Chapter LV
Overlay Networks:
New Techniques for Global Service and Network Provisioning

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ABSTRACT

Service and content delivery over the Internet is currently supported by overlay architectures of different types. There is a trend towards distributed computing and service creation in peer-to-peer and grid networks, which are able to overcome performance bottlenecks of client server architectures. Overlays are deployed for single applications or as multi purpose infrastructure for communities with focus on their special demands. Various overlay structures have also developed on lower network layers. The motivation for those overlays is to bridge or extend one networking technology on top of another in order to build common widespread platforms through heterogeneous telecommunication environments. We address such approaches especially within the standardization of Internet protocols (IP), where the main focus is on evolving techniques on higher layers.

1 INTRODUCTION: OVERLAY NETWORKS ON DIFFERENT LAYERS

Overlays on the application layer have developed since the millennium via peer-to-peer protocols where file sharing and voice over IP (Skype) reached world wide popularity. On lower protocol layers, virtual local area networks (VLAN) and virtual private networks (VPN) are well known solution in order to group users communities together by a logical network topology on top of Ethernet or other technologies. The Internet engineering task force (IETF) devoted a considerable part of standardization work to transport mechanisms for support of different platforms over

the Internet (IP) and generalized multiprotocol label switching (G-MPLS) networks.

IETF working groups e.g. on pseudo wire emulation edge to edge (PWE3) have defined tunnelling mechanisms to bridge traffic from various platforms over IP including Ethernet and even synchronized transmission for telephony. Other working groups on virtual private networks within different layers (L1-, L2-, L3VPN) extend the basic mechanisms to build overlay networks including virtual private LAN services (VPLS), virtual circuit (VC) emulation etc. based on the previously defined tunnelling mechanisms.

On the application layer, peer-to-peer (P2P) networking overlays became popular in telecommunication through file-sharing applications, which fundamentally changed the traffic profile on the Internet since the millennium. Two main advantages of the peer-to-peer principle as compared to client-server systems are

- A highly efficient distribution of data over the Internet with scalability even for spontaneous requests from millions of users to large files and
- The opportunity to build overlay networks to launch new Internet services around the globe with a minimum of own server and network infrastructure to maintain control.

P2P overlays on the Internet have a profound impact on the business of Internet service providers (ISPs) by making new services available in a short time. Together with the penetration of broadband access, P2P services mark a new phase of Internet evolution with major shifts in technology, service architecture and business models for service providers. Besides file sharing, voice over IP and gaming via P2P systems also have reached populations counting in millions and further applications are expected to make widespread use of pure P2P techniques or hybrid forms combining P2P with server architectures. Functions with a high consumption of system resources and performance requirements in computation power, storage or bandwidth for data exchange can benefit most from P2P and other overlay structures.

Overlay networks generate their own traffic pattern and usually introduce explicit or implicit routing functions e.g. by the selection process of sources for downloads in P2P networks. The data throughput in popular P2P networks is maximized by elaborate techniques including parallel multi-source downloads and incentives to motivate users to make upload capacity available. But transmission paths in P2P overlays are often observed to be suboptimal, since data flows are routed more or less independent of the underlying transport network topology.

As an alternative, content delivery networks (CDNs) have developed from pure content provisioning to support a broadening range of IP services. The advantage of P2P networks can be seen in the opportunity to move operational costs for a service from central servers to the equipment of the users. This facilitates the global launch of new services at low price or for free. On the other hand, security, reliability and control issues are more difficult to handle in a distributed architecture on user equipment. CDNs can enforce full control over the offered content and services at the cost of infrastructure to be installed and maintained within the network. In addition, operational ISPs and telecommunications network providers offer value-added overlay services in a broadband environment. Therefore at least three types of overlays are relevant above the network layer:

- Content distribution networks (CDNs) as global overlays on Internet servers supporting popular Web sites,
- Peer-to-peer applications building overlay networks on the terminals of the users,
- And overlays within the architecture of a network or service provider, utilizing own infrastructure including caches, multi-