Next-Generation Corporate Networks

Bhumip Khasnabish

The Internet Protocol will bring together two disparate networks now vital to every business: the PSTN and the Internet. Is your network ready?

We've all become accustomed to intranets—networks that facilitate seamless communications and networked computing within a single corporation. To carry out business functions, however, companies have traditionally employed several other networks to provide business services like telephony, faxing, computing, and network administration. Today, these services revolve around two basic networks: the Public Switched Telephone Network (PSTN)—which provides basic telephone services—and the Internet. As shown in Figure 1a, these separate networks handle telephone and Internet services today.

Next generation enterprise networks (NGENs) must fulfill current expectations for corporate networks, plus also seamlessly support mobility and multimedia applications. And they must do this within flexible, often adaptive, self-configuring, and interoperable architectures. NGENs also must be user-friendly and scalable. They must support bandwidth and quality-of-service (QoS) requirements, in addition to delivering the expected reliability and availability.

To meet these requirements, the trend is to consolidate disparate networks into one simple (IP only) high-capacity, reliable, scalable, QoS-aware network, as shown in Figure 1b. NGENs will use one set of protocols (such as IPv4 or IPv6), processes, and vendors and one set of management, administration, and billing processes. They must be able to easily accommodate emerging technologies and services.

EXPECTATIONS

Corporations expect NGENs to automate services and applications, help with process reengineering and technology consolidation, and support efficient network management and maintenance.

A few of the emerging strategies for consolidating PSTN- and Internet-based networks include

- *IP telephony* in the form of ID-aware voice plus data terminals, which includes supporting mobility in addition to facilitating add, move, and change activities.
- *Packet voice exchanges (PVXs) and/or integrated access devices (IADs)* to replace PBXs and terminals. IADs eliminate the need for multiple physical lines from a central office to a customer's premises. One physical line from an IAD can support multiple virtual circuits. PVXs can handle both data- and packet-based voice services. Use of PVXs can avoid scalability and interoperability constrains.
- *Storage area networks (SANs)* are network-, server-, or micro/pico-area-networks attached to massive data-storage facility. They support the creation and control of services.

SANs and mainframes are useful for data mining/warehousing, e-commerce, transaction execution, and peering. *Peering* allows networks to exchange traffic directly, rather than use the Internet backbone; it permits a more efficient, seamless exchange of data. An effective SAN should support the lightweight directory access protocol (LDAP), billing, and semi-distributed Web-based control and management. Software packages based on extensible markup language (XML) can facilitate interaction and information exchange over the Web without requiring massive rewrites or modifications of the existing/legacy systems/applications of the individual companies.

Whatever strategy you decide to use, it is important to consider support for the several functions that the combined network must provide or support.

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PROCESS REENGINEERING AND CONSOLIDATION

Next-generation networks must support process reengineering and consolidation applications. Such applications include those for enterprise resource planning (ERP), e-commerce, data mining and data warehousing, and peering of servers and networks. Although the objective of implementing these applications is to reduce cost and complexity, nonjudicious use of these technologies can produce adverse effects.

PROACTIVE MAINTENANCE

Performing proactive maintenance is becoming another function for corporations. This capability used to be a "nice to have" in the 90s, but it is rapidly becoming a necessity as networks become more complex. Examples of proactive maintenance include

