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Electronic Switching for Trunk Systems

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Electronic switching for trunk systems

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The past decade has seen the worldwide introduction of electronic switching with stored program control. Initially the application of this new technology was in local exchanges but today electronic systems are being introduced into trunk systems as well. One of the latest applications is No. 4 E.S.S., a very large trunk switch. This system, in combination with local systems such as No. 1 E.S.S. and new signalling arrangements, offers major innovations in telecommunication service.

The introduction of stored program electronic switching at the local level in the Bell System has led to literally hundreds of new services and features being made available and many more being developed or planned. With stored program control and new signalling arrangements in the connecting trunk systems, the door is opened to both extending the local services and introducing totally new services. These trends are discussed along with examples of possible services.

Finally, the effects on development, manufacture, administration, and the customer are reviewed.

Introduction

Stored program electronic switching systems are now in use throughout the world. In the United States over a thousand such exchanges serve nearly 20 % of the Bell System telephones. This worldwide shift in switching technology has opened the door to major innovations in communication service for both business and personal use. New services and arrangements continue to be introduced at several times the rate characteristic of the earlier electromechanical technology.

This climate of rapid change makes the task of predicting the state of the art in trunk switching in the 1980s somewhat difficult. However, some things do seem reasonably clear. Most of the forces for change are known today. Also, the technologies of stored program control, electronic switching, digital transmission, computers and the like are rather well understood. The questions seem to revolve largely around how the opportunities presented by these technologies will be used to create the telecommunication services of the 1980s and beyond. Of course the basic prediction being made here is that the rapid innovation in local services will be followed by a similar rate of innovation in trunk services as stored program control trunk switching replaces electromechanical. Perhaps it would be informative to trace some of the early history of electronic switching to judge the base on which this prediction stands.

Electronic switching began at Bell Telephone Laboratories in the classic pattern of basic research followed by systems engineering followed in turn by exploratory development and final development. Before 1950, research in the application of electronic technology to switching showed that both technical and economic problems remained to be solved. However, the invention of the transistor in 1948 suggested new avenues of attack and by 1951 new systems engineering studies were under way. These studies led to the initiation of exploratory development work, and in 1954 an electronic switching development laboratory was formed with about 30 engineers. The assignment was to develop and test an electronic telephone exchange. Incidentally, within three years this laboratory had grown to well over 200 people and in ten years to over 650.

The original plan generated by the systems engineering organization called for the use of hard wired electronic logic circuits for the control of the exchange, but the alternative of stored program control was suggested later by the development organization. However, no suitable memory existed at that time in which to store the program. In 1954 memories of high reliability holding millions of bits and with microsecond access were simply not available. Nevertheless, the advantage of stored program control was clearly understood: it was to permit easy and economical modification of the services rendered by the exchange and to permit the introduction of totally new services.

Table 1. Bell E.S.S. Exchanges

system	peak busy hour calls	terminations	usage
No. 1 E.S.S.	108000	96000	local/trunk
No. 1A E.S.S.	240000	128000	local/trunk
No. 2 E.S.S.	25000	24000	local
No. 2B E.S.S.	50000	24000	local
No. 3 E.S.S.	11000	4500	local
No. 4 E.S.S.	550000	107500	trunk

An outstanding example of service modification existed at the time. Recall that in 1951 subscriber trunk dialling was first introduced into the Bell System. This was a vivid reminder of the complexity of service modification because it required massive equipment modifications in thousands of exchanges to register 10 digits instead of 7 and to collect billing information. It was obvious that in a stored program system one needed little more than a program modification and the addition of some bulk memory. Further, the change could be made simultaneously in many offices, thus simplifying start-up problems. Therefore, in 1954 the forces for change in telecommunications service were evident and stored program control was clearly the way to cope with change. By September of 1955 there appeared to be a solution to the memory problem and a firm decision in favour of stored program control was made. The belief at the time was that electronic switching with stored program control would save both space and money and would permit the introduction of new services and features. Exactly the same claim is made today in the case of trunk switching.

