Routing Strategy for Data transfer of Varying Packet Sizes in Virtual Private Networks

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Abstract

The paper evolves a data transfer mechanism, with a view to arrive at the best performance in the minimum bandwidth path of a wired Virtual Private Network (VPN). It orients to establish a service similar to that of a private dedicated network with leased lines for the endpoints of the VPN. The methodology adequately provisions the hose model of the VPN to allow an acclaimed degree of performance across a shared architecture. The data packets are routed through independent paths in order to ensure secure communication among the network users in the customer sites. The scheme attempts to extricate an admirable class of service over transfer of increasing data size and project its large scale communicating capability. It includes NS2 based simulation results to illustrate the merits of the developed methodology and reveal the suitability of VPN for practical applications.

Keywords: *Single path routing, QoS, VPN, Bandwidth, Performance metrics*

1. Introduction

A Virtual Private Network (VPN) is a virtual topology created on top of an existing physical network such as the global Internet. It acts like a separate, private network, providing security and privacy besides saving the cost of installing physical links as in a traditional private network. The VPNs enjoy the advantages of scalability, portability, flexible operation and a reliable service to the end users [1].

The massive increase in data traffic driven primarily by the explosive growth of the internet along with the propagation of VPNs elaborates a restriction in the bandwidth requirements that demand the reconstruction of the entire network architecture, and explore changes to the existing infrastructure. The process of enabling the traffic flow to utilize the network structure and create a uniform distribution of traffic is referred to as traffic engineering (TE) [2-5]. The basic challenge owes to the establishment, maintenance, and management of TE paths to assure satisfactory service delivery, maximize resource efficiency, and avoid congestion on any single path.

The VPNs are constructed to offer services with certain QoS guarantees, of which the available bandwidth is of extreme significance. In light of the view that nodal load and delay characteristics cannot be incorporated as part of the routing strategy, the most practical way of handling delay and losses is to convert such requirements in terms of effective bandwidth needs for the connection request.

Routing is primarily the act of moving information and echoes to select the paths for traffic to flow within the network. It is a process of finding a path to connect the source and destination nodes using a scalable configuration [6]. Owing to the fact that the execution time and memory requirement of a routing algorithm increases with the size of the network and given the QoS demands from the users a properly designed routing algorithm can maximize the efficiency and improve the network performance.

The performance of sub-provisioning model of a wired VPN has been investigated and the results obtained through multipath routing found to deliver a significant improvement in the blocking performance [7]. Two algorithms for provisioning the hose model of VPN have been developed and their performance evaluated using the rejection ratio and the protected bandwidth allocation as the performance metrics [8]. A multipath routing protocol that reduces energy consumption and increase network lifetime has been suggested for Wireless Sensor Networks (WSNs). The results have been found to balance energy consumption among nodes and reduce the average energy consumption [9]. A QoS aware multipath routing algorithm suitable for real time application in WSN has been outlined [10]. The NS-2 results of an adaptive multipath routing algorithm have been found to relieve congestion using appropriate size of the buffer at the links in WSN [11]. An energy efficient multipath routing protocol has been proposed for Wireless Multimedia Sensor Networks to provide a reliable transmission environment in the minimum energy path [12]. The problem of routing in a WSN has been probabilistically approached as a path based energy minimization problem subjected to QoS routing constraints and solved to outperform the benchmark model results [13]. A quadratic constrained formulation has been solved using a mathematical program methodology to accomplish a load balanced routing on the hose model of a wired VPN [14].

There is however a continuing need to explore better mechanisms to transfer the data with minimum use of bandwidth and accomplish acceptable levels for the indices.

2. Problem Description

The basic objective is to design a strategy for transfer of data in a VPN such that it optimizes the available bandwidth and extract the desired Quality of Services (QoS). It inflicts to develop a suitable procedure for routing the resources between the chosen source and destination on a MPLS platform through different paths and acquire a superior performance for the minimum bandwidth path. The scheme uses performance metrics to measure the relative efficiency and display the NS-2 simulation graphs obtained during the evaluation phase.

