Reinventing GTE with Information Technology

In response to shifting business demands, evolving information technologies play a key role in first reengineering and then reinventing GTE.

Over the past decade, the role of information technology as a key business enabler within the telecommunications industry has increased significantly. One reason for this increase has been the continuous change in enabling technologies available to IT organizations, including operating systems, distributed computing environments, middleware, user-interface technologies, server-side facilities and services, languages, and software development methodologies.

At the same time, the telecommunications industry has undergone continuous change, altering how we think about the industry and how it operates. These changes are influencing, and in turn being influenced by, information technology. At their core, telecommunications companies are information transportation companies. As we move away from the analog, plain-old-telephone-service world, the tools and techniques developed within IT will apply increasingly to a telecommunications company's information business.

To illustrate the growing impact of IT within GTE, here we chronicle the evolution of GTE's Network Management System. Although we focus primarily on the NMS, we broadly identify three major phases in the application of IT within GTE: the initial, reengineering, and reinvention phases. Each phase exemplifies the larger forces at play, both from a business and an IT perspective.

During the initial phase, IT served a business support function within GTE, meeting day-to-day needs but not significantly affecting the business as a whole. Next, IT enabled the reengineering of many of our core business processes. Finally, IT has allowed us to make significant steps in reinventing our telecommunications business.

In our formulation of these constructs, “reengineering” signifies a new combination or application of existing technology to solve an understood tactical business problem: use of client-server systems to reduce cost by consolidating operations, for example. In contrast, “reinvention” signifies the impact of new technology in redefining an enterprise's business: emerging Internet applications and services, for example, that create completely new value chains and that change the business strategy for an entire industry. It is fitting that telecommunications—inherently an information industry—should be reinvented by the “Information Revolution,” and that IT should be the prime agent of this transformation.

The information systems and management science literature reports similar business transformation processes and business-IT strategic alignments in many other industries. Our three phases are very similar to the IT-enabled business transformation levels N. Venkatraman identifies as exploitation/integration, redesign, and redefinition. Our experience exemplifies successful IT-enabled business change, with specific features arising from the nature of the telecommunications industry.

TELECOMMUNICATIONS EVOLUTION

As Figure 1 shows, in the past couple of decades government initiatives, market pressures, and technological innovations have contributed to the evolution of the telecommunications industry.

Throughout its history, government regulation has played a major part in the evolution of the telecommunications industry, but the effects of deregulation play a greater role today. By the 1920s, AT&T and others had made the case that all phone service was best provided by a monopoly, regulated so that it provided universal service. This monopoly remained essentially intact until MCI entered the long-distance market in the late 1970s—an event that would eventually lead to the breakup of AT&T and the Bell system.

Under regulation, telecommunications companies operated their businesses with only a single goal: to deliver voice communications reliably from one point to another. Prices were mandated by the government...
required for our operations support systems. However, that low cost and high flexibility are now exchange carriers and the more recent entry of CLEC competition. The long-term effect of CLEC competition CLECs access this system via either the Internet or private networks. Second, GTE established a number of National Open Market Centers where representatives direct access to their systems. The latter required the systems provide secure partitioned access. Representative's Home Area. Telecommunications firms had two choices in furnishing operations support systems available to all competitors. This led to the entry of competitive local exchange carriers (CLECs), who resell local service in a competing provider's home area. Telecommunications firms had two choices in furnishing operations support: They could provide them manually (a very expensive solution) or they could give their competitors direct access to their systems. The network and the systems that manage them must be quickly aligned to realize the potential that led to the merger in the first place. The situation is further complicated when the merger crosses industry boundaries, especially when telecommunications companies merge and divest as never before. Local-market competition has shown that in many cases size is a valuable asset, leading US local-service providers to engage in a complex courtship dance. GTE and Bell Atlantic, for example, have recently announced merger plans. Internationally, the barriers to trade are falling, and most industrialized countries are moving toward deregulating their phone industries.

Convergence of a different kind is apparent as telecommunications companies merge and divest as never before. Local-market competition has shown that in many cases size is a valuable asset, leading US local-service providers to engage in a complex courtship dance. GTE and Bell Atlantic, for example, have recently announced merger plans. Internationally, the barriers to trade are falling, and most industrialized countries are moving toward deregulating their phone industries.

