Divestiture: A Record of Technical Achievement

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This article touches on some of the technical accomplishments that have occurred at Bell Communications Research and throughout the industry, as the result of divestiture

The two years preceding the divestiture of the Bell System was a time of speculation about the perilous journey we were all about to undertake. From my current vantage point in Bell Communications Research (Bellcore) almost two years after divestiture, I can say that the telecommunications technologists in this country can justifiably feel proud of their accomplishments these past several years.

Just some of the technical accomplishments of which I am aware are: the division of the Bell System network and the separation of the Bell Operating Companies' (BOCs') operations systems databases into inter- and intra-LATA portions; the excellent progress being made in the implementation of equal access facilities, a massive job; the network growth of the interexchange carriers to take advantage of the opportunities afforded by equal access; the reconfiguration and rebuilding of the BOC networks; the creation of active industry-wide standards activities; and the successful creation of a common technical resource by the BOC's (that is, Bell Communications Research). In this article I won't describe all these accomplishments, but I will touch on several which I have been able to observe firsthand.

Equal Access Considerations

When considering the many technical issues introduced by the massive restructuring of the telephone industry which took place on January 1, 1984, the foremost is the requirement for equal access as spelled out in the Modified Final Judgment (MFJ) [1]. The divested BOC's are committed by the MFJ to provide exchange access service to all interexchange carriers, equal in type and quality to that provided to AT&T. By September 1, 1984, each BOC began its equal access service and the implementation program is now well along. It is expected that by September 1, 1986, equal access will be offered in all 164 Local Access and Transport Areas (LATA's).

A major aspect of this task has been the design and introduction of software in telephone switching systems to implement the new switching and transmission features needed for equal access [2]. This has been a major challenge and is being accomplished in the shortest intervals yet achieved for such a large-scale software deployment. Of course, planning for this work was already underway in response to the negotiations involving AT&T and the competing interexchange carriers (at a series of Federal Communications Commission run meetings titled "Exchange Network Facilities for Interstate Access" (ENFIA)) and in response to then anticipated legislation, in particular Senate Bill S.898). The MFJ converted a high-priority commitment

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to implement equal access arrangements to a definite schedule of deployment which was part of the agreement. The MFJ negotiations also brought about more rapid closure on the dialing features to be provided than had been possible in the negotiations among the parties involved up until that time.

An important goal of the equal access requirement is to enable telephone subscribers to make a per call specification of interexchange carriers. This requires modification of switching systems to accept and use a three-digit carrier designation to route calls to different interexchange carriers. Dialing extra digits on every inter-LATA call would be a burden for those who generally use the same carrier for every inter-LATA call.

	SAME NUMBERING PLAN AREA	DIFFERENT NUMBERING PLAN AREA
PRESUBSCRIBED CARRIER	NXX-XXXX	1*-NPA-NXX-XXXX
PER CALL SPECIFICATION	10XXX-NXX-XXXX	10XXX-1*-NPA-NXX-XXXX

Where:

- -- The XXX in 10XXX is for the three-digit carrier identification code.
- -- NXX is the central office code.
- -- NPA is the numbering plan area code.
- -- XXXX are the last 4 digits of the called number.

* The 1 is not needed in all areas.

Fig. 1. Dialing patterns for access to interexchange carriers.

So the switching systems are being modified to accept a presubscribed carrier for each customer. This is a feature that emerged in negotiations leading to the MFJ. After presubscribing, the customer can dial all calls which involve their presubscribed carrier in the same manner as AT&T calls were dialed before divestiture.

To use a different carrier than the presubscribed one, a customer prefixes the call with the digits "10" and the three-digit carrier identification code for the specific interexchange carrier that is desired. The presubscription approach is a sensible way to minimize the effects of divestiture on the service provided to network users. The dialing patterns used to access interexchange carriers that are using this feature are illustrated in Fig. 1.

Another example of minimizing the effects on the user is the forwarding of the calling station number to the interexchange carriers who want this supplemental information for billing purposes. This was essential to eliminate the need for manual entry of an identification number by the customer after reaching the chosen interexchange carrier, which was also only possible from tone-dialing telephone stations. To provide the calling subscriber identity without adding perceptible delay in toll set-up took some real ingenuity.

The technical solution arrived at was to extend automatic number identification (ANI) by sending forward the calling station identification number as soon as the chosen carrier and destination central office were known by the originating central office. Hence, ANI transmittal overlaps the entry of the last four dialed digits from the customer, eliminating any extra delay in all but very exceptional cases.