3. Proposed Scheme

VPNs appears to emerge as a progressively vital source of revenue for Internet Service Providers (ISPs). It establishes connectivity between a set of geographically dispersed endpoints over a shared network infrastructure [15]. The primary focus endeavours to provide the VPN endpoints with a service comparable to that of a private dedicated network recognized with leased lines. Thus, providers of VPN services are required to address the Quality of Service (QoS) and security issues associated with deploying a VPN over a shared IP network.

A VPN as seen from the architecture in Fig.1 consists of provider core devices (P devices) that are completely VPN-unaware and provider edge devices (PE devices). It implements the VPN functionalities, customer devices (C devices) and a number of geographically dislocated (private) customer sites that are attached to PEs through customer edge (CE devices) devices and communicate with each other using a shared backbone.

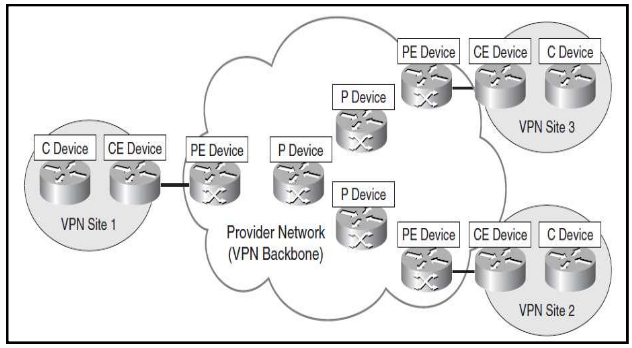

Fig. 1 VPN Architecture

The hose model, an exquisite service interface accommodates performance guarantees for the traffic to the given endpoint from the set of all other endpoints in the VPN [16]. It creates the link into the network and allows the customer to send traffic into the network without the need to pre-specify or predict point-to-point loads [17].

The hose model effortlessly used with VPNs [18] inherits ease of specification, flexibility, multiplexing gain and characterization. A traffic characterization is simple in the sense it needs only to specify the aggregates at ingress/egress points to explicitly determine the demands between all origin destination pairs. It provides the customer with a natural service model and provisions to meet the actual traffic demands offered to the network. Thus specifying the traffic facilitates dimensioning the resources to support a set of possible traffic loads in tune with its dynamic characteristics. The other associated advantages are that it encapsulates additional multiplexing at the access points as well as within the network and characterize the traffic due to the smoothing action that results from aggregation at VPN endpoint's hoses.

Multiprotocol Label Switching (MPLS) is a mechanism in high-performance telecommunications networks which directs and carries data from one network node to the next. It is a highly scalable, data-carrying procedure that creates virtual links between distant nodes. The scheme provides a unified data-carrying service for both circuit-based clients and packet-switching clients and emulates a datagram service model. It enables to manage a network for quality of service (QoS) and support different mixtures of traffic [19-20].

It involves setting up a specific path for a given sequence of packets, identified by a label in each packet, thus saving the time needed for a router to look up the address of the next node to which the packets are to be forwarded. The packet-forwarding decisions are made solely on the contents of this label, without the need to examine the packet itself. When a packet enters the network at a particular router, it is labeled differently from the same packet entering the network at a different router, and avails the use of the ingress router to make the forwarding decisions.

It may be required to force a packet to follow a particular route which is explicitly chosen at or before the time the packet enters the network to suit specific demands. It is then necessary to encode and explicitly identify the route through what is known as source routing. The routers in addition to choosing the packet's next hop are empowered to decide a packet's precedence or class of service. It can use different discard thresholds or scheduling disciplines to different packets and infer from the label the service category expressed as the combination of a Forward Equivalent Classes (FECs) and a precedence or class of service.