Converged networks will soon provide seamless information transport, whether the content is voice, data, or video. An initial practical application of this convergence—IP telephony—provides the means for making phone calls over an IP network. Gateway devices are being developed and deployed to provide a bridge between the Internet and the phone network, so that an IP phone call can be transferred onto the telephone network at the central office closest to the call's receiver. Operations support systems must evolve to cope with the added complexities of a converged network, such as managing various quality-of-service levels, integrating disparate content streams, and interfaçng with multifaceted end systems.

**Competitive pressure**

The Telecommunications Act mandated that telecommunications companies open their local service markets to competition. Beyond simply allowing head-to-head competition, the act decreed that existing telecommunications companies make their operations support systems available to all competitors. This led to the entry of competitive local exchange carriers (CLECs), who resell local service in a competing provider's home area. Telecommunications firms had two choices in furnishing operations support: They could provide them manually (a very expensive solution) or they could give their competitors direct access to their systems. The latter required the systems provide secure partitioned access. GTE took a two-pronged approach in its response to this mandate. First, we developed a secure software solution that handles those CLEC requests that can be automated. CLECs access this system via either the Internet or private networks. Second, GTE established a number of National Open Market Centers where representatives handle those CLEC requests that require manual intervention. The long-term effect of CLEC competition and the more recent entry of incumbent local exchange carriers (ILECs) is as yet unclear. It is clear, however, that low cost and high flexibility are now mandatory for our operations support systems.

**Competitive technologies**

The underlying network technology over which telecommunications companies provide services is also changing at an ever-increasing rate. New transport mechanisms, such as the Digital Subscriber Line family (xDSL), now allow high-bandwidth digital communications over standard telephone lines. This technology could provide a large percentage of homes and businesses with high-speed data pipes and the services such pipes enable. xDSL services will see their first large-scale deployments in 1999. Technologies like Synchronous Optical Network (Sonet) and Asynchronous Transfer Mode (ATM) feed the exploding need for backbone bandwidth. The challenge with all these technologies is how to rapidly integrate them so that the new service offerings they enable can quickly be brought to market. In general, as network components become more intelligent—and as our operations support systems provide more management functions—the network and the systems that manage it will merge to become a single, large, distributed system.

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Figure 1. Evolutionary timeline for the IT and telecommunications industries. On the Protocols line, TL1 (transaction language 1) is a widely used telecommunications protocol, as is CMIP (common management information protocol). For a description of the other key terms in this figure, see the sidebars on pp. 52 and 55.
Enabling Technologies for Reengineering

In the early 1990s, telecommunications companies began adopting Unix-based servers and workstations for use as information system platforms. The set of technologies that accompanied Unix-based systems and supported client-server distributed computing included

- Unix-based workstations, which brought to the desktop high-resolution graphics and sophisticated user interfaces based on Motif and X Windows,
- Client-server architecture, which networked shared data processing hosts and workstations,
- Widespread adoption of TCP/IP connectivity, which became increasingly cost-effective for both wide-area and local-area networks,
- Object-oriented programming, as C++ became the de facto standard,
- Geographic Information Systems, which became available as embeddable components,
- Mature relational database management systems (RDBMSs)

- The telecommunications management network (TMN) model, which became the planning framework for operations support systems.¹ ²

Given the technology set available to and adopted by IT organizations, a generation of radically new system architectures emerged to support business operations. The Unix-based, client-server, RDBMS architectures presented the telecommunications industry with avenues to deploy more scalable, flexible, inexpensive, and evolvable solutions than were possible with legacy environments. These architectures also provided IT with an attractive migration path for legacy system replacement and systems convergence, which allowed the business reengineering of this phase.

These enablers led to the development of "heavy" clients that required significant client workstation computer power. Typically, although sizable production-support teams implemented large IT projects, they often lacked access to the sophisticated tools or technologies needed to support such deployments. Finally, IT deployments were typically platform and operating-system specific because of the software's lack of generic interoperability. The systems directions chosen by IT in the early to mid-1990s were not a complete and immediate success. The planning, development, deployment, and administration of client-server systems proved to be costlier and more difficult than first envisioned. Distributed computing environments like DCE proved laborious to use and master. Poorly designed client-server systems suffered from significant performance and scalability issues. Debates ensued about the relative benefits of two-tier versus n-tier architectures within client-server systems. Nonetheless, by the mid-1990s, IT organizations had learned how to use available technologies to deploy systems that supported the telecommunications business.

