A LOCAL PCM SWITCHING SYSTEM FOR VOICE AND DATA

UN SYSTÈME DE COMMUTATION TEMPOREL LOCAL POUR LA VOIX ET LES DONNÉES

REINHARD SCHELLER AND MANFRED WIZGALL
INSTITUTE OF SWITCHING AND DATA TECHNICS
UNIVERSITY OF STUTTGART
D-7000 STUTTGART, SEIDENSTRASSE 36, F.R.G.

Dans cet article sont étudiés l'architecture et le mode d'opération d'un système combiné pour la commutation des voix et des données. Ce système de commutation utilise le prin - cipe de commutation temporel.

Deux types de réseaux de connexion sont utilisês:
Pour la voix un réseau de connexion PCM, pour les données un réseau de connexion d'enveloppes en sous-canaux.

La structure de côntrole de système est characterisée par des processeurs dé - centralisés. Ils contrôlent les concen - trateurs, les commutateurs et l'unité de signalisation. Ces processeurs sont contrôles eux-mêmes par un processeur de commutation.

Sont présentés ici le domaine d'applcation, le concept, l'architecture et le mode d'operation.

The architecture and operating mode of a combined switching system for the switching of telephone connections (voice) and data connections (line switching principle) is presented.
This switching system uses time division techniques. For voice a PCM switching array and for data a special data switching array is provided. Data switching makes use of envelopes and subchannel multiplexing.

The control structure of the system is characterized by decentralized intelligence. Various microprocessors control the con - centrators, the switching arrays and the signalling unit. A common switching pro - cessor supervises the decentralized pro - cessors and performs some central functions.

The special field of application, the concept, the architecture and operating mode of the system are outlined in the paper.

to be presented at
the ISS'79 Paris

1. Introduction

Networks for digital communication (telex as well as other data-networks for line and/or packet switching) are growing rapidly. Nevertheless, the total number of subscribers in these networks will remain small compared with the very large number of telephone subscribers (e.g. 14o million telephone stations and 500 000 data stations in europe).

In this paper a local switching system is presented which combines the function of a PCM telephone switching exchange and a data (line) switching exchange.
Chapter 2 outlines under which conditions such a combined telephone and data exchange could be economic. Furthermore, the demands to such an exchange are discussed. Chapter 3 covers the concept of this switching exchange and Chapter 4 deals in detail with its architecture and operating mode.

A list of abbreviations, used within this paper can be found in Fig.3.

2. The Combined Telephone and Data Exchange

2.1 General Remarks

The telex network and many other line and/or packet switching networks have altogether up to some millions of subscribers. Besides these subscribers a large number of telephone subscribers has modems and performs world wide data communications with bit rates up to 4.8 kbps via telephone channels.
It cannot be predicted to which extent this modem-data traffic changes over to the upgrowing specific data networks.In many cases it seems, however, to be desirable to offer also the opportunity of having access to (one or more) pure data networks and their manifold facilities to those modem-subscribers.
This aim can, however, lead to problems if regions with low data traffic densities are considered where the installation of a particular data network, line and/or packet switching, is uneconomic.
With regard to these problems this paper presents an economic solution for a combined switching exchange for telephone and data traffic.

2.2 Demands to a Combined Telephone and Data Exchange

The following listing outlines the demands to be fulfilled by a combined switching system:

- Connections of analog and /or digital telephone stations
- Use of modems by telephone subscribers for data communication via speech channels, analog and digital ones
- Possibility for data subscribers without modems to use DCE's and signalling procedures according to CCITT X.20, X.21
- Possibility for data traffic with modems to run through the telephone switching array and then to be "crossconnected" to the data switching array and vice versa.
- Telephone subscriber signalling according to international standards.
- Possibility for data subscribers of the exchange using DCE's to be connected directly for calls among themselves; the same holds for telephone subscribers
- Establishment of outgoing and /or incoming connections to and from other exchanges either to data nodes or data exchanges,resp., as well as to telephone exchanges. The system serves therefore as an entry point for the telephone as well as for one or more data networks
- For switching and transmission PCM techniques are applied.

These demands are met by the combined switching system being presented.

