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Upgrading of conventional telephone exchanges for new services – technical and commercial aspects

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Summary. *The Swiss administration has decided to adapt and upgrade the conventional telephone network, exchanges included, to minimize the difference of services offered to subscribers when new digital exchanges will be introduced. The paper describes some of the technical projects such as new peripheral equipment with more facilities, SPC equipment for step-by-step and crossbar exchanges to replace the relay circuits, new call diverters and the realization of a toll-free service. Economic aspects are also discussed.*

1 Introduction

The Swiss telephone network today comprises nearly 3.5 million subscribers, spread over approximately 1000 exchanges. Today, only analogue electromechanical switching exchanges are in service, using mainly step-by-step switching, register-controlled selection or crossbar technologies. These installations required a total investment of 5.5 billion francs, of which approximately 3.6 billion francs are written off.

The mean annual increase in subscribers has dropped to less than 3 % in recent years, which brings near to saturation. This means that new installations are required only as replacements for outdated exchanges.

One of the principles of Swiss PTT's policy on services is to offer all customers the same services at uniform rates so that rural areas with light telephone traffic – regardless of profitability – should suffer no disadvantage.

Processor-controlled digital switching systems permit the economical introduction of a large number of new subscriber services, operational aids and other features. The introduction of such systems presents the administration or operating company with the alternatives of either abandoning the afore-mentioned principle, in that only additional services are offered at new digital exchanges, or:

- delay the introduction of additional services until most of the branch exchanges have been replaced, which would be neither economical nor compatible for good customer service
- replacing conventional exchanges very quickly – let say in five years. Unfortunately the financial means are not available to carry this out
- expanding the functions of the analogue network and existing switching systems in order to offer at least some of the commercially attractive subscriber services.

Quite some time ago, the Swiss PTT decided by taking the appropriate precautionary measures to ensure smooth transition to the extent possible from the conventional telephone network to the integrated digital telecommunications system, also for the offered services.

2 Possible technical solutions and examples

New features for subscriber services can be realized in a number of ways. To a large extent, however, implementation is determined by network structure including call routing, signalling systems, technology and profitability.

21 Auxiliary equipment or additional functions at the subscriber end

Auxiliary equipment or additional functions at the subscriber station *(Fig. 1)* are justified and feasible if the signalling criteria already existing on the subscriber loop comprise the features necessary for realising the function, provided the electrical characteristics of the subscriber loop are not altered and the function is simple enough to be realized economically. This particularly applies to the following services:

- repeated dialling
- abbreviated dialling
- call diversion and/or direct dialling
- call charge indicator
- automatic answering of calls

Up to now the subscriber could be offered some of these services by means of a large range of individual auxiliary devices. The technical and commercial possibilities were, however, not utilized systematically. The new series of subscriber stations and of service-specific add on equipment developped in Switzerland will extend and systematize these facilities. The Swiss PTT will start to offer this equipment this year.

22 Auxiliary equipment

Auxiliary equipment *(Fig. 2)* is looped in at the main distribution frame or taps off signals from the subscriber's line conductors. Auxiliary equipment has various advantages. Functions may be centralized for a larger number of subscribers, which, for reasons of economy, is necessary in the case of more complex equipment. Besides the a/b-wires, the c-wire which is customary in Switzerland can also be tapped off from the main distribution

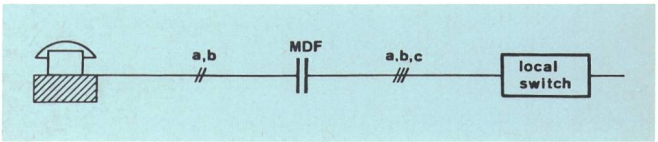

Fig. 1
Supplementary functions in subscriber station or attached to subscriber station

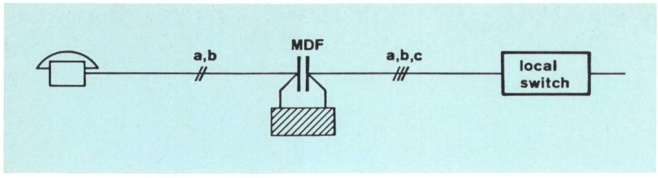

Fig. 2
Supplementary equipment in the subscriber loop, connected at main distribution frame

frame. Power supply hardware is assured from central battery without interruption. Operation and maintenance can be centralized. The main disadvantage of auxiliary equipment is that, in the event of mutations, jumping wires have to be changed at the main distribution frame, which makes considerable demand on the operating personnel's time.