The years that followed were times of great challenge and difficulty but led to great satisfactions as well. In March of 1958 the first telephone call dialled under stored program control was made in the laboratory. In November 1960 the experimental exchange at Morris, Illinois, went into regular service. In May 1965 the commercial design, No. 1 E.S.S., went into service in Succasunna, New Jersey. Today the Bell System is engaged in a total conversion of its exchanges, both local and trunk, to stored program electronic switching (Fleckenstein 1974, 1976). The systems presently being employed are listed in table 1.

Not included above are a number of other electronic stored program systems used for operator services or p.b.x. service.

There is also a special network of about 40 No. 1 E.S.S. four-wire trunk switches serving the U.S. Government. This 'Autovon' network started in 1966 and was clearly the first use of stored program control for trunk switching. The No. 1 E.S.S. was modified for this application because with appropriate programs it could provide the numerous special services required. Later some regular No. 1 E.S.S. installations were introduced into the trunk network of the Bell System. Use of No. 1 E.S.S. as a trunk exchange is continuing. However, the major impact of electronic switching on trunks in the U.S.A. is expected to come via No. 4 E.S.S.

No. 4 E.S.S.

The importance of No. 4 E.S.S. is that it is a vivid indicator of what is possible in trunk switching in the 1980s. The key characteristics of No. 4 E.S.S. that suggest the nature of trunk switching in the coming decade seem to be as shown in table 2.

Table 2. Key features of No. 4 E.S.S.

1. stored program control
2. large capacity
3. low blocking
4. solid state network
5. processor aided maintenance
6. simplified transmission interface

The design of No. 4 E.S.S. is well covered in the literature (Johnson 1973; Tuomenoksa & Vaughan 1974; Vaughan 1972; Vaughan, Ritchie & Spencer 1976). For the purposes of discussion, the design can be described as an integrated circuit processor (see Staehler & Watters 1976), duplicated for reliability, driving a time division switching network. The transmission path is digital, 8-bit pulse code modulation, and the switching network is of the time-space-time type using a 1024×1024 space division structure surrounded by 128 time slot, time division switches. The central space division switch can be totally reconfigured a million times per second to accommodate the 8-bit signals offered 8000 times per second by each of 128 time slots. Trunk supervision and signalling are buffered through signal processors that handle assembly of dialled digits and similar routines to minimize the load on the central processor. Figure 1 shows a block diagram of this system.

Analogue trunks connect via analogue–digital converters to interface with the digital network. Digital carrier trunks only have to interface through a buffer to handle phase differences between the digital office and the digital trunk. Synchronization of the digital frequencies is, of course, required as in any multilink digital transmission system. Signalling over the trunks can be by conventional means. Note, however, the c.c.i.s., common channel interoffice signalling, terminal at the left side of the diagram. This is a fast data link to other trunk or local offices to permit communication of more information in less time than is possible by the conventional trunk signalling methods. C.c.i.s. offers faster call completion but more importantly opens the door to new services, especially those that rely on data generated at the originating point of the call, for example, the calling number or special routing instructions (see Dahlbom 1972; Kaskey & Nance 1976).

The key features listed on table 2 derive from the above characteristics of the design. First, the stored program processor is many times faster than the No. 1 E.S.S. design. This gives a capacity gain of more than four times. Not only is there a large capacity increase but the processor is more convenient to use. For example, the No. 4 E.S.S. program is recorded on disk files which are easily rewritten. In No. 1 E.S.S. twistor cards, usually written at the factory, are mechanically replaced to change the program. Thus, the new processor is more like the usual computer in the ease of program change but with no relaxation of the long established dependability objective of no more than two hours down time in 40 years.

