solutions. Anirudh Ramachandran, Srinivasan Seetharaman, NickFeamster and Vijay Vazirani presented the design, implementation, and evaluation of Flex Sample, a traffic monitoring engine that dynamically extracts traffic from subpopulations that operators define using conditions on packet header fields. Flex Sample uses a fast, flexible counter array to provide rough estimates of packets membership irrespective subpopulations. Based on these coarse estimates, FlexSample then makes per-packet sampling decisions to sample proportionately from each subpopulation, subject to an overall sampling constraint. They applied Flex Sample to extract subpopulations such as port scans and traffic to high-degree nodes and find that it is able to capture significantly more packets from these subpopulations than conventional approaches. A. Medina, N. Taft, K. Salamatian, S. Bhattacharyya and C. Diot makes two contributions for POP-to-POP traffic matrices (TM) . The primary contribution is the outcome of detailed comparative evaluation of the three existing techniques. They evaluated those methods with respect to the estimation errors yielded, sensitivity to prior information required and sensitivity to the statistical assumptions. The secondary contribution of their work is the proposal of a new direction for TM estimation based on using choice models to model POP fan outs. These models allow us to over come some of the problems of existing methods because they can incorporate additional data and information about POPs and they enable to make a fundamentally different kind of modeling assumption. Their proposed approach can be used in conjunction with existing or future methods in that it can bemused to generate good priors that serve as inputs to statistical inference techniques'. Chaudet, E. Fleury, I. Guerin Lassous and H. Rivanostudied the passive approach that attaches specific devices to links in order to monitor the traffic that passes through the network and the active approach that generates explicit control packets in the network for measurements and the problem of assigning tap devices for passive monitoring and beacons for active monitoring. Minimizing the number of devices and finding optimal strategic locations is a key issue, mandatory for deploying scalable monitoring platforms. They presented a combinatorial view of the problem from whichthey derived complexity and approximability results, as wellas efficient and versatile Mixed Integer Programming (MIP)formulations

III. DISTRIBUTED MEASUROUTING ALGORITHM

Up to this point, our traffic model is based on the assumption that agents at end hosts have full control over their traffic and they can access the current TE cost value of all paths. Obviously, none of these is true in the real-world IP networks. In this section, we study our Nash equilibrium model that both considers effective non-sampling rate and TE-violation penalty in a dynamic/distributed, round-based variant. Suppose agents at end hosts are activated every Ts seconds and are allowed to change their routes simultaneously. Since they all intend to migrate traffic to a path with minimal cost value, such global migration behavior will result in greatly increased congestion on the optimal path (from measurement's perspective) and lead to oscillations. Fischer et al. proposed the so-called (α-β)-exploration-replication policy in [11] to avoid traffic migration oscillation by using adaptive path-sampling methods. Although [11] is designed for the cost model defined for latency, we apply and modify it to our newly defined non-sampling rate cost model.

In this section, we present our adaptive algorithm, Dis-tributed MeasuRouting (DisMR), which runs on each individ-ual routers to make routing decisions on how to adjust routing split ratios for each destination traffic. In order to do this, each router

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first needs to measure the non-sampling rate Ψ(R,Vi) for each link to next-hop routers Vi and exchanges informa-tion with other routers by using Distributed Ψ-Propagation Algorithm. After receiving A(Vi,D), the expected average non-sampling rate of the path to every destination D via Vi from next-hop routers, each router can compute Ψ(R,D,Vi) locally and use this information to conduct the Adaptive Weight Calculations. A(Vi,D) can be treated as the condensed information of expected non-sampling rate beyond Vi. Here we assume synchronized routing-updates of these link/path costs. The impacts of asynchronous update issue could be solved similarly in [5] where we defer as our future work. In summary, each router R needs to maintain the following sets of information for all possible next-hop routers Vi ∈ N(R,D) to every destination D:

1) Ψ(R,Vi): the non-sampling rate value that also includes the penalty value to reflect the current link utilization on link R → Vi.
2) A(Vi,D): the expected average non-sampling rate value to destination D via Vi (Vi 99K D) which is received periodically from neighbor router Vi.
3) w(R,D,Vi): current dynamically changeable weights for traffic routed from current router R to destination D via Vi.

