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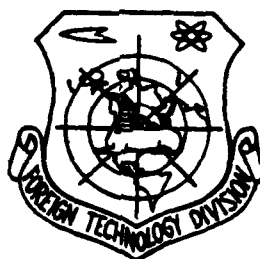
FOREIGN TECHNOLOGY DIVISION



STORED PROGRAM TELEPHONE SYSTEMS
AND FUTURE TRENDS

by

Miha Unk



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STORED PROGRAM TELEPHONE SYSTEMS AND FUTURE TRENDS

(Programsko vodeni telefonski sistemi in tendence bodocega razvoja)

by

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Stored program telephone exchanges - the present day generation of telephone exchanges - have been introduced in many telephone networks of different countries. Different crosspoints are used and their functions are adapted to the national needs.

First steps have been taken towards the future telephone systems, i.e. towards the integrated telephone systems offering new quality and possibilities. The existing SPC exchanges have already been designed for the interconnection of these new systems.

1. Introduction

The electromechanical systems have already reached the limit of their development possibilities. This is true regarding applied technology and its improvements, as well as regarding the complexity of logical functions. Such telephone exchanges have also reached a stable level of production and maintenance cost, which is difficult to be further reduced. This situation has brought about the adoption of electronics into the telephony. Today electronics fulfill a considerable role which will be even more important in the future. Electronics and electronic elements are in the full bloom today. The manufactured elements are of much smaller size; their quality is higher than that of the

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electromechanical elements; they use little energy and they are fast. The introduction of electronic elements is taking place in various manners depending on the respective telephone exchanges. In some cases, they are introduced only partially as subsystems; in others their adoption is full and results in entire electronic exchanges. In addition to introduction of new elements, the essential fact is to be found in the creation of a quite new quality resulting from the adoption of the stored program control (SPC) into telephone service. Such control makes possible program operated telephone exchanges in which the programs are those which generate instructions to be fulfilled by the computers. These programs, which enable the realization of telephone functions, can be changed and adjusted. In this way it is possible to change the data which are, then, being fed into the programs and stored in memory banks. On such basis a much higher adaptability, which is indispensable to both present and future modern telephone networks, is impressed into the SPC systems.

The concept of the SPC, which is the same as the one used in the computer centers or for the special communication systems, is also applied in public automated telephone exchanges. The principle of the SPC has been known for a long time. The first such telephone exchange, which represented the practical realization of the SPC, has been installed in Morris, U.S.A. the end of 1960. Since that time telecommunication equipment manufacturers in the world, have in their development and production programs the SPC telephone exchanges. It should be said here that the SPC system is used because of future integrated systems, whose first roots can be found in early digital connections exchanges.

Of course, the road to such achievements was not an easy one. It began in laboratory experiments through prototype

exchanges in test operation in public telephone networks, up to the mass production. This path was difficult and for many projects it was frustrating. Eventually success was reached by selecting appropriate concepts which led to the capability of the new systems to be interconnected with the existing networks. Business considerations were also important. A significant number of present electronic telephone exchanges testifies that success has been achieved in reality. There are many such telephone exchanges which are now in operation or on order. The Bell System in the U.S.A. will have, by the year 2000, orders for all of the larger cities which will be connected to the electronic telephone exchanges. This is easy to believe since already by the end of 1975, there were about 10 millions subscriber connections.

2. The capability of the SPC exchanges.

The centralization of the functions and data in one location also makes possible a very efficient management; maintenance and operation of exchanges. The data which are available to computers, can be transferred to long distances. In this way new possibilities are offered to the PTT (post, telephone, telegraph) administrations, beginning with centralized control and supervision through to the maintenance and management of entire telephone networks. All these possibilities have, of course, their economic and business justification. There is less maintenance, and the quality of the performance is much higher. New areas of operation are being introduced now, and more will be needed in the field of telephony, telecommunications and data transfer. The new signalling systems along a cumulative channel simplify the transfer and reduce equipment requirements. Very quick exchange of information among computers of individual telephone exchanges reduces the time necessary to establish a connection at the level of national and international long distances. Here, their information capability and the quality of transfers is also essential.