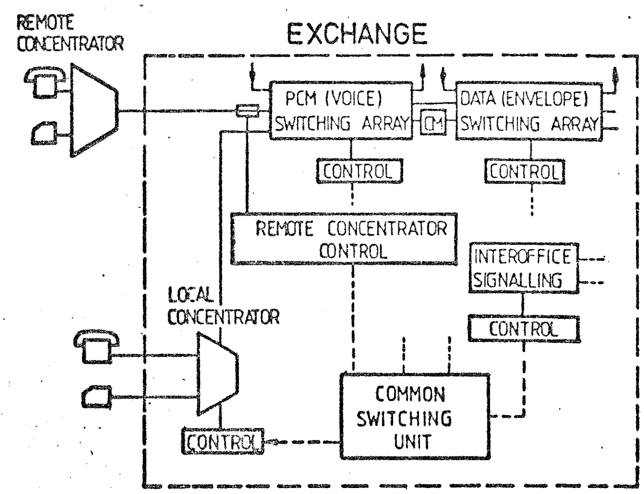

FIG. 1: BASIC STRUCTURE OF THE COMBINED SWITCHING SYSTEM FOR VOICE AND DATA

3. The Concept

The basic structure of the combined switching system for voice and data is shown in Fig. 1 . Data and telephone subscribers are connected to common remote concentrators. The concentrators perform concentration for telephone subscribers,and only multiplexing for data subscribers with DCE's. Subscribers situated closely to the exchange can also be connected to a corresponding local concentrator within the exchange. Both types of concentrators are connected with one or more PCM 30/32 highways to the PCM switching array (PSA). A certain number of time slots between the concentrators and the PCM switching array becomes reserved for data traffic. Each of these reserved telephone channels provides 64 kbps for data connections. Most of all data connections work with bit rates between 600 and 4800 bps. To make efficient use of these reserved 64 kbps channels subchannel multiplexing techniques according to CCITT X.51 are applied / 1./. These PCM time slots for data traffic are permanently switched through the PCM switching array and then connected to a special data switching array (DSA). This DSA is designed for so-called envelope switching (8+2) according to CCITT X.51.
In / 2 / a detailed discussion of the problem can be found whether to use (6+2) or (8+2) envelopes.
Interoffice signalling will be done by means of an interoffice signalling unit with common channel signalling system No. 7.

Each functional unit has its own microprocessor control.
The common switching unit performs some control and supervisory functions for the whole system.

Fig. 2 shows the various types of traffic flowing through the PSA and DSA. At the PSA PCM 30/32 systems terminate from the following directions:

- PCM systems from other telephone or combined switching exchanges (P1) carrying telephone and/or data traffic
- PCM systems from remote (P2) and local (P3) concentrators carrying telephone and data traffic
- PCM systems from the DSA carrying only data traffic (P4). Subchannels are used for data connections between data subscribers with DCE's.
- For socalled cross-connections between data subscribers with modems and data subscribers with DCE's the converter modules (CM) are necessary to convert modem signalling and transmission techniques to those of the DCE's and vice versa (P5).

At the data switching array (DSA) the PCM highways (HW) to and from the PSA (D4, D5) terminate, as well as the 64 kbps multiplex lines from and to other distant data switching exchanges (D1).

