

Chapter 4

APT: A Practical Tunneling Architecture for Routing Scalability

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ABSTRACT

The global routing system has seen a rapid increase in table size and routing changes in recent years, mostly driven by the growth of edge networks. This growth reflects two major limitations in the current architecture: (a) the conflict between provider-based addressing and edge networks' need for multihoming, and (b) flat routing's inability to provide isolation from edge dynamics. In order to address these limitations, we propose A Practical Tunneling Architecture (APT), a routing architecture that enables the Internet routing system to scale independently from edge growth. APT partitions the Internet address space in two, one for the transit core and one for edge networks, allowing edge addresses to be removed from the routing table in the transit core. Packets between edge networks are tunneled through the transit core. In order to automatically tunnel the packets, APT provides a mapping service between edge addresses and the addresses of their transit-core attachment points. We conducted an extensive performance evaluation of APT using trace data collected from routers at two major service providers. Our results show that APT can tunnel packets through the transit core by incurring extra delay on up to 0.8% of all packets at the cost of introducing only one or a few new or repurposed devices per AS.

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INTRODUCTION

The Internet routing scalability problem reflects a fundamental limitation of the current Internet routing architecture: the use of a single, inter-domain routing space for both transit provider networks and edge sites. A natural solution is to separate these two fundamentally different types of networks into different routing spaces. As estimated by Massey et al. (2007), removing edge-site prefixes from the inter-domain routing system could reduce the global routing table size and update frequency by about one order of magnitude.

In addition to improve scalability, this separation can provide other benefits. End hosts will not be able to directly target nodes within the routing infrastructure, and this topology hiding feature will increase the difficulty of DoS (Denial of Service) and other attacks against the Internet core. Edge networks will enjoy benefits such as better traffic engineering and the ability to change providers without renumbering. The idea of separating end customer sites out of inter-domain routing first appeared in Deering (1996) and Hinden (1996), in which the scheme was named “Map & Encap”: the source maps the destination address to a provider that serves the destination site, encapsulates the packet, and tunnels it to that provider. This idea started to attract attention from vendors and operators after the recent IAB report (Meyer et al., 2007) and has been actively discussed at the IRTF Routing Research Group (IRTF RRG Working Group, n.d.; Li, 2011). However, the original proposal was only an outline. It did not solve a number of important issues such as how to distribute the mapping information, how to handle failures, how to ensure security, and how to incrementally deploy the system.

In this chapter, we present *APT (A Practical Tunneling architecture)*, a design for a concrete

realization of the Map & Encap scheme that addresses all of these above issues. APT uses a hybrid push-pull model to distribute mapping information, a data-driven notification mechanism to handle physical failures between edge sites and their providers, and a lightweight public-key distribution mechanism for cryptographic protection of control messages. APT can be incrementally deployed with little to no new hardware, and incurs extra delay on no more than 0.8% of all packets, according to our trace-driven evaluation.

Note that separating core and edge networks only redefines the scope of inter-domain routing; it does not change any routing protocols. Therefore, other efforts of designing scalable routing protocols, e.g., compact routing (Krioukov et al., 2007) and ROFL (Caesar et al., 2006), are orthogonal and are not affected by the change in architecture.

BACKGROUND

Since APT is a realization of the Map & Encap scheme, we begin with an explanation of how Map & Encap works.

There are two types of networks in the Internet: *transit networks* whose business role is to provide packet transport services for other networks, and *edge networks* that only function as originators or sinks of IP packets. As a rule of thumb, if the network’s AS number appears in the middle of any AS path in a BGP (Rekhter et al., 2006) route today, it is considered as a transit network; otherwise it is considered as an edge network. Usually Internet Service Providers (ISPs) are transit networks and end-user sites are edge networks (e.g., corporate networks and university campus networks). The IP addresses used by transit networks are called *transit addresses* and the IP addresses used by edge networks are called *edge addresses*. The cor-

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