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This article provides internetworking design, implementation case studies, and examples, with the intent to help you identify and implement practical internetworking strategies that are both flexible and scalable.

This article was developed to assist professionals preparing for Cisco Certified Internetwork Expert (CCIE) candidacy, though it is a valuable resource for all internetworking professionals. It is designed for use in conjunction with other Cisco manuals or as a standalone reference. You may find it helpful to refer to the Internetwork Design Guide, which provides detailed descriptions of the internetworking strategies and technologies used in this article.

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Dial-on-Demand Routing

Cisco's dial-on-demand routing (DDR) feature allows you to use existing telephone lines to form a wide-area network (WAN). While using existing telephone lines, you can analyze traffic patterns to determine whether the installation of leased lines is appropriate. DDR provides significant cost savings over leased lines for links that are utilized for only a few hours each day or that experience low traffic flow.

The following article addresses the dial-on-demand routing (DDR) feature that allows you to use existing telephone lines to form a wide-area network (WAN):

- [Dial-on-Demand Routing](#)

Increasing Security on IP Networks

Network security is a broad topic that can be addressed at the data link, or media, level (where packet snooping and encryption problems can occur), at the network, or protocol, layer (the point at which Internet Protocol (IP) packets and routing updates are controlled), and at the application layer (where, for example, host-level bugs become issues).

As more users access the Internet and as companies expand their networks, the challenge to provide security for internal networks becomes increasingly difficult. Companies must determine which areas of their internal networks they must protect, learn how to restrict user access to these areas, and determine which types of network services they should filter to prevent potential security breaches.

Cisco Systems provides several network, or protocol, layer features to increase security on IP networks. These features include controls to restrict access to routers and communication servers by way of console port, Telnet, Simple Network Management Protocol (SNMP), Terminal Access Controller Access Control System (TACACS), vendor token cards, and access lists. Firewall architecture setup is also discussed.

The following article addresses the broad topic of network security:

- [Increasing Security on IP Networks](#)

Integrating Enhanced IGRP into Existing Networks

The Enhanced Interior Gateway Routing Protocol (IGRP) combines the ease of use of traditional routing protocols with the fast rerouting capabilities of link-state protocols, providing advanced capabilities for fast convergence and partial updates. When a network topology change occurs, the Diffusing Algorithm (DUAL) used with Enhanced IGRP provides convergence in less than five seconds in most cases. This is equivalent to the convergence achieved by link-state protocols such as Open Shortest Path First (OSPF), Novell Link Services Protocol (NLSP), and Intermediate System-to-Intermediate System (IS-IS). In addition, Enhanced IGRP sends routing update information only when changes occur, and only the changed information is sent to affected routers.

Enhanced IGRP supports three network level protocols: IP, AppleTalk, and Novell Internetwork Packet Exchange (IPX). Each of these has protocol-specific, value-added functionality. IP Enhanced IGRP supports variable-length subnet masks (VLSMs). IPX Novell Enhanced IGRP supports incremental Service Advertisement Protocol (SAP) updates, removes the Routing Information Protocol (RIP) limitation of 15 hop counts, and provides optimal path use. A router running AppleTalk Enhanced IGRP supports partial, bounded routing updates and provides load sharing and optimal path use.

The following article addresses the Enhanced Interior Gateway Routing Protocol (IGRP):

- [Integrating Enhanced IGRP into Existing Networks](#)

Reducing SAP Traffic in Novell IPX Networks

One of the limiting factors in the operation of large Novell Internetwork Packet Exchange (IPX) internetworks is the amount of bandwidth consumed by the large, periodic Service Advertisement Protocol (SAP) updates. Novell servers periodically send clients information about the services they provide by broadcasting this information onto their connected local-area network (LAN) or wide-area network (WAN) interfaces.

The following article addresses how to deal with the nuances of Novel IPX networks:

- [Reducing SAP Traffic in Novell IPX Networks](#)

UDP Broadcast Flooding

A broadcast is a data packet that is destined for multiple hosts. Broadcasts can occur at the data link layer and the network layer. Data-link broadcasts are sent to all hosts attached to a particular physical network.

Network layer broadcasts are sent to all hosts attached to a particular logical network.

The following article addresses the interworkings of broadcast data packets:

- [UDP Broadcast Flooding](#)

STUN for Front-End Processors

Serial tunneling (STUN) enables the integration of traditional systems network architecture (SNA) networks with multiprotocol networks. STUN also lowers operating costs by reducing the need for redundant remote wide-area links.