Mechanical counters do not record data for the billing calculations any more. Instead, there now exist other recording means, particularly in the equipment for the processing of such data. It is possible now to automatically intermediate with these centers which process such data for more extensive areas. The advantages of new systems are to be found not only in respect to the savings of human work, but even more in the accuracy and reduction of errors. All of the data can be properly checked against errors, and the correction of data can be routinely performed.

At the beginning of the adoption of the electronic telephone exchanges, there had been too much emphasis on the capacity of different categories of customers. Yet, the selection or establishment of such categories was mostly dependent on existing assumptions and guessing about what is the best use. Of course, the various categories of usage depend on many factors, one of them being the degree of development of the existing telephone networks.

The processing and adjustment of the data and various parameters are much simpler in the SPC exchanges. They are performed in the shortest time and simultaneously in all exchanges. This, for instance, is the case with the changing of telephone numbers in a network, with changes in telephone rates, in the adoption of new services, etc.

This is true particularly when compared to classical electromechanical telephone exchanges. It is worth pointing out that a particular advantage of the electronical telephone exchanges is the saving of the space they need. The introduction of the SPC into existing exchanges, or of SPC exchanges with a coordinate switching field, brings about savings of 10 to 20%. Semi-electronic exchanges, supplied

with miniature relays or with reed relays which are hermetically sealed, reach savings of up to 20 to 60%. Compared to a classical telephone exchange with coordinate relays the savings in space at the full electronic exchange 4ESS reach up to 75%, as attested by its manufacturer.

3.A survey of SPC systems.

Eleven years have already passed since the first SPC telephone exchange had been launched into commercial use. During these years many electronic telephone exchanges have been developed, manufactured and installed (see the table). Electronic telephone exchanges are constructed differently depending on requirements set by the respective PTT (Post, Telephone, Telegraph) managements and governments in various countries. Some PTT administrations require new systems to have hermetically sealed relays. Yet, there are systems which still are satisfied with open relays. There are also systems which utilize also still classical electromechanical connectors. The most advanced feature of such connectors is to be found, first of all, in their smaller size while at the same time retaining the mechanical means. The actuated connection is maintained by a mechanical relay which uses electrical energy. The hermetically sealed connection is realized here in various ways. For instance, it is of interest to mention how this was done by Siemens in its EWS system. The connection is either electrically or magnetically maintained. The latest systems which are appearing now, have a semiconductor connection and the clock switching multiplex.

The introduction of computers and electronics into telephony is taking place in many ways: from the modernization and updating existing telephone networks all way

through to totally new concepts in telephone exchanges. The English GEC has already manufactured about 600 computers of the Mark 1 type, with which the telephone network in England was modernized. Now and then computers are introduced to save space: STR in Zurich has supplied a rotary telephone exchange with computers. In this way the space which was saved, was used to construct MFC signallization with tonal-frequency selection. LM Ericson has developed register organization ANA 30, with which it is possible to update the existing coordinate telephone exchanges. The development of this system, which is being installed under the name of ARE, is conducted by constructing quite a new exchange. This was economically justified since there are millions of connections with coordinate connectors, which can potentially adopt this system. Other manufacturers, among which the leading system is SP-1 with 1,300,000 sold connections, use the coordinate relays in the switching field. The electronics are being introduced in varying degrees. Computers usually require specified instructions which enable them to again achieve a specific adaptability and capability to introduce new functions and services. The newly conceived exchanges use a miniature relays with a hermetically sealed contactor. Bell (in the U.S.A.), in its telephone exchanges No.1-ESS and No.2-ESS, has decided in favor of the hermetically sealed reed relays. The latest No. 4-ESS uses semiconductor elements and the principle of clock switching. The Bell ESS exchanges have not only opened the way for electronic telephony, but are also the first in the mass deployment of electronics in telephone networks. In the Metaconta system 1,800,000 connections have been already installed and sold, out of which 75% are Metaconta system 10 C. In Japan, the miniature relay is being used in systems D-10 in KDX. In the meantime, Ericson has used in AKE-13 a miniature relay, which is similar to the ETS-4 system in the latest AXE system, with a hermetically sealed reed relay which opens the possibility of semiconductor