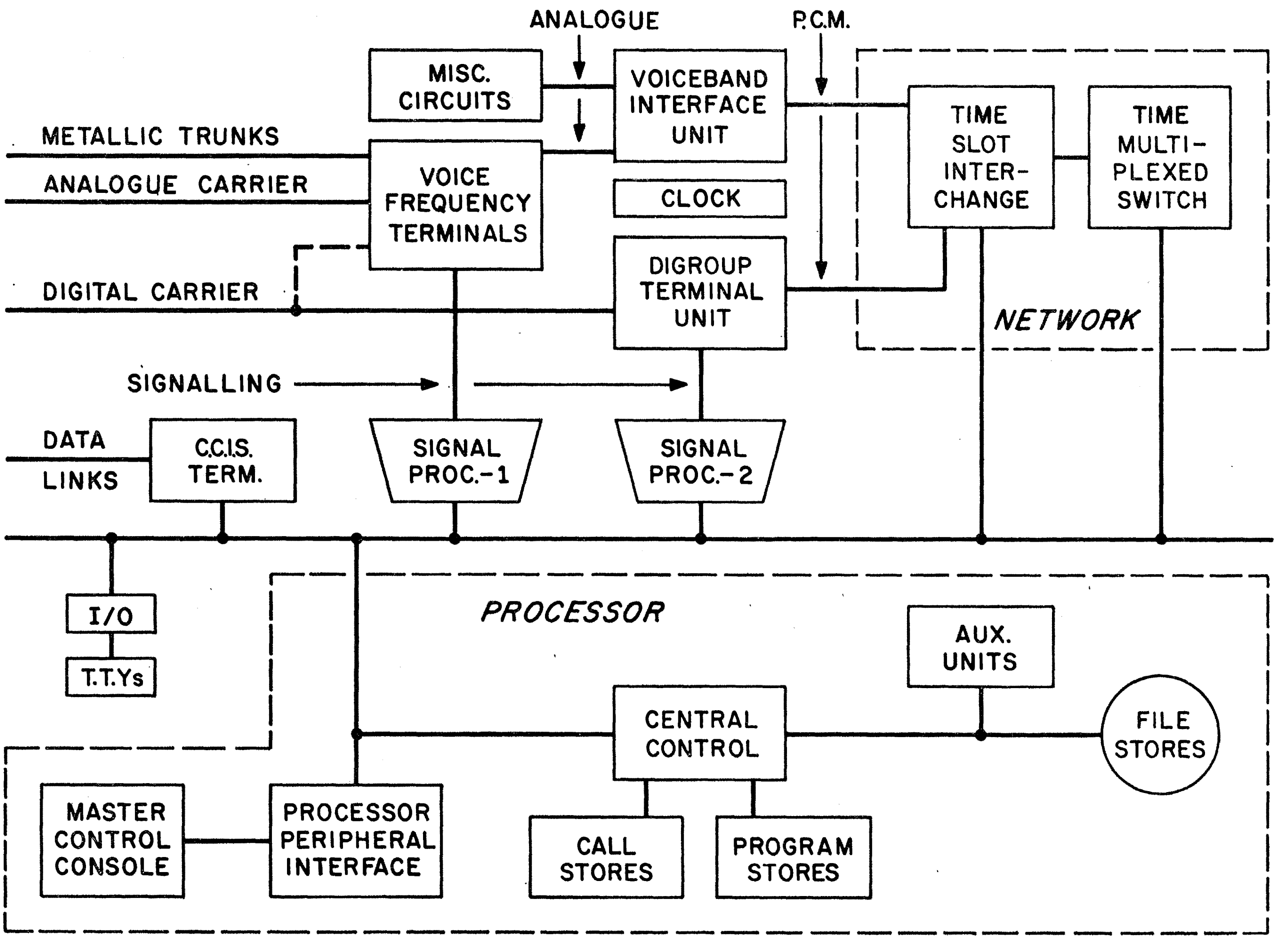

FIGURE 1. The No. 4 E.S.S. office.

The large capacity and low blocking of No. 4 E.S.S. also relies on the use of a digital switching network. The No. 1, 2 and 3 E.S.S. local switching systems all use analogue transmission through networks built of reed matrices. These Ferreed or Remreed networks pass the direct currents and significant powers required for local lines. Indeed, powering the telephone instrument, ringing its bell, etc., are major obstacles to electronic networks at the local level. Trunk switching avoids these problems and can profitably take advantage of the size reduction of electronics. Electronic networks of the size of No. 4 E.S.S. can be built either with analogue or digital technology. An analogue design based on PNPN device integrated circuits was seriously considered for No. 4 E.S.S. However, the digital time-division approach has a special advantage: it allows the construction of large access switches – switches equivalent to $n \times n$ crosspoint arrays where n is a large number. In most analogue switches one uses several (usually 4–8) stages of 8×8 or 10×10 switch arrays. In time-division, digital designs, fewer stages of, perhaps, 100×100 or more are more usual. The larger arrays sharply reduce the probability of being blocked and in large networks greatly improve both the traffic capacity and the ease of control. Thus, low blocking and high network capacity are seen as key features of the No. 4 E.S.S. design. Of course, both the processor and the network must be matched to the capacity objective. Note also that a network with low blocking can sharply reduce costly rearrangements needed to balance traffic loads among different sections of the network.