References


In the early 1990s, GTE's domestic telephone operations embarked on a series of reorganizations and staff consolidations. Similar business process reengineering (BPR) initiatives were sweeping most industries. At GTE, the goal was to centralize operations to improve productivity and reduce costs. Although still a regulated monopoly, GTE was subject to cost constraints in the form of rate caps imposed by utility commissions. Its regionally dispersed operations inherently limited GTE's ability to reduce costs.

Business drivers. The key business drivers in this phase came from process reengineering and centralization efforts aimed at improving productivity and reducing costs. Although still a regulated monopoly, GTE was subject to cost constraints in the form of rate caps imposed by utility commissions. Its regionally dispersed operations inherently limited GTE's ability to reduce costs.

GTE Case Study

A crucial area where IT and the business of providing telecommunications services intersect is that of operations support systems. This case study specifically illustrates how technology and business combined to shape the evolution of network management systems at GTE.

Reengineering: Changing core processes

In the early 1990s, GTE had yet to introduce centralized network management. Operations support systems were segregated and network operations facilities geographically fragmented. We had numerous regional centers—19 in 1990—to oversee small segments of GTE's domestic telephone network, each with its own complement of network management systems. The impact of IT was largely limited to business management systems such as billing data collection and inventory databases, and to the software in the network elements themselves.

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Technology enablers. At the same time, advances in computing technology became available to developers of operations support systems. The enabling technologies described in the "Enabling Technologies for Reengineering" sidebar shaped the environment in which GTE built its consolidated network operations center and integrated network management system. These technologies include Unix-based workstations, client-server architectures, widespread TCP/IP connectivity, geographic information systems, relational databases, and the Telecommunications Management Network (TMN).

System solution. GTE Laboratories used these early 1990s technologies to develop TONICS (Telecommunications Operations Integrated Network Control System). TONICS integrated the management of all transmission, switching, signaling, and customer equipment. TONICS now manages 5,000 central office switches, many thousands of Sonet, ATM, and frame relay devices, thousands of SS7 network elements and connections, tens of thousands of X.25 and IP devices, and more than 60,000 trunk groups in its telephony network. The system currently offers fault- and performance-management capabilities for GTE’s voice, data, and video services over wireline and wireless networks. TONICS is installed on more than 500 client workstations at GTE’s national network operations center in Irving, Texas, and more than 50 server pairs in data centers nationwide.

As Figure 2 shows, TONICS is a two-tiered client-server system resident on GTE’s enterprise TCP/IP intranet. Servers, based on relational database management systems (RDBMSs), support continuous operation using fault tolerance software and an automated failover mechanism that seamlessly moves the workload to a backup server if the primary fails. Both clients and servers are Unix-based. Clients maintain consistent internal network models, locally enforce access control, and manage operation context. The displays run X Windows (Motif), include geographic information systems, and are context-sensitive (based on a model-view-controller paradigm).

Results. The deployment of TONICS, among other things, changed our business operations in several ways.

Centralization. Much of the financial benefit of GTE’s centralization depended on economies of scale that could only be achieved with the introduction of advanced operations support systems such as TONICS. The converse was also true. The impact of IT depended on centralizing operations—the old dispersed operational structure would have provided little support for IT solutions.

Improved productivity. As expected, GTE’s network operations center achieved major improvements in productivity. The centralized operation required far fewer people and provided more cost-effective continuous operations. Experts in network disciplines who formerly had only regional scope now acquired company-wide influence and recognition.

Improved quality and efficiency. As a single point of contact, the network operations center clarified service responsibilities for customers, suppliers, and GTE organizations. The consolidated center established uniform practices for all GTE networks and adopted standard processes that led to ISO 9000 certification. It also enabled uniform user training, and simplified planning, procurement, and administration.