Two new subscriber services will soon be put into operation throughout Switzerland with auxiliary equipment; a third is being studied:

- call diversion
- call charge registration for detailed charge accounting
- automatic changed number announcement

221 Call diversion or service 21

A microprocessor-controlled piece of auxiliary equipment can be looped into as many as 16 subscriber lines. By means of a speech-controlled two-wire amplifier, calls can be diverted to any given diversion number, even abroad. The customer needs no auxiliary equipment at his end. Dialling procedures for programming, activating and deactivating are carried out from a normal telephone set, with pulse or push-button dialling in accordance with the CEPT procedure. The calling party pays for the connection to the diversion point and the service 21 subscriber pays for the connection between diversion point and diversion target. Charges for both stretches begin only when the connection is answered at the diversion target.

222 Call charge data registration, detailed charge accounting

In Switzerland, the system of pulse metering with 12 kHz pulses on the subscriber line has been in operation for many years. By picking up and analysing the length of the call and the charge pulses, all data necessary for detailed charge accounting can easily be registered in a piece of auxiliary equipment.

The program controlled device surveys up to 400 subscriber loops. It is equipped for pulse and push-button dialling and can be remote-controlled and interrogated via a data link from a centralized office.

223 Automatic changed number announcement

At present anyone dialling a withdrawn subscriber number hears a tape recording telling him to call the inquiry service. To relieve the telephone operator and to improve customer services an automatic answering and information device has been developed as a piece of auxiliary equipment. The electric circuit can, in accordance with an assigned entry, give out the number of the subscriber to be called, by means of synthetic voice. At the main distribution frame it must be connected to the position of the number which is no longer valid. This device can handle up to 1280 entries.

23 Replacement of the control units in conventional exchanges

The control units in conventional exchanges *(Fig. 3)* were originally designed using relay technology. Their technical capacities, both for the subscriber and for the operation, were limited and intensive use resulted in premature mechanical wear.

The advancing developments, in particular the production of microprocessors, permitted the profitable replacement of centralized controls. Thanks to an upgrading programme for exchanges with register controls, it is possible to meet the following goals:

Raising the quality of service and improving operation

- Data handling and modification without changing hardware
- Computer aid in fault location and statistical error evaluation
- Remote control

Adaptation to new requirements

- Push-button dialling
- Identification of calling subscriber's telephone number
- MFC signalling

Increasing flexibility for future requirements

- Call and charge data registration
- New subscriber services such as: «Don't Disturb» service, barring international and/or intercontinental outgoing calls, hot line, and call diversion to tape recording.

In 1978 – a first modernisation project for the 7A-rotary system had just been completed very successfully – the Swiss PTT in collaboration with its suppliers drew up a specification. From 1981 to 1983, the PTT carried out extensive tests in three sample installations, and these were completed with a field trial. The first upgraded installations were put into operation in autumn 1983.

231 Upgrading of step-by step switching exchanges *(Fig. 4)*

The speech network is retained. Instead of relay registers, the following new functional units are fitted in