Trunk exchanges tend to be large and to connect with many different transmission facilities. Also the economic value of each call is increased by the longer distance of trunk calls so it becomes especially important to ensure good maintenance of both the exchange and the transmission facilities. Here is another area where stored program control offers major advantages. One can use this same processor to aid in the maintenance and administration of not only the exchange but the transmission facilities as well. Not only can the quality of the job be improved but maintenance effort is reduced and much of the paperwork can be put into the computer. In the case of No. 4 E.S.S. it is estimated that the paperwork is reduced by 90 % and a far better maintenance job is done with one third of the people. The cost savings generated by these factors alone are forcing the abandonment of electromechanical switching.

The introduction of large economical trunk switches with features made possible by stored program control tends to change the character of the trunk network (Mummert 1976). For example, the large size leads to a need for less hierarchy in the network. The processor aided maintenance and the use of c.c.i.s. as well as the digital network tend to blend the switching and transmission together and dissolve the previously sharp boundary between them. Thus some of the transmission system maintenance and surveillance is shifted to the exchange processor. With the records in the processor it also becomes far easier to make rearrangements required by growth or traffic. Network management to deal with abnormal conditions has opportunities for obtaining both data and control that simply could not be imagined with the electromechanical systems.

The introduction of a digital exchange also has an impact on the choice of connecting transmission facilities. The digital exchange inserts an economic bias in favour of digital transmission because of the lower cost achieved by the elimination of analogue–digital converters. In the case of No. 4 E.S.S. this creates a strong tendency to make all of the shorter connecting facilities digital. However, longer distance facilities are still largely analogue transmission because their presently lower transmission cost is not overcome by the terminal savings. As new technologies emerge this situation could, of course, change. In the five No. 4 E.S.S. offices in service as of 1 February 1977, the digital connecting facilities slightly outnumber the analogue, but in one office (Dallas, Texas) the facilities are nearly two thirds digital (Giloth & Vaughan 1976).

Service with E.S.S. and c.c.i.s.

In the early days of E.S.S. it was often claimed that stored program control was important because of services we had not yet conceived (Ketchledge 1957; Keister, Ketchledge & Lovell 1960; Keister, Ketchledge & Vaughan 1964). Indeed, many of the services now offered on No. 1 E.S.S. and which are today viewed as especially valuable were not imagined in the 1950s. Nevertheless, the opportunity for service innovation and the need for new services were accurately foreseen. Today, trunk switching is in the same position. The need is clear; the opportunity is clear; the doubt is only in the details of implementation and the political and economic forces that may distort the technological result.

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Given a stored program high capacity trunk switch with improved signalling facilities, such as c.c.i.s., and a local switching plant similarly equipped, what sorts of services become possible? The point to be kept in mind is that the services to be described may or may not resemble services that will actually be developed and offered to customers, but they do suggest the wide range of opportunity for innovation. Therefore, it is virtually certain that some substantial set of new services will be developed and brought to the market place. Some examples follow of what the technology might offer.

Call screening

Via c.c.i.s. the calling number can be forwarded to the called number's exchange. This allows the handling of the call to vary depending upon the calling number. For example, one could imagine a service where calling numbers from a prearranged list are allowed to complete normally but all other calls are routed to a secretary, to an announcement, or given a special ring cadence. Indeed, one can imagine calls for a master number being terminated to different telephones depending on the area from which the call originated. A service business might find this useful. Emergency services might use the calling number itself to locate the site of the emergency. In any case, the ability exists to vary the routing and handling of the call depending on both the originating and terminating numbers. The point is that the technology offers the opportunity. These services or some variant might be practical and useful as well. It is hard to imagine getting through the 1980s without some such services being made available.