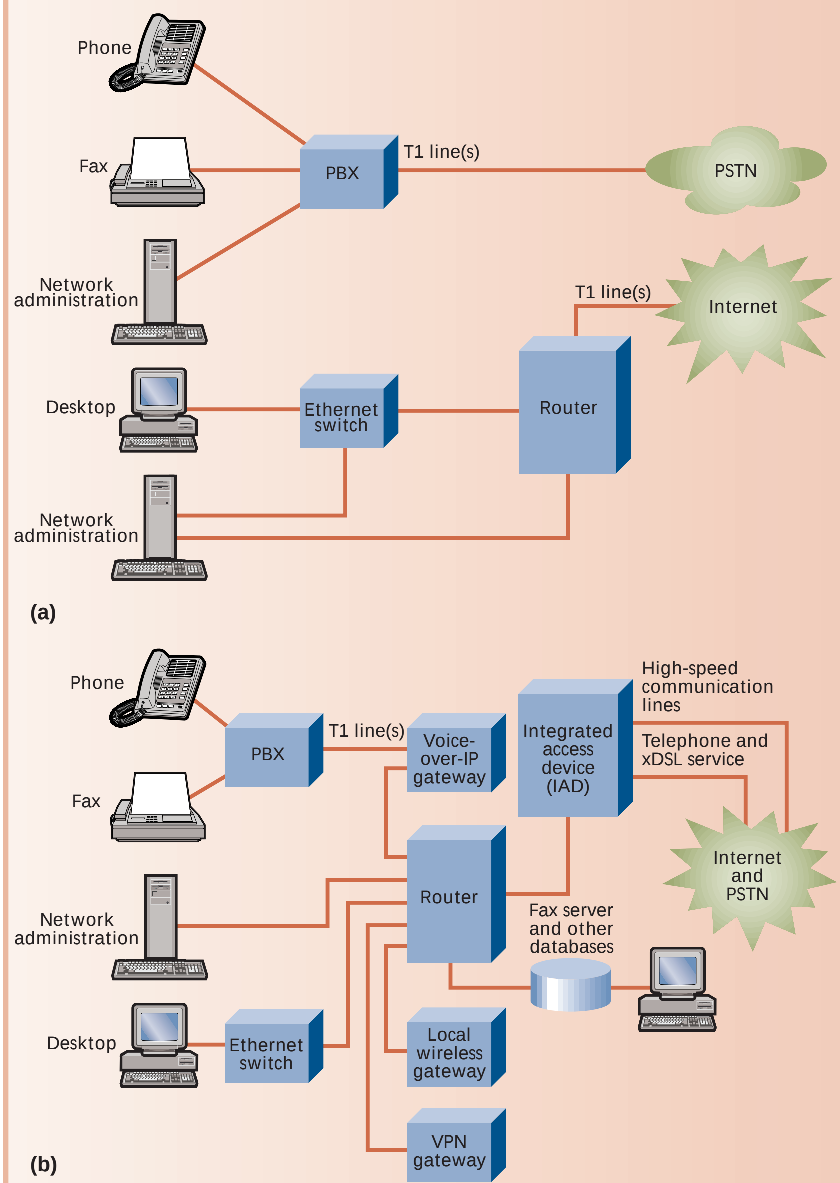
- software or system configuration and version-management applications using Desktop Management Task Force's Desktop Management Interface (DMI) or Sun's Jini;
- remote/self-configuring and maintenance of desktop computers and applications; and
- network and traffic configurations management using time- or traffic-pattern-triggered network and traffic management policies.

SUPPORTING QoS

Maintaining the QoS calls for optimizing network access and traffic routing. A QoS-aware network recognizes various categories of data and attempts to guarantee an associated service level, which is defined by parameters like allowable delay, delay jitter, packet loss, and so on.

For IP-based services, QoS issues are currently being addressed in the Internet Engineering Task Force's diffserv, intserv, and multi-protocol label-switching (MPLS) working groups, Internet 2's QoS Forum (http://internet2.edu), and in efforts at other similar organizations. (For a list of URLs for these and other organizations, see the Resources sidebar.)

Figure 1. Today, enterprise networks usually have at least (a) two parts, but (b) future networks will combine the two.



Essentially all these organizations are attempting to figure out parameters for the required *service-level agreement* (SLA). These parameters spell out the reliability, availability, response time, and security necessary to satisfy an application's QoS requirements. Enforcing SLA agreements requires tools for monitoring, configuration, and provisioning management.

Small to medium-sized organizations may want to outsource the operation of their corporate networks or may choose to cosource them by using both internal and external resources. This would help these businesses be more proactive in monitoring traffic and managing it. Outsourcing can also help better predict service and capacity requirements for infrastructure planning and migration.