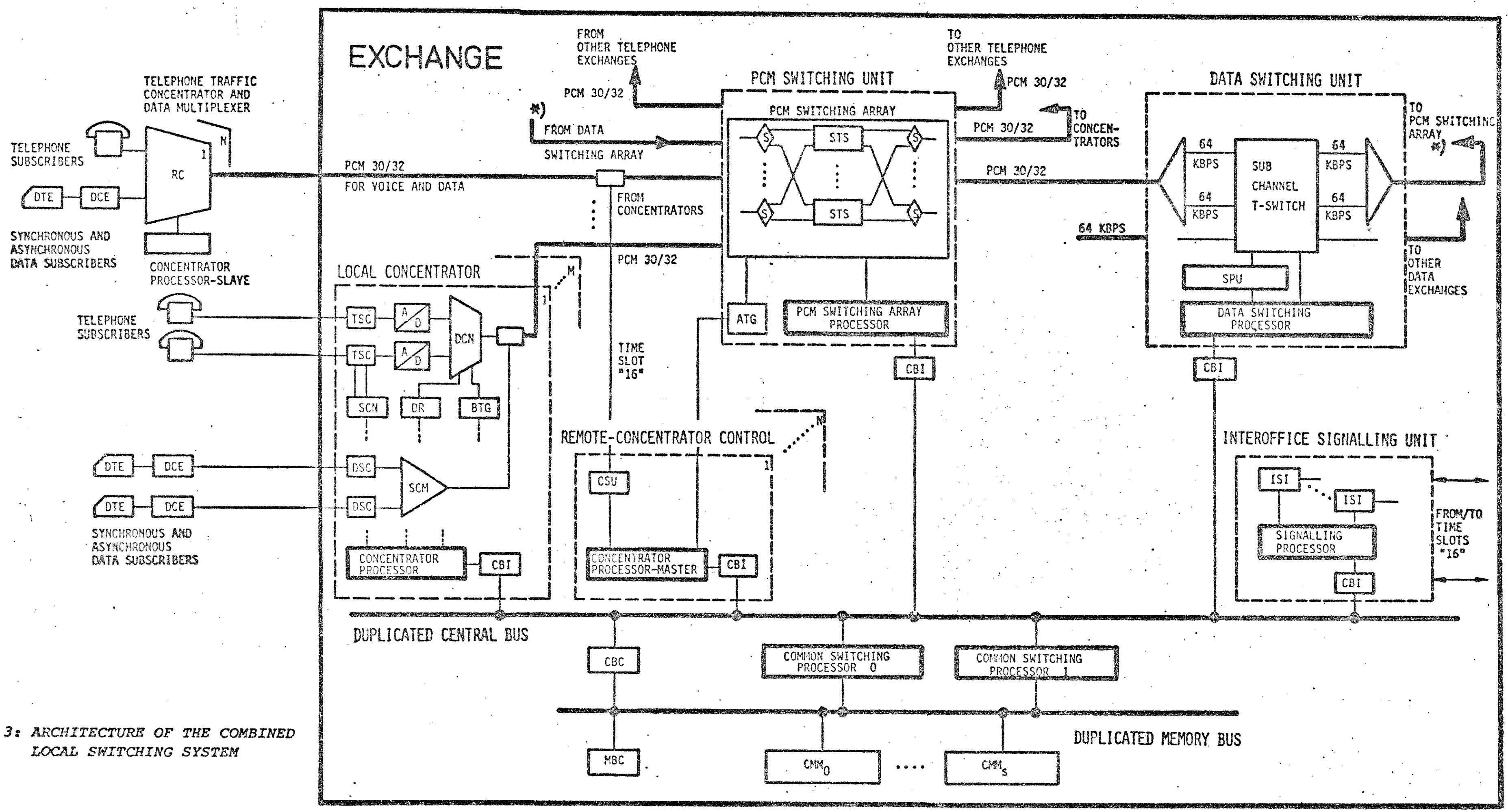

FIG. 3: ARCHITECTURE OF THE COMBINED LOCAL SWITCHING SYSTEM

(S) Space Switch   STS 3-Stage Switching Array

LIST OF ABBREVIATIONS

ATG	Audible Tone Generator	CSP	Common Switching Processor	IB	Inhibit Bit	PS	Padding Bit Suppressor
BTG	Busy Tone Generator	CSU	Concentrator Signalling Unit	ISI	Interoffice Signalling Interface	PSA	PCM Switching Array
CB	Central Bus	DCE	Data Circuit Term. Equipment	ISU	Interoffice Signalling Unit	RC	Remote Concentrator
CBC	Central Bus Controller	DCN	Digital Concentrating Network	LC	Local Concentrator	SCM	Subchannel Multiplexer
CBI	Central Bus Interface	DR	Digit Receiver	MB	Memory Bus	SCN	Scanner
CIH	Clock Interrupt Handler	DSA	Data Switching Array	MBC	Memory Bus Controller	SPU	Signalling Processing Unit
CM	Converter Module	DSC	Data Subscriber Circuit	OS	Operating System	T	Time Stage
CMM	Central Memory Module	DSP	Data Switching Processor	PI	Padding Bit Inserter	TSC	Telephone Subscriber Circuit
COM	Control Memory	DTE	Data Terminal Equipment				