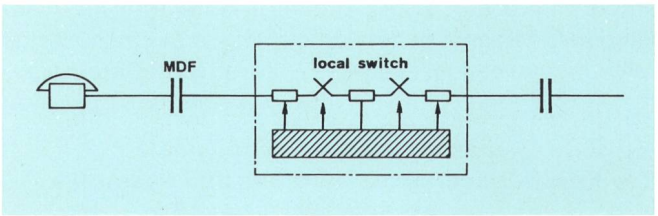

Fig. 3
SPC units replace relay units

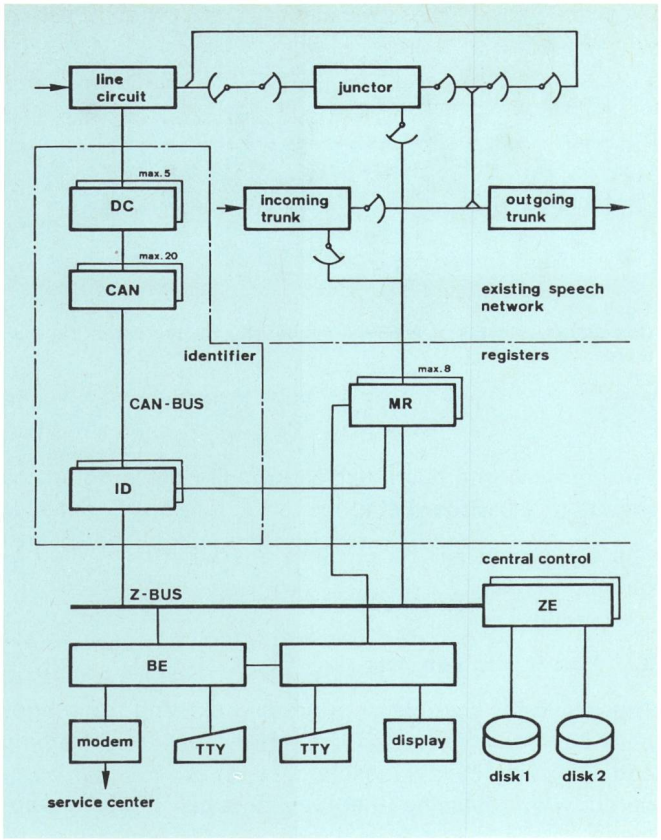

Fig. 4
Blockdiagram modernisation of step by step exchanges

- Central unit (ZE)
- Identifier (ID)
- Operation unit (BE)
- Multiregister (MR)

The multiregisters form the partially central and the remaining units the central control area. The functional units are interconnected via a central bus (Z-BUS). For safety reasons, the central unit and the identifier are doubly equipped. All functional units are 8080 microprocessors controlled.

The central unit controls and surveys the exchange of information via a central bus as well as the back-up memory (floppy disc) and all functional units. The data conversion list for the specific exchange is also stored in the back-up memory.

The task of the identifier is to ascertain the number of the calling subscriber. For this purpose the identifier has access via code connections (CAN) to the decentralized coding units (DC) in the subscriber line circuit. Identification is by 20 kHz signal.

The operation unit permits dialogue between operating staff, and the system. Input and output are available via TTYs.

Up to eight multiregisters can be connected to the central bus. One such multiregister forms one security unit and serves eight register sets.

For testing the registers, a mobile device, also computer-controlled, had been developed.

232 Upgrading of crossbar switching exchanges

(Fig. 5)

The branch and connection area are retained. Instead of relay control, the following new functional units are provided:

- Multiregister with pseudo-register (MR)
- Marker Interface (MI)
- Identifier (ID)
- Central Control (ZS)
- Charge metering (TXM)

In principle, the functional units have similar tasks as stated under 231. Two of these are described more fully.

The control units provide the information necessary for the correct functioning of the markers of the various switching stages. The marker interfaces (MI) which must guarantee the connection were adapted to the technology of the centralized control. The new MI circuits have taken over additional marker functions, thus permitting the replacement of some worn out electromechanical elements in the markers.

With centralized charge metering, the call charge data can be recorded for all subscribers on an upgraded crossbar switching exchange. All necessary information is reported by the central control (called and calling parties) or by the cord circuits (answer or release of a connection) to the charge metering unit. This unit can be remote-controlled and interrogated via a data link. For safety reasons, it is doubly equipped. This new equipment will be introduced in 1987.