The flow diagram explaining the theory of transfer of message through independent paths to ensure the minimum utilization of bandwidth and guarantee a wide range of QoS criteria is shown in Fig. 2.

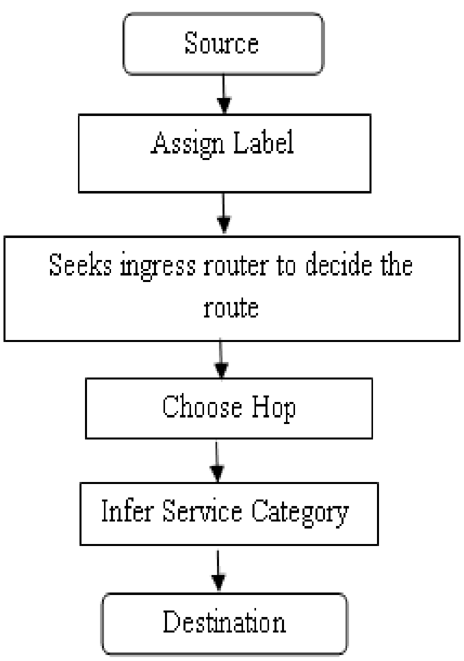

Fig. 2 Flowchart of the Proposed Approach

4. Simulation Results

The strategy is evolved to transfer data through three different paths connecting the same source and destination nodes in a network formed with fifty nodes. The procedure is formulated to carry the packets through only one path at a time and the flow explained using diagrams in Figs. 3 to 5. The performance is evaluated with the help of NS-2 simulation for a data size of 1000 over the paths across identical time frames.

Fig. 3 Data Flow in Path 1

Fig. 4 Data Flow in Path 2

Fig. 5 Data Flow in Path 3

The indices measured in terms of packets received, routing delay, packet loss, energy expended and energy*delay metric for the three paths are tabulated in Table1. The readings compare the performance of the transfer mechanism in the three paths and project the fact that the minimum bandwidth path extracts the highest values for the metrics. The formulation allows to route the most number of packets with minimum delay, suffer from a lower expenditure of energy and provide the minimum energy*delay metric. The transfer of the same packets in the other two paths with the higher bandwidths acquires slightly reduced indices in proportion to the usage of bandwidth.

Table 1. Performance Metrics

Paths	***Bandwidth***	***Packets Received***	***Routing Delay * 10^{-3}***	***Packet Loss***	***Energy Expended*10^{3}***	***Energy*Delay***
1	0.12	22	0.89	1	0.42	0.37
2	0.16	11	2.41	1.2	0.61	1.47
3	0.53	7	3.45	2.7	0.84	2.89

The NS2 graphs in Figs. 6 to 10 relate to the case when the data transfer is accomplished through the path that uses the minimum bandwidth. The variation of bandwidth and the number of packets received in the chosen time frame are shown in Figs. 6 and 7. The routing delay expressed through the same time frame in Fig. 8 appears to be initially high in view of start up and later reach reasonably low values after phases of transition. The gradual increase in the energy expended with time is seen in Fig. 9 and demonstrates the merits of the algorithm. The packet loss increases initially and remains the same in the entire period of transmission as observed from Fig. 10.