Emerging protocols include customer premises and/or desktop devices with native support of TCP/IP (Transmission Control Protocol/Internet protocol) and UDP/IP-based (User Datagram Protocol/Internet Protocol-based) access. UDP is commonly used to support real-time or delay-sensitive/loss-tolerant services over IP. The end goal is to permit such devices to support varying qualities of service. (For more information, see Bhumip Khasnabish and Majid Ahmadi, "Enterprise Network and Systems Management," *J. Network and Systems Management*, Mar. 1999; and Bhumip Khasnabish and Roberto Saracco, "Intranet Services and Communication Management," *IEEE Communications*, Oct. 1997.)

Resources

Standards bodies

- **Institute of Electrical and Electronics Engineers, http://www.ieee.org: IEEE sets and supports development of various communication standards, including the IEEE 802.xxx standards.**
- **International Multimedia Teleconferencing Consortium, http://www.imtc.org: IMTC develops standards for multimedia teleconferencing.**
- **International Telecommunication Union, http://www.itu.int: The Geneva-based ITU sets communications standards that are widely used in Europe and Asia.**
- **Internet Engineering Task Force, http://www.ietf.org: IETF is the main standards body for the Internet Protocol. It publishes requests for comments and standards on mobile IP, next-generation IP protocols, the Internet, quality of service, and PSTN interoperability.**

General information

- **QoS Forum, http://www.qosforum.com: This group supports the standardization and use of quality of service technologies. It hosts a technology resources page that offers tutorial information.**
- **Media Gateway Control Protocol, http://www.telcordia.com/newsroom/pressreleases/981116mgcp.html: Belecore and Level 3 Communications merged their technical specifications for integrating PSTN devices and IP. Called the Media Gateway Control Protocol (MGCP), the specification is available at this link.**
- **pulver.com Inc., http://www.pulver.com: Publishers of research on internet technology and telephony, pulver.com also produces the Voice on the Net trade shows.**

Articles and book

- **Yi-Bing Lin, Bhumip Khasnabish, and Imrich Chlamtac, "The Wireless Segment of Enterprise Networking,"** ***IEEE Network*****, July/Aug.1998, pp. 50-55.**
- **Bhumip Khasnabish and Majid Ahmadi, "Integrated Mobility and QoS Control in Cellular Wireless ATM Networks,"** ***J. Network and Systems Management*****, No. 1, 1998, pp.71-89.**
- **Bhumip Khasnabish, "Interior Design: Inside the Server Room,"** ***Network Magazine*****, Nov. 1997, pp.105-109.**
- **Bhumip Khasnabish, "Broadband To The Home (BTTH): Architectures, Access Methods and the Appetite for It,"** ***IEEE Network*****, Jan./Feb. 1997, pp. 58-69.**
- **Mallikarjun Tatipamula and Bhumip Khasnabish, eds.,** ***Multimedia Communications Networks: Technologies and Services*****, Artech House, Boston, 1998.**

SUPPORTING MULTIMEDIA

Multimedia applications include the use of voice, video, and image clips in e-mail. To further complicate the situation, users are asking for unified messaging—anywhere, anytime access to voice mail, e-mail, and faxes over IP.

Groupware and other applications that support remote collaboration form another class of multimedia applications. Corporations use such applications for problem solving, service provisioning and management, videoconferencing, and Web- or CD-based employee training and distance learning.

The hottest technical problem in supporting multimedia services over IP is that real-time traffic (data or packets) must reach its destination within a preset time interval (delay) and with some tolerance of the delay variation (jitter). This is difficult because the original UDP/IP operates on a best-effort basis and permits dropping packets on the way to a destination.