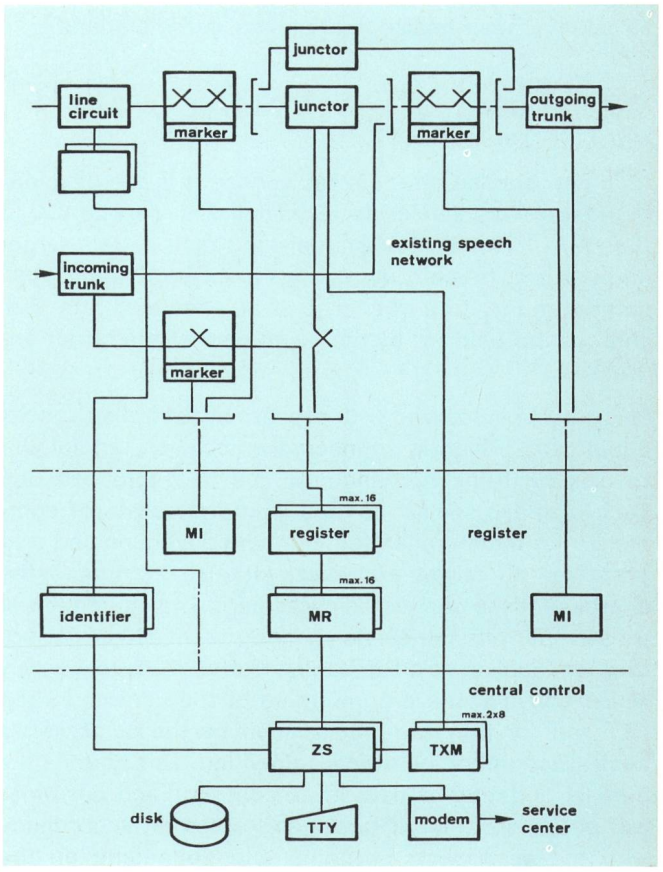

Fig. 5
Blockdiagram modernisation of crossbar exchanges

24 Special regional service centers or exchange facilities

Even by upgrading existing exchange facilities many new services cannot be realized at all, or cannot be provided on an economical basis. Light traffic density per branch exchange and the highly complex nature of some services in many cases impede an economical implementation by installing the appropriate special equipment in each branch exchange. Through centralization in regional, or, in special cases, even national, service specific nodes, the existing telephone network is used as a concentration and/or expansion stage in order to provide the necessary traffic load. For the national numbering plan, the call routing procedures and the call charge processing permit uniform access numbers with uniform charges which can be used to reach such nodes from anywhere in the country. In Switzerland, the PTT has been able to reserve some trunk code numbers for these types of traffic and to match call routing nationally. There are, however, some limitations for the exchange of control criteria between the subscriber and the special equipment. With the increasing introduction of push-button dialling this problem is, however, becoming less and less significant. Special importance is attached to dimensioning the trunk groups for services with heavy traffic load.

241 Previous applications

The technology described is in itself not new and has been used for some time in many national networks. For example, in recent years the automatic alarm-call service, access to mobile telephone services and paging systems, Videotex and Voice Store and Foreward systems have been realized in this way in Switzerland.

242 Toll-free service

As a new service, the toll-free service is in the developing stage. This service is very similar to service 800 in the USA. It enables subscribers to reach certain target addresses at home or abroad via a uniform national call number, either free of charge or at a reduced rate. Call charges are paid for by the customers at the target addresses.

This service is realized with processor-controlled special equipment, which is connected as auxiliary equipment to existing trunk exchanges in the four-wire network. Each of these special centres is in possession of complete information regarding number conversion and program for all target addresses. It also computes the charges for the connected customers. The equipment at present permits the servicing of up to 10,000 target addresses. Each centre can handle traffic of approximately 500 erlang. For the programming of the centres by the PTT and for program-modification by the customer, a centralized operation office is provided. This permits the parallel updating of data in all centres. Each customer can put in up to eight target addresses. In accordance with the customer's program, and depending on the point of origin of the call, the day of the week or the time, calls are diverted to the desired target address.

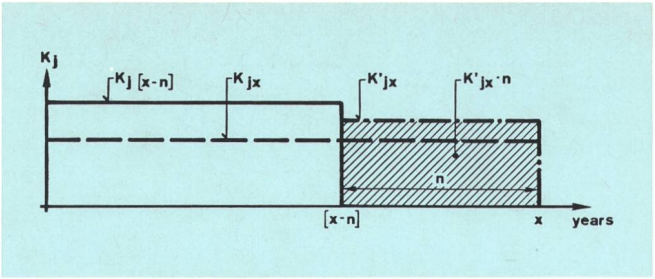

Fig. 6
Calculation of costs of invested capital (K_j) for premature replacement

Furthermore, the customer can modify the program by means of a keyboard station.