No.	System	Supplier	Comutation element	1st exchange in operation
1	ESS No. 12 Bell System	Western Electric, USA	HK - M	1965 Succasunna N. J
2	Metaconta 10 C	ITT, ISKRA	HK - E	1976 Wilrijk
3	Metaconta L	ITT	HK - M MS - M	1972 Rabat, Roissy
4	NX - 1 E	North Electric USA	KS	1971 (Fayetteville N. Carolina)
5	ETS - 4	North Electric USA	MS - M	1975 (Long Beach California)
6	D - 10	Japan	MS - M	1971 Kasumigaseki
7	KDX	KDD Japan	MS - M	
8	SP - 1	Northern Telecom.	KS	1971 Alymer
9	PRX	Philips Netherlands	HK - E	1972 Utrecht
10	AKE - 13	LM - Ericsson Sweden	MS - M	1972 Rotterdam
11	AXE	LM - Ericsson Sweden	HK or PV - P	
12	ARE	LM - Ericsson Tesla	KS	1973 Mundelstrup
13	No 1 EAX No. 2 EAX	STE - Automatic Electric	HK - M	1972 St. Petersburg
14	EWS	Siemens W. Germany	HK - M	1974 München
15	TXE - 4	STK England	HK - E	1975 Sutton Coldfield.
16	E - 10	SLE - CITEREL France	PV - C	1970 Lanion
17	ESS No. 4 Bell System	Western Electric USA	PV - C	Chicago 1976
18	Century DCO DTM	Stromberg Carlson USA	PV - C	1977
19	No. 3 EAX	USA	PV - C	
20	IFS - 1	PTT Switzerland	PV - C	

in operation	EXCHANGES		in operation	CONNECTIONS		As of date	Note
	ordered	Total		ordered	Total		
850			10,000,000			End 1975	
			466,500	984,600	1,451,100	Jul y 1976	
			59,370	284,400	343,770	Februar , 1976	
			390,000			August 1976	
30						August 1976	
78	81	169	664,200	670,800	1,335,000	1976	
30	108	138	110,000	720,000	830,000	December 1975	
85 until the end ¹⁹⁷⁶						May 1975	
		58			400,000	August 1976	
7	12	19	38,700	48,500	87,200	May 1973	
2						August 1976	
						August 1976	

Table continued

Explanations relating to the preceding table

Legend: KS - coordinate relay
MS - miniature relay
- M: mechanic hold
- E: electric hold
HS - hermetically sealed contactor
- M: magnetic hold
- E: electric hold
PV - semiconductor contact
- P: area multiplex
- C: clock multiplex

Note: 1. Marked are orders and the equivalent connections (1 connection to the transit exchange is cca. 4 equivalent connections). Data relating to the number of exchanges and of orders are approximative.

connections. The Phillips, which supplied the Dutch PTT with the system PRX, and which sells it elsewhere in the world, has succeeded in already selling one million connections. Together with the manufacturers, the German PTT has invested great efforts into the research of the new systems. This was why they introduced their EWS system somewhat later, and why their first telephone exchange was put into operation only two years ago. In England they were striving for a long time to find the best solution, and eventually there the TXE-4 system was selected. This one was constructed for middle and large exchanges and led to the modernization of the English telephone network during the last two years. In France it was decided to attain the necessary number of connections in seven years (by 1982). They have narrowed down their selection to the SPC system Metaconta and AXE, in addition to their national PCH system.

4. Issues and experiences in the adoption of the SPC exchanges

The SPC principle of managing telephone exchanges was initially applied to middle and larger exchanges, while the central computer was involved in a considerable part of

operations with smaller exchanges. This means that the adoption of new principles also had to face those problems which were related to the processing and switching of a great number of telephone message units. All manufacturers reported difficulties with the SPC equipment in new projects, yet difficulties were eliminated later. This is also true for other telephone equipment. Thus, during the introduction of the SP-1 system, about 400 program changes were performed in the first year. One half of these changes were related to programs which were involved with the establishment of telephone connections. This is quite understandable since these programs had to communicate with other countries and therefore it was difficult to properly define and describe such relevant foreign programs. A similar experience was noted concerning the other telephone equipment. For instance, during only the four years from the introduction of the SP-1 system, there were 205 such program changes.