Voting

Many businesses should be able to make use of an arrangement allowing people to vote or express some preference by telephone. Imagine a contest in which the several individuals appear on nationwide television and at the climatic moment telephone numbers are displayed associated with each contestant. The public can then call the number of their choice to vote for the contestant they prefer. The local E.S.S. office could record the dialled digits and give the customer a brief acknowledgement tone and increment its count for that contestant by one. It could even refuse to accept a second vote from the same telephone. Periodically the E.S.S. office could forward its tally to a central point where the nationwide (worldwide) summary could be formed. All of this could be done rather quickly so that in a matter of minutes the winner could be announced.

Many years ago there was, in the United States, an amateur hour on the radio, the Major Bowes Amateur Hour, and one could telephone in one's vote. They collected many votes even though the process was slow and usually meant paying for a trunk call. Traffic capacity was limited as well. A fast 'local call' system of high traffic capacity would certainly seem to have application in the entertainment field since people seem to enjoy such voting. While this is not meant to bring a revival of the Roman Colosseum, nevertheless the sports and amusement possibilities cannot be ignored. In any case, marketing organizations would be expected to make major use of such a service. It would seem that even with special terminals it would be a long time before political votes could be cast this way. On the other hand, if every voter had his own validation number known only to him and perhaps changed at each election, maybe the political application need not be so far off. In any case, the point is that the technology is available with E.S.S. and c.c.i.s.

Meanwhile radio and television stations continue to generate mass calling by announcing numbers and offering a prize for the first caller or the tenth or some other. These concentrated patterns of calling often create traffic problems and can seriously interfere with other traffic. If such mass calls can be turned back by the local office, the trunk network could be protected. Clearly, the c.c.i.s. data link could be used to interrogate the exchange serving the called number to determine whether to forward or turn back the offered traffic.

Voice store and forward

Data store and forward systems have been available for many years and serve a large market. Voice recording equipment is equally available and can be connected to a telephone line to record messages, make announcements, etc. In some business offices centralized recorders are controlled by the dial of the telephone to permit starting, stopping, playback, etc., usually to record dictation. With the control possibilities of a stored program exchange and the data capabilities of c.c.i.s. one can easily imagine a voice store and forward service where a voice message can be recorded and forwarded to the destination at a later time. Alternatively, the same message can be passed to a number of destinations. It is message switching, but the message is delivered as a voice signal. It might be a way to use idle trunk capacity at night to move traffic for delivery the next day.

If one were to equip the trunk exchange with this voice storage capability it would centralize the function and perhaps permit some economies. Indeed, there appear to be a number of services in which centralization of the equipment in the trunk exchange is economical and c.c.i.s. permits remote control. Another example where such centralization might be advantageous is a service that relies on a nationwide data bank for routing or control information. In such a case it may be economical to limit the number of exchanges having access to the national data bank. Here again one sees opportunity created by E.S.S. and c.c.i.s. to achieve services impractical in the older technology.

It must be stressed that the point is not the practicality of usefulness of these particular services. They are not suggested for any purpose other than to bring out the potential of the technology. They do argue that the trunk network of the future will gain the same benefits from stored program control E.S.S. that have so profoundly altered the character of local telephone service.

Factors influencing the 1980s

Having made an effort to show technological opportunity for major new services in trunk exchanges, an attempt will now be made to show need. The need will be examined in terms of factors tending to influence the evolution of telecommunications.

One of the most obvious factors is growth. Regardless of the alarm with which one might view the growth in world population, there is no doubt that there continue to be more people making more telephone calls. The growth in transatlantic traffic from a few calls handled by shortwave radio to today's customer-dialled satellite and cable traffic is a truly remarkable example. While the world's telephone traffic is growing, the data traffic is growing even faster. Certainly there is need for quantity but, as in the case of transatlantic calls, one suspects that improved quality of service breeds even more rapid growth. Thus one can argue that, as the variety and usefulness of telephone service improves, the appetite for more is increased. This suggests caution in extrapolating old growth rates into a time when service quality is markedly improved.