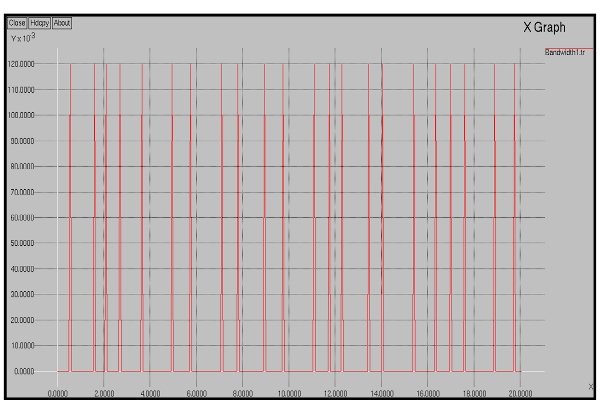

Fig. 6 Bandwidth vs. Time

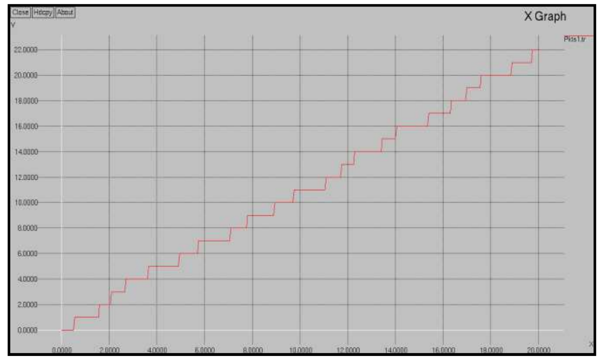

Fig. 7 Packets Received vs. Time

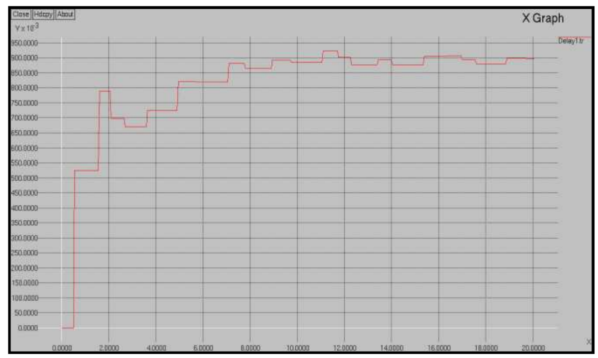

Fig. 8 Routing Delay vs. Time

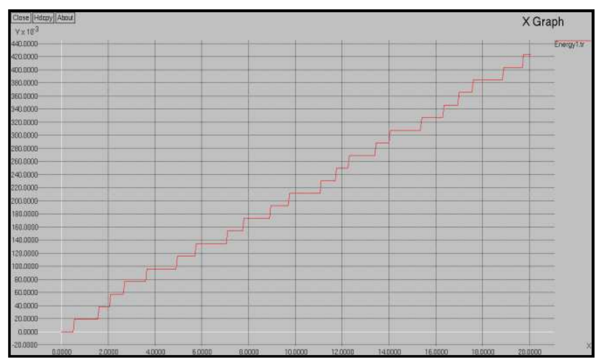

Fig. 9 Energy vs. Time

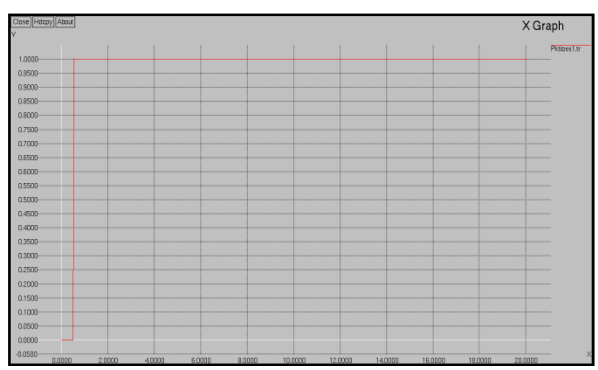

Fig. 10 Packet Loss vs. Time

The bar diagrams displayed through Figs. 11 to 14 relate to the indices obtained when higher data sizes are transmitted in the minimum bandwidth path and elaborate its viability of the proposed scheme for large scale transmission. The average network PDR in any case measures close to hundred as long as transmission in the path continue.