In fact, the principle of minimizing the effect of equal access on service has affected more of the software and hardware in the involved end offices and access tandems than might be imagined. For instance, software for vertical features and business features all had to be modified to work properly in the new environment.

A second major aspect of equal access has been the development and introduction of a two-level hierarchical network design for the LATA's that provides transmission quality for all interexchange carriers equal to that provided to AT&T [3]. The upper-level switching machines of the hierarchy are called access tandems, and the reason for having them is to allow small volumes of traffic to be economically routed to various interexchange carriers. When the volume of traffic between a particular equal access end office and a particular interexchange carrier warrants, direct trunk groups may be established. The network design is shown in Fig. 2.

Access to the interexchange carrier at its point of termination (POT) can be provided three ways: 1) by routing traffic directly from an end office, 2) by routing traffic via a concentrating access tandem, or 3) by establishing a high-usage direct route with overflow via the access tandem. Calls via the access tandem include an extra link, raising the question of whether the transmission performance can be equal. After the transmission design was developed, which assigned zero loss to the tandem inter-LATA connecting trunks (see Fig. 2), the expected voice performance of the plan was modeled and the quality of service was estimated [4]. This modeling was possible only because of the extensive work over the past two decades in modeling the subjective effects of network transmission parameters.

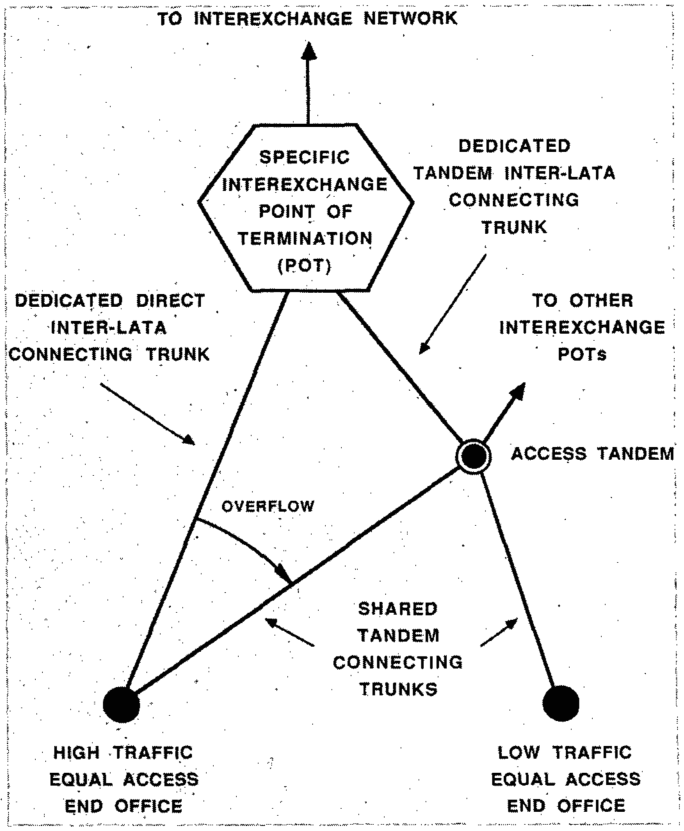

Fig. 2. Equal access network design.

The customer opinion model used was the Long Toll Model [5], based on the opinions of over 10,000 Bell System customers who had just completed calls over long toll connections. The predictions showed that performance would meet the underlying objective of equal quality. Experience with actual equal access implementation is confirming these conclusions.

Partitioning of the Network

The division of a single, interconnected Bell System into 164 LATA networks and an inter-LATA network occasioned major technical challenges beyond equal access implementation. AT&T Communications was assigned 80 percent of the then existent 4ESS large toll switching systems, all the TSPS operator service position systems for toll and assistance, and the extensive common channel signaling network interconnecting the higher levels of the switching hierarchy. On the other hand, the BOC's retained all those switching offices then being used for local service.

Interfacing of the long distance common channel signaling with local switching offices was in the very earliest stages of evolution at the time of divestiture. The fundamental goal of networking all stored-program controlled (SPC) switching systems with data links was deferred until a new plan in which all interexchange carriers could participate was available. While of great long-term importance, the evolution of the SPC network has been second in priority to the immediate need to restructure the LATA networks.

Each BOC had to develop a plan for interexchange access tandems as well as for tandems to carry intra-LATA traffic. In many cases the functions have been combined. Tightly integrated facilities had to be sorted out; the MFJ does not allow facilities to be jointly owned by the BOC's and AT&T Communications (although sharing of facilities is allowed for a transitional period). This sorting out of facilities involved another massive software development effort, this time centered about the operations support systems called PICS/DCPR and the TIRKS™ system. Both of these systems are maintained and enhanced by Bellcore. PICS/DCPR is short for Plug-in Inventory Control System with Detailed Continuing Property Records, and TIRKS stands for Trunks Integrated Records Keeping System.