The technological factors of the improving art of switching have already been discussed in part. However, the technological factors are much broader than switching. We are in the midst of a computing and communications revolution. The abilities of computers seem to have few limitations that time and money are not likely to correct. Integrated circuit implementations continue to erode the problem of cost. Today's pocket calculator mimics yesterday's computer. Not only do we see new giant machines of ever-improving capability but now the microprocessor is bringing computing technology into nearly everything we use or do. Microprocessors have now even invaded the home.

The home computer hobby in the United States is reported to have spawned tens of thousands of sales, over 150 clubs, and half a dozen magazines (Anon. 1977). In addition, microprocessor-driven games are enjoying great popularity as attachments to television sets. Simultaneously, industry is using the same technological advances both to increase its computer usage and to form more complex computer networks wherein computers in remote places use communications to operate together. Just as with the telephone, the need for switching grows as the network gets larger. While an appropriately arranged computer can act simultaneously as a computer and as an exchange, in many cases it is economically advantageous to separate these functions. This may justify use of a data message switching exchange to store, switch and forward the data. On the other hand, it is possible in many cases to handle this traffic over the regular telephone network. For example, much real-time interactive computing is handled over dialled telephone connections between the central computer and the remote terminals. The c.c.i.s. signalling system itself is no more than an intercommunications system linking computers that also happen to be serving as telephone exchanges.

One other aspect of the technology should be mentioned. In the days of electromechanical switching the components used were special to switching. The step-by-step switches, the crossbar switches, the wire spring relays, and the like, had only limited use outside telephone exchanges. In the new electronic age the situation has changed markedly. Electronic logic and memory devices, for example, are used in all sorts of electronic equipment, and the volume of that equipment being manufactured has grown tremendously. Thus, parts to build electronic exchanges are already manufactured in large volume, and widely available at low cost. Today the idea of building any kind of a control circuit immediately suggests using integrated circuits to build it. Twenty years ago when we were trying to build our first electronic exchange out of those strange new things called transistors we horrified our electromechanical design friends. Today the questions of cost, reliability, size, weight, power and the like have all gone to favour the electronic approach. It is not surprising therefore that the electronics industry has grown so large so fast.

Still another major force for more and better telecommunications is the growing number, size, and complexity of industrial organizations. The growing number of so-called multinational corporations is also well known. All large companies tend to have far-flung operations and a corresponding need to communicate. Passing from the era of small, local businesses to that of huge international corporations not only takes more telephone service but it develops needs for totally new services. Indeed, the telecommunication needs of large corporations have had a significant influence on the features developed for both electromechanical and electronic switching in the United States, if not of the world. Of course, some of the services originally developed for use in electromechanical systems have been greatly improved in the electronic versions.

Take, for example, a.c.d., automatic call distributor. Such systems, for distributing telephone calls to a central number across a number of receiving stations, are old. Numerous electromechanical versions were developed to spread the load in applications ranging from telephone operators to department store order takers. However, the needs of industry continued to grow. Consider the airlines ticket reservation process. With the growth of air travel, airlines have introduced centralized reservation bureaux served by computers. Not only do these bureaux demand new and far more complex switching arrangements but they need traffic data as well to control properly the size of their operating force, plan rearrangements, etc. Note that this need for traffic data and its use to control rearrangements lie in an area hitherto reserved almost totally to the telephone company. This is something of an adjustment for the telephone traditionalist, to let the customer rapidly rearrange facilities on the basis of traffic. However, consider the problems of the airline with a few bureaux scattered across the country. At night it may close down all but one. At each it wants to know the grade of service it is giving, including the delay before answer, to know the utilization of the bureau clerks, etc. It wants to respond to calls to the bureau differently depending on the city of origin. Usually the customer does not know that he is being served by someone perhaps thousands of miles away. Thus, every call to a clerk must start with a voice announcement heard only by the clerk as to the city of origin.