Critical non-real-time traffic—such as topology and routing-table update information—is loss-sensitive. The entire network could collapse if it looses *any* packets. The effective solutions (Bhumip Khasnabish and Anindo Banerjea, "Transmission and Distribution of Digital Video, Part II: Field Trials and Prototype Implementations," *IEEE Network*, Mar./Apr. 1999) call for using IP with

- preventive and/or proactive traffic

management schemes at access, network, and nodal operation levels; and

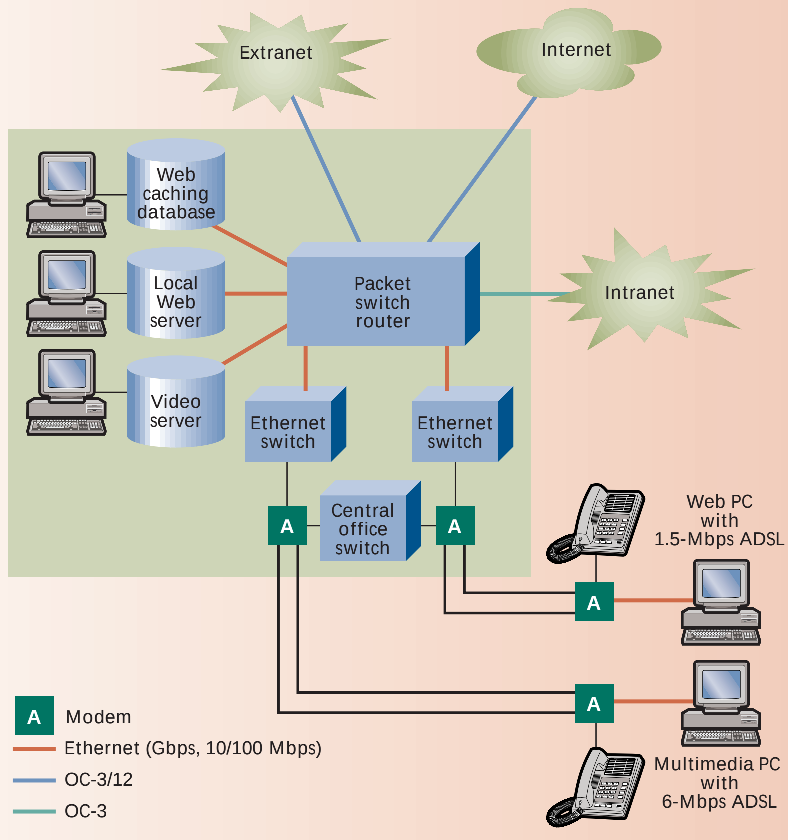
- reactive traffic management schemes at nodal, access, and network operation levels.

Preventive control mechanisms at the access level use traffic descriptors, traffic contract, and conformance testing to exercise control. At the network level, sharing and/or spreading traffic across various routes to a destination is most useful for non-real-time traffic. At the nodal (queuing) operations level, judicious use of traffic shaping at the intermediate nodes can help network administrators exercise traffic management and control.

Reactive control mechanisms at nodal operations call for discarding packets if the queue size is growing quickly and the incoming packets are neither important nor urgent. At access level, you can mark (using the IP type-of-service byte) or discard packets on the basis of port or connection type if over-subscription persists. At network level, you must control traffic flow rate in physical and virtual connections by using the route congestion information flowing back and forth between various source-destination pairs or patterns. To be effective, the reactive scheme requires a faster response/reaction time than the rate at which congestion is occurring.

For nonurgent, loss-sensitive traffic, nodal buffer size can be designed to be as large as needed without degrading traffic transmission performance or adversely affecting performance expectations at the application level. For urgent or delay-sensitive traffic, a network must use suitable scheduling and/or cut-through routing. For example, for a given traffic profile and service discipline, you can calculate the buffer size for tolerating the loss of one packet in one million packets. However, for delay-sensitive traffic (such as voice or real-time video) both the number of intermediate hops and the nodal buffer space must remain small so that the packet transport delay and delay variation stay within certain limits. Adding more storage space (buffer) at the nodes would not solve the problem.

Figure 2. Future wired networks could use ADSL to support Internet, intranet, and extranet services.



To minimize the maximum queuing delay, the network design should consider minimizing the "number of *active* nodes crossed" from source to destination. Consequently, the concept of virtual (private) networking comes into picture. In VPNs, paths are almost always preset, and the route characteristics are well guaranteed via SLA parameters as negotiated with the service providers.