Increased flexibility. TONICS proved especially flexible. New development was cheaper, thanks to TONICS’ object-oriented foundation and its reliance on standard components such as its commercial database management system. Using a single platform for network management, we were able to rapidly introduce new features throughout the center.

Faster response to market changes. Increased system flexibility and generality also directly improved GTE’s ability to adapt to market change. As GTE introduced new network technologies, the system adapted readily to manage the new networks and quickly incorporate these technologies into regular business operations. GTE’s international operations
Where once GTE focused on convergence of wireline and wireless voice networks, the drive now is toward convergence of voice, video, and data networks.

Reinvention: Enabling new processes

By late 1997, TONICS was well established and its capabilities highly regarded. The development staff, however, began to see it in a different light. Although TONICS supported a blend of centralized and distributed operations, its Unix client was a single monolithic process and its server communications were based on a proprietary messaging protocol. These elements contributed to system complexity and fairly high maintenance costs.

Between 1993 and 1998, significant changes in the tools available to IT organizations altered telecommunications companies' operating environment. Also, the Telecommunications Act, which increased competition among local service providers, had spawned numerous CLECs. During this period, we began to see IT changing the way GTE does business, primarily by helping define the businesses GTE chose to enter.

Business drivers. Key among the business drivers for changing GTE's operations support systems were network convergence, new network technologies, mergers and acquisitions, increased security requirements, pressures on cost, and network management service opportunities.

Where once GTE focused on convergence of wireline and wireless voice networks, the drive now is toward convergence of voice, video, and data networks. Once the realms of separate management systems, these networks must increasingly be treated as an integrated whole. In the near future, our network management systems will be called upon to manage

- a completely converged wireless-and-wireline high-speed data network,
- the subtending information appliances that perform some combination of phone and computer functions, and
- the applications that run on those appliances.

xDSL is a prime example of the new network technologies that must be integrated into GTE's management process. These are not just new devices with their own idiosyncrasies. If deployed in the numbers projected, the volume of xDSL modems will dwarf all other network components combined. Such numbers require us to re-examine the scalability of our current systems.

In addition, making the average customer a high-speed data services consumer will require a change in how we perform customer service. Here we see a new technology driving market entry: Without the emergence of the Internet as a destination for general consumer networks, technologies such as xDSL, although possible, would have gone unnoticed by telecommunications company executives.

As companies merge, their IT operations support systems must be aligned to let the new entity compete immediately and effectively. For example, in 1997 GTE formed a new business unit, GTE Internetworking, around a core of internetworking capabilities acquired with the purchase of BBN. BBN was also a provider of network services (in fact, of much of the Internet backbone) and had its own network operations center. This center has since become a management center for GTE Internetworking. We now face the challenge of integrating diverse management tools, philosophies, and operations centers to provide a comprehensive view of network performance.

The Telecommunications Act removed many barriers to competition and new market entrants and imposed new conditions on existing players. Penning up operations support systems and network access to competitors requires a new focus on secure external access.

Finally, to remain competitive in a deregulated marketplace, GTE must keep operational expenditures to a minimum. This means that our systems must support a low total cost of operation. There are several dimensions along which this cost should be minimized, most of which apply beyond network management systems.

- Software development resources are currently at a premium. Systems must be designed to let new developers come up to speed quickly and be immediately productive. We want to be able to design, develop, test, deploy, and support system modules in isolation from each other.
- Given scarce resources, we cannot and should not develop all software internally. The system must lend itself to leveraging commercial off-the-shelf components and vendor-provided management capabilities.
Enabling Technologies for Reinvention

From the mid-1990s to the present, while GTE’s IT organization grappled with client-server systems development and support, a series of new enabling technologies surfaced or matured as a result of the Internet revolution. At the same time, older technologies matured and evolved. In operating systems, Windows became a viable, important development and deployment platform for IT systems. In the development arena, everything from CASE tools to compiler implementations saw dramatic improvements. Interoperability, ubiquitous access, and security became standard requirements for all planned systems efforts. The following technologies serve as our reinvention phase enablers.