Algorithm 1 describes the distributed Ψ-metric propagation procedure of DisMR in details. Every Ts seconds, the set of Ψ(R,D,Vi) values are updated at each router by using the information of current Ψ(R,Vi) and previous A(Vi,D) from neighbors (line 7) where Ts controls how often the partici-pated routers update their traffic split ratios. Subsequently, the new A(R,D) values are re-calculated by using the current weights w(R,D,Vi) and broadcast to all of the neighbor routers (line 9-10). Meanwhile each router will execute the Adaptive Weight Calculation procedure to reassign the weights w(R,D,Vi) for all possible next-hop routers Vi ∈ N(R,D) to every destination D by using updated information of Ψ(R,D,Vi) (line 12).

Algorithm 1: Distributed Ψ – Propagation Algorithm:

1: assume current node is R
2: While every T_s secs do
3: initialize new update message $M(T_s)$
4: for each destination D in routing table do
5: for every next –hop nodes V_i Є N (R,D) do
6: measure Ψ (R,V_i)
7: $\Psi(R,D,V_i) = \Psi(R,V_i) \cdot A(V_i,D)$
8: end for
9: $A(R,D) = \sum_{v_i Є N(R,D)} \varpi(R,D,V_i) \cdot \Psi(R,D,V_i)$
10: Append A(R,D) in $M(T_s)$
11: end for
12: Execute one of the Adaptive-Weights calculations
13: Send $M(T_s)$ to all neighbor nodes
14: After receiving $M(T_s)$ from neighbor node U_i
15: for each $A(U_i,D)$ in $M(T_s)$ do
16: if U_i Є N (R,D) then
17: update $A(U_i,D)$ from $M(T_s)$
18: end if
19: end for
20: end while

Algorithm 2: Adaptive Weight Calculation:

1: after ψ(R,D,V) information is updated
2: for each destination D in routing table do
3: for every next-hop node V_i ЄN(R,D) do
4: $\varpi_{new}(R,D,V) = \varpi(R,D,V)(R,D)$ do
5: end for
6: for every pair of next-hop nodes V_1, V_2 Є N(R,D) do
7: if $\Psi(R,D,V_1) > \Psi(R,D,V_2) + e \times m_c$ then
8: Calculate $P_M = \psi(R,D,V_1) - \psi(R,D,V_2) / \psi(R,D,V_1) + \boldsymbol{\alpha}$
9: if with probability P_M then
10: if $(R,D,V_2) \neq 0$ then
11: $\Delta = (1 - \boldsymbol{\beta}) \cdot \varpi(R,D,V_2) \cdot \Delta \boldsymbol{f}i\boldsymbol{x}$
12: else
13: $\Delta = \boldsymbol{\beta} / N(R,D) \cdot \Delta \boldsymbol{f}i\boldsymbol{x}$
14: end if
15: $\varpi_{new}(R,D,V_1) = \varpi(R,D,V_1) - \Delta$
16: $\varpi_{new}(R,D,V_2) = \varpi(R,D,V_2) + \Delta$
17: end if
18: end if
19: end for
20: Use $\varpi_{new}(R,D,V_i)$ to distribute the traffic
21: end for

Algorithm 2 presents the Adaptive Weight Calculation pro-cedure of DisMR. For every pair of next-hop routers (e.g., say V1, V2), it first compares their cost metric Ψ(R,D,Vi),i = 1,2 and conducts the migration procedure if the difference of their cost values is more than the migration threshold 1 ($\epsilon \times m\_$) (line 7). Otherwise, DisMR will not change the weights of V1 and V2. Subsequently, it computes the migration probability (line 7-9) and the adaptive migration amount (line 10-14) according to the (α-β)-exploration-replication policy [11]. For every pair of next-hop nodes in each round (line 3), we denote V1 to be the node with larger cost value, Ψ(.) and V2 to be the alternate node. From statistic point of view, the adaptive migration amount Δ should be calculated depending on node V2. If V2 is already used (e.g., w(R,D,V2) ≠ 0), then Δ = (1−β)•w(R,D,V2)•Δfix from proportional sampling perspective. If V2 is unused (e.g., w(R,D,V2) = 0), then Δ = N(R;D) •Δfix from uniform sampling perspective where Δfix is the unit of weight shifted in one round and it controls the convergence speed of DisMR (details are discussed in Section IV-A). The migration probability is decided as PM =(R;D;V;)− (R;D;V2) based on [11] in order to avoid oscillations from global synchronized migrations (line 8). This adaptive migration policy ensures that smaller non-sampling rate gains, Δ= ΨP − ΨQ, only cause a smaller migration possibility and avoid oscillation. The implementation of dis-tributing traffic according to W(R,D,Vi) for each router can use the hashing methods described in [3–5]. If W(R,D,Vi) are constant, there is no packet reordering occurred. However once W(R,D,Vi) are shifted, a fraction of the traffic needs to be rerouted and probably causes packet reordering. The solution is to make the time interval when W(R,D,Vi) shifts occur not smaller than the time TCP needs to recover from packet losses in [3].