The equipment will be put into operation from the beginning of 1985.

3 Economic aspects

The economic aspects of upgrading existing exchanges have been examined. It is not self-evident that retaining and adapting existing exchanges is economical compared with replacing them by cheaper digital equipment.

A brief explanation is followed for the method used for calculating profitability. It is based on a cost comparison (interest and write-offs) of the invested capital to the maximum operational lifetime. It enables the PTT to ascertain the time when premature replacement of an exchange is more economical than upgrading the equipment.

To calculate profitability the sum of all investment for the equipment described in chapters 22 and 23 has to be taken into consideration.

The following hypotheses must be established:

- Maximum operational lifetime of equipment: x years
- Interest rate: y % of the invested capital
- Maintenance and operating costs: z % of the invested capital
- Revenue of subscribed services: R_j

Some new services are offered to the subscriber on a monthly subscription rate. The revenue R is calculated according to the marketing forecasts and using conventional methods. Finally, R_j has to be substracted from the yearly costs.

Calculation of costs of invested capital (K_j)

a) for premature replacement

In this case the equipment is replaced by a new system n years before scheduled replacement date.
the invested capital is therefore no longer amortized in x years, but in (x—n) years.

$K_{j\,total} = K_{j\,(x-n)} \cdot (x-n) + K'_{jx} \cdot n$

K_j: costs per annum (interest + write-offs of invested capital)
K_{jx}: K_j in x years (electromechanical system)
$K_{j\,(x-n)}$: K_j in (x—n) years (electromechanical system)
K'_{jx}: K_j in x years (digital system)

Figure 6 shows a graph of this calculation.

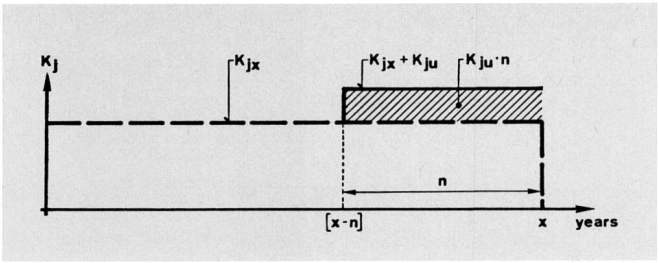

Fig. 7
Calculation of costs of invested capital (K_j) for upgrading of an electromechanical system

b) for upgrading of an electromechanical system

Equipment is upgraded n years before scheduled replacement date. The invested starting capital is amortized in x years. The invested capital for the upgrading in n years:
$K_{j\,total} = K_{jx} \cdot x + K_{ju} \cdot n$
K_{ju} is the K_j of the additional capital invested for upgrading the equipment. *Figure 7* shows a graph of this calculation.

Calculating with a different number of years (n) enables us to draw two curves ($K_{j\,total}$ of replacement and $K_{j\,total}$ of upgrading). The point at which the two curves intersect determines the number of years (n) after which premature replacement of the exchange is more economical than its upgrading.

Calculations based on parameters of the Swiss telephone network show that the upgrading of telephone exchanges which have been in operation for less than 15 years is more economical than premature replacement by digital equipment. This conclusion is based on an annual increase in the telephone network of approximately 3 % and on the assumption that the building in question has enough extra space.

4 Conclusions

The Swiss PTT are endeavouring to offer all their subscribers the same services. The introduction of electronic exchanges with their additional subscriber services does, however, upset the balance of the telephone network. To remedy this situation the premature replacement or the upgrading of certain exchanges and the network was examined. Through extensive planning on all network hierarchies an economically acceptable solution, realizable in the short term, can be found. The methods described demonstrate that the upgrading of existing exchanges and the network constitute an alternative which will satisfy the requirements of telephone customers for the next 8 to 15 years. It should also be mentioned that some projects aimed at rationalizing operation such as trafic measurement, metering of subscriber lines and trunk lines, have been successfully and economically realized using what is known as 'Rucksack technology'. Upgrading facilitates the introduction of digital equipment as pressure placed on the PTT by customers is reduced, thus it permits smooth introduction of digital exchanges in the short and the medium term.

Upgrading is a pragmatic solution, whose value for the Swiss network is based on economic viability.

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