The airline wants calls handled in order of arrival and if the bureau cannot answer promptly because of traffic, a delay announcement must be passed to the customer. The airline may want several versions of the delay announcement and may want to adjust the delay before the announcement is given. Some calls have to be given special priority and this complicates matters further. Then the airline wants to break its clerks up into groups called 'splits' with each split taking an assigned type of traffic, say from a particular geographic area. Of course, rearrangements of the splits must be made by the airline as traffic varies, and they may want 25 or more splits. Not only does modern a.c.d. service to an airline call for many features for the clerks or agents, but the supervisors have even more features in order to manage the agents. Note further that the airline usually wants exactly the same service at several widely separated locations. This means that the electronic exchanges are needed in all of these places. It is not much of an extrapolation to imagine the desire for the same elaborate telecommunication arrangements in, say, London and New York. The need seems obvious.

Corporations often have their own telecommunication experts, and they devise special arrangements that they expect the telephone company to implement. Thus these large and important customers are both expert and demanding and as such are a considerable stimulant to progress. One can generate a long list of new and improved services developed or under development to serve business needs. In looking ahead to the 1980s one perceives no relaxation in the demands of business for services tailored to their operations. In fact, their appetite has been whetted by local electronic switching, and an electromechanical trunk network is becoming a less and less acceptable excuse for not providing services that require an electronic trunk network. It can be argued that a number of agencies, including organizations engaged in international trade, will exert pressures to extend full electronic telecommunication service to the entire world. Inferior telephone service can become a trade disadvantage. The business may go to where the services are more adequate.

One last force to be reckoned with is mobility. People are becoming more mobile than ever before. Transportation facilities continue to improve. Your new supersonic transport that so sharply reduces the time and effort of a transatlantic crossing is a classic example and a most impressive one. With increased travel comes increased telephone usage, and these travellers do create pressure for a telephone service as good as they have seen elsewhere.

There is another arena in which greater mobility is creating pressure directly on trunk exchange service. That is high capacity mobile telephone service, putting telephones, with the ability to handle tens of thousands of simultaneous calls within a city, into cars. A single, large, stored-program exchange would control a multiplicity of radio sites. As a car making a call moved through the city the radio path would be switched from site to site to keep the signal strong. The transceiver in the car would be retuned under control of the exchange as a part of the site-to-site trunk switching. A telephone call to a car would require a broadcast call to all cars seeking a response from the particular car. Its response would lead to establishment by the exchange of an appropriate radio path via an appropriate site. Then ringing, answer, and conversation could proceed in a normal manner. The mobile service exchange would, of course, handle the land line side of the call in usual fashion.

High capacity mobile telephone service is a complex service clearly calling for the versatility of a stored program electronic exchange. Fortunately the technology is fully capable of supporting such a development. The political and regulatory problems may be more difficult to handle. Indeed, opportunities for great technological triumph can be blocked by administrative and political uncertainties. In the United States this is no small factor in envisioning our telecommunications in the 1980s.

Summary

To summarize the impact of these forces and opportunities as trends for the future can perhaps be best done by examining the trends in terms of design and development, manufacture, administration, and the customer.

Trends in design and development

1. *New technology*

The developer must stay alert to the ever-changing technology, shifting from one functional implementation to another as technology and economics dictate. For example, No. 1 E.S.S. started with ferrite sheet memories that were later replaced by magnetic cores, and the later No. 1A E.S.S. started with magnetic cores and is changing over to semiconductor memories.

Microprocessors suggest more use of distributed control. Lower costs of integrated circuits suggest less concern over memory use, although a decade ago it was a prime concern.

2. *More features, sooner and cheaper*

A continual effort must be made to improve programming productivity (Ketchledge 1976). The computing industry has the same needs and its solutions may be of great value to E.S.S. The success of E.S.S. has made E.S.S. software a major problem. It suggests that software should be made portable from one system to another and that perhaps more customer features should be programmed on trunk exchanges.

3. *Blending of transmission and switching*

Historically, transmission and switching have been quite separate disciplines, as separate as relays and vacuum tubes. Systems such as No. 4 E.S.S. destroy that separation. The exchange is used to test and maintain the transmission facilities. In the laboratory the designers must understand the combined transmission and switching technology because the design will often be a part of both worlds.