PICS/DCPR is the well established mechanized system that the Bell Companies have been using for plug-in equipment inventory and materials management. Part of the PICS system is a detailed investment database supporting the accounting records for all central office equipment (not just plug-in equipment). These records, in 19 separate installations which contained a total combined central office investment base of $53 billion worth of equipment, had to be sorted into intra- and inter-LATA segments by January 1, 1984 so that each company would begin its post-divestiture life with a proper set of investment records for regulatory purposes.

This tremendous effort, which required major new features in PICS/DCPR, was completed on time with minimal disruption to regular BOC functions. Furthermore, a completely functioning PICS system was replicated for AT&T Communications to manage equipment added to their inventory by the intra/inter-LATA split.

In the case of the TIRKS system, the work to support divestiture is still continuing within Bellcore. The 21 TIRKS systems deployed in the BOC's are used for circuit provisioning. The databases of each system contain the detailed records on about a million circuits each. The data from these records had to be combined with data resident in other automated systems to build a complete record of circuits and inventory. This data gathering effort was followed by the determination of asset ownership and circuit control. Next, points of interface on each circuit were determined. Finally the data were separated into two partitions, one to be retained by the BOC and the other to be handed off to AT&T Communications. The process will not be fully completed until 1986.

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Having split the ownership and control of the existing network, many network planning and service provisioning processes had to be changed so that the networks would continue to work together. For example, pre-divestiture, the design of a switch-to-switch message trunk was always the responsibility of a single company, either one of the BOC's or AT&T Long Lines, regardless of equipment ownership. In the post-divestiture environment, design responsibility for switched exchange access services goes hand-in-hand with equipment ownership, and the ownership of an end-to-end circuit is now split between BOC's and interexchange carriers. This creates a need for trunk segment design methods to meet the demanding requirements of the equal access transmission plan [6]. The types of trunk segments that comprise a BOC to interexchange connection are illustrated in Fig. 2.

A most important result is that characteristics which were always handled implicitly now have to be made explicit. New codes have been specified which now enable two companies, a BOC and an interexchange carrier, to design their trunk segments so that the overall trunk will meet specified performance objectives. Software has been developed in the TIRKS system to support the message trunk design process.

As mentioned earlier, divestiture interrupted the progress that was being made towards a stored-program controlled network. Not only were the BOC's left with no common channel signaling (CCS), but they were left with no 800 Service database since this established service was assigned to AT&T. The BOC's are now planning to provide equal access 800 Service for all interexchange carriers as well as intra-LATA 800 Service. They are planning to implement CCS systems and databases for translating 800-numbers to actual network terminating numbers. The Signaling System 7 protocol established by the International Telegraph and Telephone Consultative Committee (CCITT) will be used by the BOC's since it is best suited to the long-term evolution of their LATA networks. Once CCS is in place in a BOC network it will be useful for many new network capabilities including future integrated services digital network (ISDN) services.

Another important function which was split between the BOC's and AT&T Communications was operator services. AT&T retained toll and assistance operations and the associated TSPS systems. The BOC's retained directory assistance and intercept operations and the systems which support these functions. The BOC's are implementing plans to replace the intra-LATA toll and assistance operator services functions now leased from AT&T Communications with their own operator systems. This process has already begun.

In this first phase, the BOC's will continue to lease access to AT&T's CCS and their Billing Validation Application for calling card service. Later each BOC may deploy its own databases and use its own CCS networks for intra-LATA calling card service. A major technical challenge that BOC's are attacking with the technical support of Bellcore is to establish a modern system and network structure on which they can build future services.

Network Compatibility

An important requirement of the MFJ was that the newly established regions move as rapidly as possible toward the procurement of products to meet their internal network needs independent of AT&T and of each other. The key to this is the development of generic requirements and modular interfaces unrelated to any specific manufacturer's products. These generic requirements and modular interfaces promote compatibility in the exchange networks. In the high technology, high risk areas of the BOC networks, Bellcore has provided technical support through a structure of Technical Advisories, Technical References and Technology Requirements Industry Forums [7]. This information flow, chronicled in the Bellcore Digest of Technical Information [8] and positioned to represent the best view of BOC common needs, recognizes that there will be individual BOC variations to meet their individual network and service strategies. While much remains to be done, the process appears to be working well in providing telecommunications industry vendors with the information needed to be effective entrants into the markets of their choice.