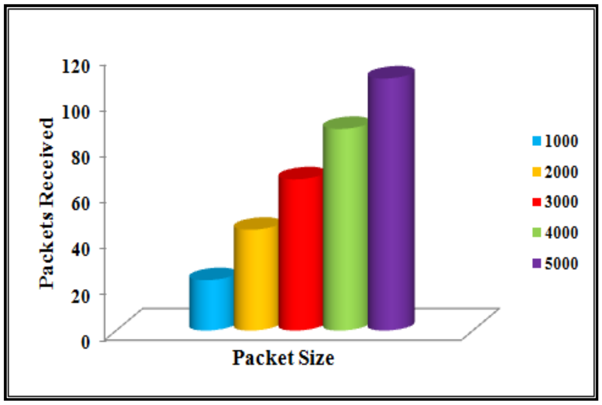

Fig. 11 Packets Received vs. Packet Size

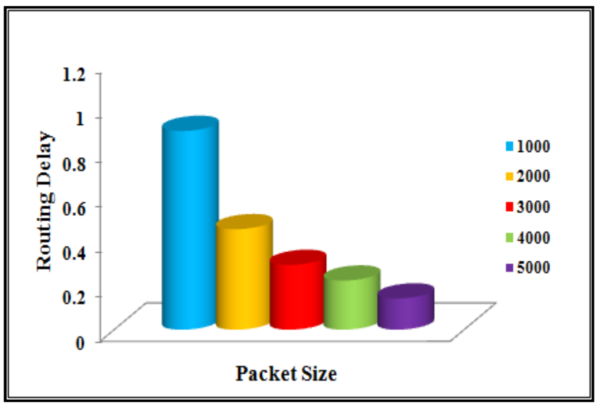

Fig. 12 Routing Delay vs. Packet Size

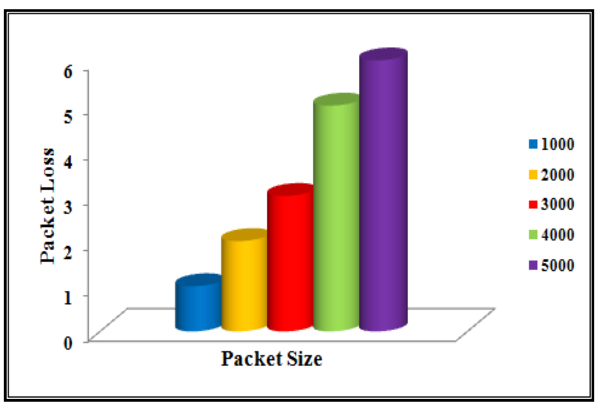

Fig. 13 Packet Loss vs. Packet Size

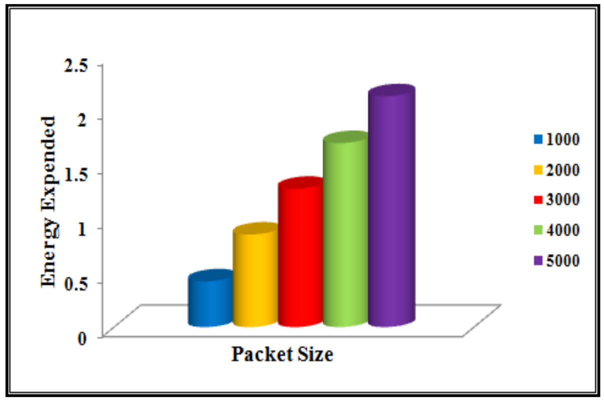

Fig. 14 Energy Expended vs. Packet Size

5. Conclusion

A single path routing strategy suitable for the hose model of a VPN has been designed to transfer varying size data packets between chosen source and destination entities. It has been articulated to enforce the passage of data with minimum utilization of bandwidth in its attempt to accredit the realistic needs of the traffic environment. The performance obtained for a chosen wired network using simulation has been found to offer relative scales in accordance with the increase in bandwidth. The significance of the routing pattern has been established through the metrics computed in the respective transmission periods and favours its use in the emerging scenario. The suitability of the methodology to handle larger sizes of data adds to its benefits and envisages a higher degree of practical utility.

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