- The Web, Java, and CORBA
- TO-NICS, which has more than 500 users and operates continuously, incurs high administrative costs. New network devices and users are added to the system daily. With several distinct modules and associated user communities, new software loads are distributed frequently, with attendant workstation upgrades and consistency tracking. To ensure smooth operation and cost efficiency, new systems must minimize this burden.
- To further ensure TO-NICS’ operating efficiency, we must partition and deploy system components independently of each other, even while the system as a whole functions in concert.
- Choice of deployment platform greatly influences total cost of operation. We would like operational systems to be platform-independent.

Finally, as companies focus on core competencies, noncore functions must be outsourced without affecting critical business functions. Conversely, core competencies are being used to insource or provide service bureau functions to others. Because the CLECs spawned by the Telecommunications Act lack GTE’s depth of experience with network management, they are potential customers for an outsourced network management service.

Technology enablers. As the demands on GTE’s operations support systems increase, new technologies and development methodologies have emerged from the IT industry that enable us to redesign our systems to meet these demands. The “Enabling Technologies for Reinvention” sidebar describes these technologies in detail, which include the Web, Java, CORBA, component-based development, security, data visualization, workflow software, and intelligent network devices.

Systems solution. During 1998, GTE Laboratories began developing the next-generation TO-NICS system, called NeMoW (Network Management on the Web). NeMoW provides fault- and performance-management capabilities that are accessible through a secure Web gateway. The system fits into a larger framework for network management that comprises

- a set of components, each of which can be developed, deployed, and maintained independently;
- a standards-based programmatic interface to each of the components, which enables services to be accessed by upper-layer applications;
- mechanisms for the development of applications that can remain independent of changes within the network, or at lower layers of the TMN model;
- centrally administered, platform-independent user interface components; and
- secure partitioned access to component services via Internet, intranet, or extranet.

The framework shown in Figure 3 is composed of layered components that communicate through a CORBA bus. The lower layers abstract out complexity and provide service to the upper layers. At the lowest, element management layer (EM L), the system provides mediation, data collection and long-term
storage, connection management, and activation. These services are used by components at the Network Management Layer (NML), which include:

- Service assurance, specifically fault and performance management. This component monitors the network’s health and proactively detects potential faults. NeMoW addresses the fault and performance management aspect of service assurance, as did its predecessor, TONICS.
- Testing and fault isolation, which, in the event of a network error, helps isolate and diagnose the problem.
- Configuration, which includes inventory management, provisioning, and order fulfillment. This component lets us discover, record, and change the network’s state.

NeMoW implements user interface functionality as a set of Java classes, which are clients of the NML CORBA interfaces and provide graphical views that interact with the service assurance, testing, and configuration aspects of the network.

The final component is a gateway that enables secure access into or among components. Based on the Internet Inter-ORB Protocol (IIOP), this module provides encrypted transport, user authentication, authorization services for access control, and auditing of all gated operations.

**Results.** The following business-practice changes occurred or are occurring because of technological advances or market pressures realized during the reinvention phase.

Shared network management outsourcing. The new architecture for network management with lightweight, Internet-ready, secure, distributed Java-CORBA components lets GTE more easily offer outsourced network management services to other telecommunications companies. This outsourcing is not limited to GTE’s traditional business partners, but could also be offered to companies such as ISPs or large businesses for whom network management is not a core competency.

The ability to support network management outsourcing represents a significant revenue opportunity for GTE. Further, in this era of deregulation and loop...
unbundling—such as leasing part of our facilities to other telecommunications companies—it is often necessary to provide the lessee with some view into the leased portion of GTE’s network. The NeM oW architecture lets GTE accomplish this task in a secure, coordinated manner.

Pluggable business solutions. Both domestic and international business units can now deploy a pluggable set of business solutions configured to meet their needs. One unit might want only the fault-management modules, while another might opt for both the fault- and performance-management modules. Previously, “heavy” integrated clients only let a unit take most or all the functionality at once.

Iterative releases that support rapid time to market. As a result of deregulation, traditional telecommunications companies face unprecedented competition in all operations areas. GTE’s new network management architecture lets its IT organization deploy rapid, high-quality enhancements to system software in support of new products and services. Such responsiveness is crucial for a large company such as GTE, which must compete with fast-paced Internet startups.