New Standards Environment

The restructuring of the telecommunications industry into customer, exchange carrier and interexchange carrier subindustries has had a profound effect on the awareness and importance of telecommunications standards in the U.S. The role that AT&T played for over a century in planning the national telecommunications network ended with divestiture.

In the months preceding the divestiture, the FCC published a Notice of Proposed Rulemaking in which it expressed concerns for network continuity and the need for a planning mechanism to provide the interconnection and interoperability standards necessary to assure the viability of public telecommunications made up of multiple networks.

The notice evoked broad industry support for a new national telecommunications committee which was proposed by the Exchange Carriers Standards Association (ECSA), an association of the major telephone operating companies. ECSA proposed a committee which would operate under the rules of the American National Standards Institute (ANSI) and be open in membership to all interested parties.

The ECSA-sponsored committee was initiated in February 1984 as Committee T1 [9]. The interest in telecommunications standards was such that T1 immediately attracted a membership which made it the largest ANSI-affiliated committee. T1's membership currently numbers more than 120 member organizations representing exchange carriers, interexchange carriers and resellers, manufacturers and vendors, user groups, government agencies and consultants. With the growth in multinational companies, T1's members represent companies with affiliations in countries such as Canada, Japan, Sweden, FR Germany, and France.

T1's focus is on interconnection, interoperability and performance standards, which are major concerns to the U.S. network. However, in addition to its goal of deriving American National Standards, T1 has been the principal source of contributions to the U.S. CCITT Study Groups on matters such as ISDN and CCS. Acceptance of U.S. positions in this arena is in the best interests of the U.S. network providers and U.S. manufacturers seeking world markets.

T1 is organized into six Technical Subcommittees (see Fig. 3) and more than 20 specialized Working Groups. All the entities resulting from divestiture, particularly Bellcore as the BOCs' technical resource, figure prominently in the Working Groups. Some of the draft standards on which T1 has worked are listed in Fig. 4.

T1C1	-	**Carrier to Customer Premises Equipment Interfaces**
T1X1	-	**Carrier to Carrier Interfaces**
T1D1	-	**Integrated Services Digital Networks (ISDN)**
T1M1	-	**Internetwork Operations, Administration, Maintenance and Provisioning**
T1Q1	-	**Performance**
T1Y1	-	**Specialized Subjects (such as digital coding and environmental standards)**

Fig. 3. Committee T1 Technical Subcommittees.

T1's success is a compliment to an industry which has undergone such major changes within a short period of time. T1 has brought all interested elements together in a cooperative industry forum for the purpose of developing mutually beneficial industry standards. T1's success and its acceptance by the industry prompted the FCC to give T1 its vote of confidence as the source of network standards in March 1985.

1. **ISDN User-Network Basic Access Signaling Specification**
2. **Standard For ISDN Basic Access Interface For Application At The Network Side Of The NT1**
3. **US Standard For Common Channel Signaling**
4. **Compatibility Standard For A Switched Access Interface Between An Exchange Carrier And An Interexchange Carrier**
5. **Interconnection Of Cellular Radio Service Systems To Exchange Wireline Systems**
6. **Digital Networks Synchronization Standards**
7. **32 KBPS ADPCM (Low Bit Rate Voice Algorithm And Line Format)**
8. **A User-System Language For Telecommunication Networks**

Fig. 4. Examples of work toward draft standards by Committee T1.

Challenges Met and Remaining

Looking back, we can now recognize that it was telecommunications technologists who unleashed the forces that led to the revolutionary changes that have rocked the industry. At this critical time, telecommunications technologists have risen to the challenge of implementing the networks that divestiture required on an extremely rapid schedule. The voids which many had feared in the post-divestiture structure have been partly filled by the establishment of Bellcore, an effective technical resource to supplement the technical staffs of the BOC's, and the creation of ECSA and its Committee T1 to deal with network interface issues. Perhaps most telling, the test of keeping the U.S. network functioning through the transition has been met.

This is not to say that all problems have been solved. A key question that remains is, "How can the U.S. maintain a position of leadership in providing new capabilities in a public network that has such divided responsibility?" Technical plans for the public network must be responsive to user needs, and users are concerned with end-to-end solutions to their communications problems. Now a typical domestic long-distance call can involve two providers of customer premises equipment, two exchange access carriers, and an interexchange carrier. Not only is it difficult to resolve problems with existing services, but there is no single driving force for new public network services on a national basis. ISDN standards will provide a framework for digital services but not the detailed service definitions. Unless some solution can be found to this problem of driving new public network services, it is hard to imagine how the full benefits of ISDN capabilities can be achieved in the U.S. environment.

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