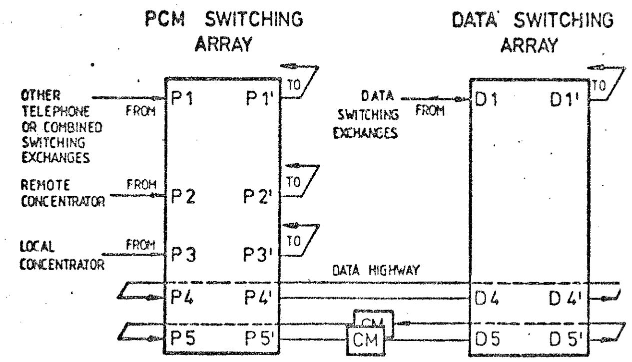

FIG. 2: PRINCIPAL WAY OF ESTABLISHING CONNECTIONS THROUGH THE SWITCHING ARRAYS

The principal way of establishing paths through the switching system for internal as well as external telephone and data connections is drawn in Fig.2. Some examples are given:

CASE 1: Internal connection between two telephone subscribers via the PCM switching array, e.g. connection from input P2 of the PSA to output P3' and vice versa P3-P2'.

CASE 2: Internal connection between two data subscribers via the data switching array DSA, e.g. permanent connection P2-P4' (PSA), then D4-D4' (DSA), permanent connection P4-P2' and vice versa.

CASE 3: Internal data cross connection between a telephone subscriber using a modem and a data subscriber using a DCE,e.g. P3-P5' to the converter module CM, D5-D4', then permanent connection P4-P3';and vice versa, permanent connection P3-P4', D4-D5', way to the converter module P5-P3'.

CASE 4: External telephone connection, e.g. P2-P1' and vice versa P1-P2'.

CASE 5: External data connection to a data subscriber connected to a distant data switching exchange within a data switching network, e.g. permanent connection P2-P4', D4-D1';and vice versa D1-D4' and permanent connection P4-P2'.

The system can also support those telephone subscribers who sometimes also want to perform data connections using DCE's. For this case, a prefix has to be dialled using the telephone set, that causes the switching system to switch the subscriber line from a telephone subscriber circuit (TSC) to a data subscriber circuit (DSC) to enable data connections using DCE's. Of course a similar switch over has to be performed in the subscriber station.

4. Design of Architecture and Operating Mode

Fig. 3 shows the architecture of the switching system. It is built by 7 different modules:

- The remote concentrator RC
- The remote concentrator control RCC
- The local concentrator LC
- The PCM (voice) switching array PSA
- The data switching unit DSU
- The interoffice signalling unit ISU
- The common switching unit

In the following subchapters these units will be described in detail.

4.1 The Concentrator and its Control Complex

Fig. 4 shows the structure of the remote concentrator RC. Telephone subscribers are connected to telephone subscriber circuits(TSC),which perform all functions known as BORSHT, i.e.: Battery, Overvoltage, Ringing, Signalling, Hybrid, Testing. Each TSC has a three bit memory which can be tested, set and reset by the scanner(SCN).Bit 1 represents the state of the subscriber line, bit 2 indicates whether a change in the subscriber state has already been processed by the system or not, bit 3 indicates, whether the subscriber is connected to ringing tone ("called") or not.

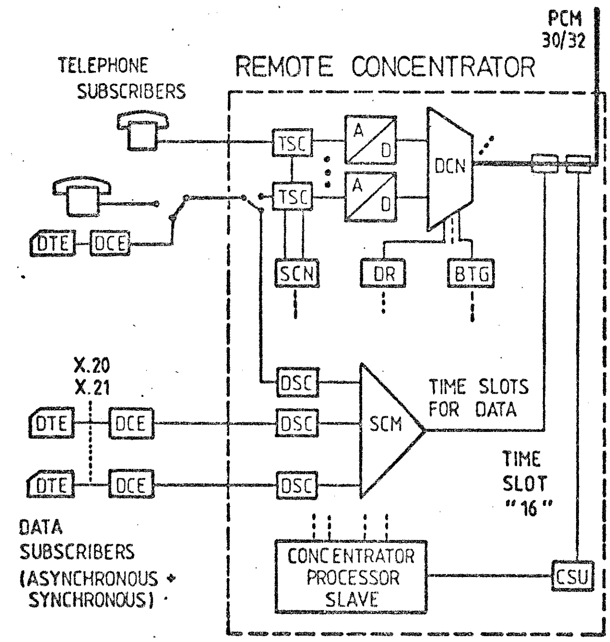

FIG. 4: THE REMOTE CONCENTRATOR

The scanner rejects all call attempts (change of the subscriber state indicated by bit 1 becoming L) if a special socalled inhibit bit IB is set. This bit is set if it is not possible to serve further call attempts due to the lack of idle PCM channels or digit receivers. This is a part of the overload protection mechanism.