IMPROVING WIRED ACCESS

Several access options are emerging for hardwired connections. Varieties of digital subscriber line (xDSL) are popular because the infrastructure to support them is less expensive than that of other options. Corporations are also using cable connections to link corporate LAN gateways. Optical fiber connections are supra-high-speed options to link corporate LAN gateways, but more expensive. "Emerging High-Speed Access Technologies," (*IT Professional*, Mar./Apr. 1999) discusses some of these options in detail.

One example of providing such services uses asymmetric digital subscriber line (ADSL) technologies; it is shown in Figure 2. This architecture can support local Web servers, Web caching, merchant services and e-commerce, the point-to-point tunneling protocol (PPTP) for secure LAN access, and multimedia services such as IP-based video- and audioconferencing.

WIRELESS ACCESS

For in-building wireless telephony/PBX, the base station should support the required mobility (hand-off capabilities), QoS, and channel capacity. Standards for wireless telephony have arisen: the European CT-2 standard ("CT" stands for cordless telephony) supports around eight handsets per base station, and The Digital European Cordless Telephone (DECT) standard supports up to 12 handsets per base station over a 100- to 200-meter diameter.

A wireless PBX must also support users both within and outside a location. The wireless connection must be secure, and the system must authenticate the user before allocating a channel or circuit.

To successfully integrate wireless services into a network, consider

- capacity planning to support efficient operations today;
- capacity and infrastructure planning for evolving the network to support new applications and operations;
- support of acceptable (less than 10 percent) blocking and hand-off from the handset to the base station, which includes reduced blocking between the base station and wireless PBX, and acceptable blocking at the wireless PBX to Intranet or PSTN (access-level blocking results in redialing for service, and in-transit blocking causes hand-off failure); and
- backup for unexpected events, such as facility outages.

Although the initial deployment of a wireless PBX can be expensive, it pays off in improved employee productivity and enhanced customer (internal and external) satisfaction.

For wireless communications within a single corporate network, you should consider an IP-based virtual network to support ubiquitous and uniform terminals and services. In this environment, network segments must interoperate seamlessly with public and private carriers. Additional operations, administration, and maintenance costs for managing such a worldwide virtual network also need careful analysis.

Other prime issues are discovering the called mobile unit or terminal for completing a connection request and maintaining the integrity of the offered connections or calls in-progress. Systems typically accomplish this by either paging, broadcasting, and/or mobility tracking or management methods. Tracking methods include

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- location and mobility tracking databases (home and visitor location registers), such as the ones used in the public PCS networks;
- Global Positioning System (GPS) coordinates for tracking the location of a terminal and then using low-overhead mobility management techniques for maintaining connection continuity; and
- various satellite-based systems.

An advantage of an IP-based global virtual network is that users can use the same handset whether within a company building or while traveling.

ENTERPRISE NETWORK MANAGEMENT (ENM)

Three issues need careful considerations in implementing emerging network management options:

- *Interoperability*. Vendors and organizations are proposing a variety of architectures, platforms, and protocols. The more types of networks you have, the more complicated your interoperability challenge.
- *Architectures*. Assess each architecture to determine its scalability and how well it deals with heterogeneous systems.
- *Synchronization*. Technological advancements must synchronize with business needs.

For example, consider the service-level agreement parameters for the PSTN. Required reliability for the PSTN is 99.999 percent—"the five 9s." A user must also receive a dial tone within three seconds 95 percent of the time. The PSTN must support an average holding time (call length) of three minutes or 180 seconds. The PSTN's connection drop rate during a call is almost *zero*, because it always uses the latest released circuit to start a new connection. For networks to provide PSTN-like services, they must use IP for both signaling and media and still meet similar requirements.

Emerging network management strategies include

- those for virtual private networks, which use privately managed logical channels (or a mesh of channels) over public physical links for enterprise network management;
- virtual network management, which is a flavor of customer network management; and
- management of the virtual enterprise—that is, the entire business and all networking processes are virtually defined. In this case, multiple levels of overlay can create complexity.

NGENs have a difficult charter that is twofold. First, they must continue to provide the reliability and functionality now provided by older tested technology. Second, they must also support future technology and service evolution. Doing both well could be a make or break competitive advantage for your company. ■

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