In the quality of the performance the real picture appears as soon as the telephone operations during fixed time spans are considered. The experience of Phillips reported that the initial performance was just as good as was that of the electromechanic telephone exchanges, and also that snags which took place, were due mostly to the programming errors. Later, however, the performance was substantially improved and was better than that of the electromechanical telephone exchanges.

The same picture is found regarding the maintenance, which actually performed better than the best electromechanical systems. The Japanese D-10 system was calculated to expect 5 complaints per 100 customers/months. In practice, however, the result was much better with only one complaint per 100 customers/months. In addition, the complaints related mostly to the equipment and to the behavior of customers. Other manufacturers reported similar experiences. The incidence of difficulties was related to the quality of subsystems and other

particular elements involved in switching multiplexes and in electronic elements.

5. Improvements and future trends.

The development of a system, just as of anything else, follows a path which is determined by the degree of the overall technological development at a given time. Specifically, electronic elements demonstrate a very fast rate of growth which is evident in the case of electronic telephone exchanges. It is remarkable how the existing system allow the application of the innovating changes which are, then, fed back and supported by further growth. The latter is very much due to the compatibility of new developments with the previous state. A computer in SPC telephone exchange is the unit in which such changes are really taking place.

The No 1 ESS computer system already succeeded in tripling its operational capabilities. The new 1 A computer was in no time 2.4 times better. Also going exceptionally quickly is the development of the memory systems. Semiconductor memory banks promise particularly high savings in space and in markedly lower costs.

Substantial changes are also present in switching elements. In the case of the ESS system the changeover from the "ferreed" to the "remreed", resulted in significant savings in space. Semiconductor switching elements, which excel in the speed of operation, promise to present the best results.

Alongside of the progress of technological elements, other fields are also being developed. This relates first to the production and inspection of units in manufacturing plants, then during the installation and the testing of telephone exchanges while in operation. The same observation is valid for the

the maintenance and management of the telephone exchanges. Among other things, great savings are also reached in programming processes in more languages. This is, for instance, the case with the CCITT multilanguage unit for SPC telephone exchanges, and in the CCITT SDL language for the description of functions and system operations. No less important is the language for communications between man and machine. This language, which is universal for all the SPC systems, has greatly simplified the maintenance of different systems in the same network.

So far the utilization of the SPC principle of telephone exchange management has been limited only to medium and large telephone exchanges, but with the introduction of micro-computers it has also been extended to telephone exchanges of smaller capabilities.

The increase in the number of impulse-coded modulated transfer channels opens the door for the adoption of digital telephone exchanges. Their introduction into existing networks is possible because both technical and economic reasons exist. In this area, the first system was the French E 10 system, and others followed. This summer the Bell system has put into operation four digital telephone exchanges No.4 ESS. The latter is a real giant and its capacity is five times higher than the capacity of the largest telephone exchange with coordinate relays 4 A. Other data are also impressive: this telephone exchange takes only one quarter of the space and its maintenance costs are reduced by one third, and the direction capability of the computer, which covers this telephone exchange, has been increased to more than 500,000 calls during the peak hour. The Stromberg Carlson firm has offered its Century system; this telephone exchange was installed last summer. A system of local telephone exchanges (developed both in tandem and PABX), would be economically

most interesting for capacities between 200 and 20,000 subscribers. Other firms also advertise new digital telephone exchanges and foresee the addition of new digital switching units into the existing SPC electronic telephone exchanges. Such policy has also been adopted by Siemens in its EWS system, and then by North Electric in its ETS-4 system, etc.

Conclusion

It is easy to conclude that electronic telephone exchanges which use the SPC have received the full approval and recognition in the telephony. In some of the telephone networks the SPC has already been well established. The SPC adjust easily, they are convenient and meet the requirements of today and, as it appears, those of tomorrow. The majority of such telephone exchanges is designed as semi-electronic, while some of them are foreseen for the addition of digital modules. The present development is directed towards the integrated systems and the first digital telephone exchanges which have the same SPC system of programming already exist.

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