Chapter 20
Multiprotocol Label Switching
Virtual Private Networks: Problems, Protocols, Possibilities

Jan Schankin
Christchurch Polytechnic Institute of Technology, New Zealand

Eduardo Correia
Christchurch Polytechnic Institute of Technology, New Zealand

ABSTRACT

Multiprotocol Label Switching (MPLS) was originally designed with the intention of improving the speed with which routers could forward packets in Internet Protocol (IP) networks. Due to significant improvements in packet forwarding, this is no longer an advantage, but the technology has found large-scale industry-wide acceptance because of its greatly widened scope and application. Multiple extensions and enhancements to the protocol make it capable of solving an array of current service provider and customer network requirements for a converged network in an IP dominated world. The chapter considers the use of MPLS for the provisioning of a virtual private network over a shared physical infrastructure, and discusses the logic and functionality of key protocols associated with MPLS. It then goes on to explore the problems, protocols, and possibilities of these technologies in current environments.

INTRODUCTION

Multiprotocol Label Switching (MPLS) is by no means new. The concept was introduced in 1996 in “cut through routing” (Newman, Edwards et al, 1996), which involved ‘switching’ IP over ATM networks by applying and using a label to forward packets. Toshiba and IBM also introduced technologies that in some way used labels to forward data (Davie, 2000). Cisco, an organization with a focus on Ethernet and Internet Protocol (IP), not ATM, then took the concept and adapted it for Ethernet. Initially a proprietary protocol, it was later rebranded as ‘Label Switching’ under the banner
Multiprotocol Label Switching Virtual Private Networks of the Internet Engineering Task Force (IETF). A few years later, it was once again rebranded as MPLS, with support for Layer 2 (L2) and Layer 3 (L3) virtual private networks (VPNs) that are capable of transporting a wide range of protocols over IP. In fact, MPLS populates lookup tables and distributes labels in a variety of ways, and is not so much a protocol as it is a set of protocols that make IP truly universal, both for local and service provider networks. As such, it is considered by many people to be the rightful successor to Frame Relay and Asynchronous Transfer Mode (ATM) (Sosinsky, 2009).

It is not cost-effective for providers, whether they are telecommunications companies (telcos) or Internet Service Providers (ISPs), to offer each service on its own separate network (Xu, 2010). These providers have found MPLS VPNs a viable solution to the growing demand for highly available, highly secure, and highly cost-effective services. This chapter describes the purpose, problems, and possibilities of MPLS and associated enhancements and extensions used to create provider provisioned virtual private networks (PPVPNs), and their support for various connection scenarios, traffic requirements, and applications. While MPLS is associated with large networks and providers, it also affects the very nature of wide area network (WAN) links and therefore impacts customers, who, for example, cannot easily propagate an Open Shortest Path First (OSPF) default route across an MPLS WAN.

The chapter first covers the basics of MPLS and the ways, in which several other protocols and extensions interact to create L3 VPNs across a shared physical infrastructure. The standard for this particular type of PPVPN, referred to as “BGP/MPLS IP VPN”, is outlined in RFC 4364 (Rosen & Rekhter, 2006). The chapter then goes on to explore the problems, protocols and possibilities of a BGP/MPLS IP VPN or, as it is referred to, an MPLS L3 VPN, starting with an overview of various customer-to-service provider connection scenarios, including internet access and multihomed environments. It concludes with some reflections on what MPLS has become, where it will take the industry and considers the implications for the role and future of IP.

BACKGROUND

Service provider networks face the problem of connecting multiple customers at various locations across a shared physical infrastructure. Legacy networks followed a strict connection-oriented approach in which data is sent across a pre-established physical or logical path. This deterministic approach followed the method used by the original analogue public switched telephone network (PSTN) and led to the development of other circuit switched technologies such as Integrated Services Digital Network (ISDN) and in its original form Synchronous Optical Networking (SONET) or Synchronous Digital Hierarchy (SDH). Some packet switched technologies follow the connection-oriented approach by establishing virtual circuits between two or multiple points across a shared network, including the old but reliable X.25 and unreliable Frame Relay, as well as ATM and MPLS (Perros, 2005).

These technologies function at either Layer 1 (L1) or L2 but on a fundamental level, they actually serve the same purpose as the now ubiquitous IP protocol, which functions at L3. It seems strange, especially for a new generation of network engineers for whom networks are automatically IP and ATM or Frame Relay legacy protocols, to view IP as a protocol that simply connects multiple Ethernet-based networks. That, though, is the actual fundamental purpose of IP: connecting local area networks through a hierarchical addressing scheme. The great flexibility, ease of implementation and maintenance plus overall cost effectiveness have led to a near total dominance of IP in local area network sector with Ethernet as the protocol of choice for the Data Link layer.