DisMR Applied in Dynamic Traffic Scenario

Here we compare the performance of DisMR with static centralized MeasuRouting in dynamic traffic scenario. We conducted these experiments using GEANT topology with the traffic snapshots on Apirl 11 and we change the traffic patterns in every 30 minutes based on the traces in [8]. Here Static-MR consistently uses the same traffic splitting strategy based on the initial traffic snapshot (00:30), while DisMR will adaptively adjust its traffic splitting policy with the new traffic pattern. Fig. 1 shows the real-time max TE-violations and the changes of measurement gain for DisMR and Static-MR in GEANT network/trace. Initially, DisMR has similar gain as Static-MR after it reaches equilibrium state (00:38) in Fig. 1(a). We observed that the measurement gain of Static-MR decreases a lot when traffic pattern changed. When the time interval increases (03:30), the degradation becomes severe but DisMR can still outperform Static-MR (e.g., $1{:}9-1{:}7$ ⊄ 11.7%). In Fig. 1(b), both DisMR and Static-MR have large TE-violation when the traffic suddenly changes but DisMR can quickly improve its TE-violation in short period of time compared

TABLE I

Δ_{fix} VARIATIONS WITH $m\_ = 10^6$, $\epsilon = 0.001$ IN ABILENE

Δfix	10^{-1}	$5 . 10^{-2}$	10^{-2}	$5 . 10^{-3}$	10^{-3}
iterations	322	440	3416	7965	23068
TE-violation	$3.524 . 10^{-5}$	$1.062 . 10^{-5}$	$9.236 . 10^{-6}$	$1.33 . 10^{-6}$	$1.10 . 10^{-6}$
Gain(DisMR) *Gain(Static MR)*	2671.9 2671.8	2671.72 2671.8	2671.57 2671.8	2671.54 2671.8	2671.57 2671.8

1:7

to Static-MR (e.g., up to $0:35$ t $100X$ at time (03:00)). In brief, DisMR has improved higher measurement gains and much lower TE-violations compared to static, centralized MeasuRouting in dynamic traffic scenario.

V. CONCLUSION

In this paper we propose a distributed measurement-aware traffic engineering protocol, DisMR, based on game-theoretic rerouting policy. It achieves the decent balance between measurement-aware routing and traffic engineering objectives by the introduction of a new routing game and distributed routing control. We show that DisMR guarantees both a provable Nash equilibrium and a fast convergence without significant oscillations. The measurement gain of DisMR at the equilibrium state is close to the maximum achievable gain calculated by offline/centralized MeasuRouting in static traffic case. DisMR also improves the measurement gain and TE-violations of MeasuRouting in dynamic traffic scenario.

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AUTHOR'S PROFILE:

[1] V.Nandini M.Tech (CSE) Department of Computer Science & Engineering at Vignan's Nirula Institute Of Technology & Science for Women, Guntur.

[2] Mr. M Vamsi kiran Assistant Professor, Department of Computer Science Vignan's Nirula Institute of Tech. & Science for women , He has deal many projects under Computer Networks domain and interested areas are Image Processing, Computer Networks.

[3]Kolluru Chaitanya Latha pursing M.Tech(C.S.E) at Vignan's Nirula Institute of technology and science for women. Interested areas are Networks and Network Security.