The following article addresses serial tunneling (STUN) and the integration of traditional systems network architecture (SNA) networks with multiprotocol networks:

- [STUN for Front-End Processors](#)

Using ISDN Effectively in Multiprotocol Networks

As telephone companies make Integrated Services Digital Network (ISDN) services available, ISDN is becoming an increasingly popular way of connecting remote sites.

The following article addresses how, as telephone companies make Integrated Services Digital Network (ISDN) services available, ISDN is becoming an increasingly popular way of connecting remote sites:

- [Using ISDN Effectively in Multiprotocol Networks](#)

Using HSRP for Fault-Tolerant IP Routing

Cisco's Hot Standby Routing Protocol (HSRP) provides automatic router backup when you configure it on Cisco routers that run the Internet Protocol (IP) over Ethernet, Fiber Distributed Data Interface (FDDI), and Token Ring local-area networks (LANs). HSRP is compatible with Novell's Internetwork Packet Exchange (IPX), AppleTalk, and Banyan VINES, and it is compatible with DECnet and Xerox Network Systems (XNS) in certain configurations.

The following article addresses Cisco's Hot Standby Routing Protocol (HSRP), which provides automatic router backup when you configure it on Cisco routers that run the Internet Protocol (IP) over Ethernet, Fiber Distributed Data Interface (FDDI), and Token Ring local-area networks (LANs):

- [Using HSRP for Fault-Tolerant IP Routing](#)

LAN Switching

Today's local-area networks (LANs) are becoming increasingly congested and overburdened. Switching is a technology that alleviates congestion in Ethernet, Token Ring, and Fiber Distributed Data Interface (FDDI) LANs by reducing traffic and increasing bandwidth. Such switches, known as LAN switches, are designed to work with existing cable infrastructures so that they can be installed with minimal disruption of existing networks. Often, they replace shared hubs. This case study describes how LAN switching works, how virtual LANs work, and how to configure virtual LANs (VLANs) in a topology that consists of Catalyst 5000 LAN switches.

The following article addresses how to deal with the fact that today's local-area networks (LANs) are becoming increasingly congested and overburdened:

- [LAN Switching](#)

Multicasting in IP and AppleTalk Networks

Over the past few years, the concept of end-users being able to send and receive audio and video (known collectively as multimedia) at the desktop has gained considerable attention and acceptance. With high-performance 486, Pentium, and PowerPC CPUs, more than 80 percent of the personal computers sold during 1995 were multimedia capable. Today, it is not uncommon for end-users to run video editing and image processing applications from the desktop.

The proliferation of more and more multimedia-enabled desktop computers has spawned a new class of multimedia applications that operate in networked environments. These network multimedia applications leverage existing network infrastructure to deliver video and audio applications to end users. Most notable are videoconferencing and video server applications. With these applications, video and audio streams are transferred over the network between peers or between clients and servers.

The following article addresses the concept of end-users being able to send and receive audio and video (known collectively as multimedia) at the desktop has gained considerable attention and acceptance that has become increasingly common in the past few years:

- [Multicasting in IP and AppleTalk Networks](#)

Scaling Dial-on-Demand Routing

This case study describes the design of an access network that allows a large number of remote sites to communicate with an existing central-site network. The remote sites consist of local-area networks (LANs) that support several workstations. The workstations run transaction processing software that accesses a database located at the central site. The following objectives guided the design of the access portion of the network:

- The existing network could not be modified to accommodate access by the remote sites.
- The central site must be able to connect to any remote site at any time, and any remote site must be able to connect to the central site at any time.
- When choosing between alternative technologies, choose the most cost-effective technology.
- The design must be flexible enough to accommodate additional remote sites in the future.

The following article addresses the design of an access network that allows a large number of remote sites to communicate with an existing central-site network:

- [Scaling Dial-on-Demand Routing](#)

RIP and OSPF Redistribution

The following case study addresses the issue of integrating Routing Information Protocol (RIP) networks with Open Shortest Path First (OSPF) networks. Most OSPF networks also use RIP to communicate with hosts or to communicate with portions of the internetwork that do not use OSPF. Cisco supports both the RIP and OSPF protocols and provides a way to exchange routing information between RIP and OSPF networks:

- [RIP and OSPF Redistribution](#)

Using the Border Gateway Protocol for Interdomain Routing

The Border Gateway Protocol (BGP), defined in [RFC 1771](#), provides loop-free interdomain routing between autonomous systems. (An autonomous system [AS] is a set of routers that operate under the same administration.) BGP is often run among the networks of Internet service providers (ISPs).

The following article examines how BGP works and how you can use it to participate in routing with other networks that run BGP:

- [Using the Border Gateway Protocol for Interdomain Routing](#)