Virtual distribution and centralized client administration. The use of the Web and Java as core technologies dramatically simplifies the administrative overhead associated with a client-server system as large as NeM oW. This results in cost savings, quicker turnaround times on new releases and patches, and simplified client administration.

Platform independence. Given the Java language’s claim of generic interoperability on multiple platforms, GTE’s network management solution promises significant savings in infrastructure and development costs. Rather than requiring expensive workstations, common desktop systems will serve as clients.

Interoperability. With the adoption of CORBA for distributed component development, the NeM oW system has opened the network management system’s interface to use by other information systems. This interoperability allows tight integration among information systems and helps GTE rapidly integrate its business processes in support of new business directions. Such efforts include maintaining a single customer view, supporting wholesale and retail operations, and bundling products and services.

Thanks to increased competition, telecommunications companies must now focus on increasing customer loyalty. GTE can achieve this goal by presenting itself as a one-stop shop for all telecommunications services: long-distance, Internet, wireless, data, video, and local telephone access. With the introduction of sophisticated workflow processing within the network management system, it becomes possible to coordinate complex business processes, such as those related to service assurance, that span different business units or strategic partners. For example, the business process coordination required for the new GTE Network Infrastructure involves interactions between five different business locations, each of which supports different aspects of the infrastructure network’s operation.

SUCCESS FACTORS AND TRENDS

Reviewing the impact of information technology within GTE over the past decade, we see an important shift in focus from the tactical to the strategic. In the early 1990s, IT supported GTE’s regular business operations. Beginning around 1993, IT started facilitating important and increasingly strategic changes to those operations, such as successive corporate-wide reengineering efforts. In the late 1990s, we have entered an era of reinvention where IT not only enables but, more importantly, helps define and redefine our business and new business opportunities.

An integrated systems plan

Our case study centers on network management as one component of the corporate service assurance business process. Network management is an example of successful systems convergence in a narrow but mission-critical area. It highlights the potential for additional economies of scale and scope in related areas of service assurance such as trouble, repair, and dispatch management, for example. Systems convergence, for vendor-supplied or internally built IT systems, became the guiding principle in the mid-1990s of a major, corporate-wide Integrated Systems Plan that would lay the path for a new strategic alignment of IT with the business.

The Integrated Systems Plan evolved along structural lines in ways specific to the telecommunications industry—relating to business processes such as service assurance, service fulfillment, and billing, for example—and layered according to the TMN model.6,7 It became the basis for new systems mapping and convergence across GTE, with the goal of converging more than 1,000 systems. We cannot accurately estimate how many other “area opportunities” similar to and distinct from our case study will emerge. But in each case, the enabling computer technologies will be similar. An evolutionary path similar to that which led to our reinvention phase for network management should produce many instances of IT driving GTE to new or “renewed” businesses.

IT’s new strategic role

The deployment of systems like TONICS helped support the initiatives of cost reduction and operational excellence within GTE. In the years that followed, especially after the Telecommunications Act
and the emergence of the Internet as a business medium, IT helped radically redefine the traditional telecommunications business itself. The path to survival is for the telecommunications company, GTE in this context, to transform itself from a provider of traditional telephone services to one that provides information services. IT possesses the instruments to make that change a reality.

Looking forward, we see that IT will continue its strategic role within telecommunications companies. As competition increases and industry-wide deregulation takes hold, telecommunications companies will continue to reinvent themselves as service providers. This should lead to an increasing virtualization of the telecommunications company that lets it sell services without necessarily owning the underlying infrastructure that actually provides those services. GTE, for example, will continue to operate its infrastructure “factories” in areas that it currently operates, but will increasingly push toward unified services and sales organizations that operate across the entire country.

The evolution from reengineering to reinvention, in the network management systems context we’ve described, parallels the evolution of other IT systems at GTE in areas such as billing automation and infrastructure provisioning. Our experience reflects trends across the telecommunications industry—an information services industry experiencing rapid changes in information technology.

Our case study depicts the successful strategic alignment of a typical telecommunications company’s IT and business sectors. Developments in information technology provided the opportunity for this alignment; changes in the information services industry made seizing that opportunity an urgent priority. As always, the challenge now is to find the next opportunity.

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