Trends in manufacture

1. *Smaller hardware and less of it*

Integrated circuits are tiny; relays are large. The impact of electronic switching on factory floor space is very great. Also, the equipment units are more functional and less specialized to the particular application. This reduces floor space and inventory and may reduce manufacturing intervals which, in turn, may further reduce space requirements. An installed No. 4 E.S.S. reduces exchange space by a factor of four. Thus the impact on the factory is one of both space contraction and a total change in assembly and test methods. At the same time switching hardware becomes much more like transmission hardware.

2. *Software*

Software manufacture consists of making copies of the program and generating parameters and line and trunk records peculiar to the installation. Some maintenance of software in the field is usual too. Software documentation must be printed as well. Hidden behind this simplicity are some difficult problems. For example, how does the design of software properly interface with manufacture, including feature addition, documentation, and field support? How are software prices developed and how is continuing feature development funded?

Trends for administration

1. *Personnel*

Retraining is necessary for operating forces to develop proper skills to maintain electronic exchanges. Also, fewer people are needed: Bell experience suggests half the people for local No. 1 E.S.S. exchanges, a third for No. 4 E.S.S. trunk exchanges. The larger exchange sizes, remote maintenance of local exchanges, and automated maintenance procedures all contribute to the smaller forces required.

2. *Space*

Space for local exchanges is cut in half and for trunk exchanges to a third are impacts that call for much long term planning. Major cost savings may be possible by reducing the size and number of buildings.

3. *New features*

What features to develop becomes a pressing question. Considerations include marketing, revenue, pricing, competition, and a few others quite aside from the technological aspects.

4. *Dependability*

Electronic exchanges have already demonstrated high dependability. Systems like No. 1 E.S.S. have demonstrated average down times of less than 7 h in 40 years. Operational errors by people are a major factor in that figure. However, as the stored program network grows and services become more complex and elaborate, customer satisfaction will demand far higher degrees of perfection than needed for POTS, plain old telephone service. Just as with computers, generally the more we rely on them the more perfect their operation must be. The point is that performance standards appropriate to the age of electromechanical switching need full re-examination in the age of electronic switching. Also, exchanges tend to get larger, putting more eggs in the basket. In addition, the electronic exchanges can detect abnormalities in connecting electromechanical exchanges as well as in the connecting transmission links and thereby increase the apparent trouble rate.

5. *Rapid change*

Changeover from electromechanical to electronic switching is, in itself, a massive change. It implies major reductions of maintenance and operating costs but takes massive infusions of capital. The technological change means that the skills of people, both managers and workers, change too. There are those beside myself who suggest that the managerial adjustment is the most difficult. Perhaps the true challenge of the 1980s will be to condition ourselves to accept it.

Trends seen by customers

1. *Better service*

The thrust of all these remarks is that telecommunications customers can expect major improvements in service in the 1980s due in significant part to stored program trunk switching and common channel interoffice signalling. Supplemented by massive improvements in local services this opens a whole new era of telecommunications. Not only will the variety of services expand but both the old and new services will be provided faster. One can hope to be able to ring any telephone in one's country in 5 s and anyone in the electronic world in 10 s.

2. *More control*

To the residential customer the increased variety of services offers greater freedom of choice. To the business customer there is, in addition, the offering of new data together with new controls that can allow services to be optimized to the needs of a particular business establishment. Note that a greater variety of services has an exponential effect on the combinations available to optimize for a particular business operation.

3. *Integration*

The telecommunications network of the 1980s will be capable of providing most of the needs of its customers. To be sure, wideband links and the like will still be needed outside of the 'telephone' network, but much of the customers' variety of needs can be met by using the power of stored program control. This implies integration of data and voice services and the integration of computers and people as customers of the network of the 1980s. Merging of transmission and switching will go hand in hand with more total system analysis of opportunities and problems.

Finally, the past decade has seen a basic change in the concept of what constitutes telephone service. Extension of this process of change to trunk exchanges seems obvious. Technology offers us the opportunity to meet the needs of our customers. Only the man-made obstacles of habit, inertia, politics, and lack of vision stand in the way of the new era of telecommunications.

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