As called subscribers are already connected to a PCM channel, their change of the subscriber state (off hook , also indicated by bit 1 becoming L) has to be processed by the SCN in any case.

Each TSC is connected to a hybrid that separates the incoming speech direction from the outgoing one. This is obviously necessary because PCM transmission works always four wire equivalent. Therefore, the DCN, Fig.5, can be divided into two parts, one for each speech direction.
That speech direction outgoing from the hybrid to the PCM switching array will be discussed first. The hybrid is connected to an analog-to-digital converter (individual A/D converters will be economic in the near future).

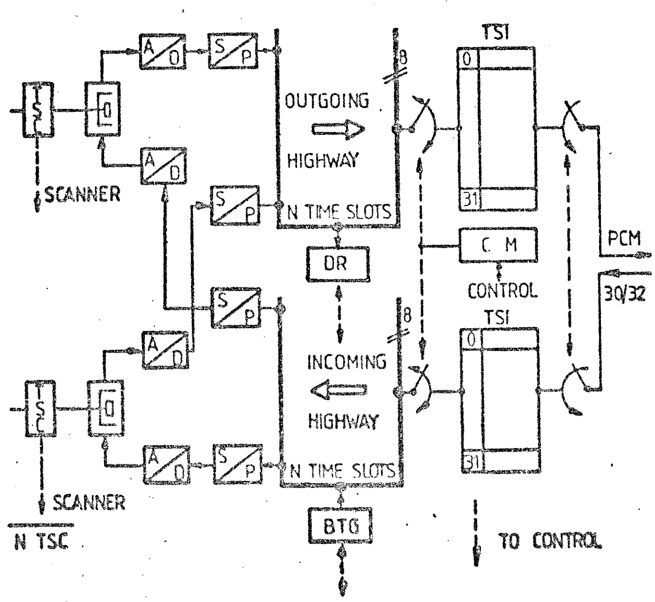

FIG.5: THE DIGITAL CONCENTRATING NETWORK (DCN)

The coded 8 bit samples are buffered in a serial to parallel converter. Up to N=512 converters, equivalent to 512 subscribers, can be connected to the 8 bit parallel outgoing HW having 512 time slots at least. The subscribers are allocated to a certain time slot permanently, that means, each subscriber has its "own" time slot on the outgoing highway. These N time slots have to form a frame with a period of 125 µsec, equal to that of the PCM transmission system. The connection between the outgoing HW and the PCM transmission system leads over a time stage (time slot interchange TSI) having 30/32 cells with 8 bits each. The TSI is controlled by the control memory (COM). The COM is read cyclically in accordance with the time slot counter of the HW. The stored information determines whether the 8 bits on the HW have to be transmitted into the TSI and if, in which of its storage places. The TSI is read cyclically too, in accordance with the time slot counter of the PCM system. The unit as a whole is therefore a concentration stage with full access for e.g. 512 subscribers to e.g. 30 or 60 channels.

The function of the lower half of the DCN for the incoming speech direction is equivalent to the upper half, just described.
The incoming 8 bit samples are written cyclically into the TSI and read out to the incoming HW under the control of the same COM; a subscriber has identical numbered time slots on both HW's. The samples are transmitted to a P/S converter, pass through the D/A converter and the analog information is transmitted to the subscriber via the hybrid.
If two PCM highways per concentrator are necessary in order to keep the blocking probability low and/or for reasons of safety, two more TSI and a further COM have to be provided. Their connection to the HW's and their function is the same as described above.

Another task of the concentrator is digit receiving. This is performed by the digit receiver unit (DR) that is connected to the outgoing HW. This unit consists of a group of digit receivers that can be connected to any of the 512 time slots of the HW. Connection is done by the concentrator processor. The MFC coded dialled digits are converted by the receivers into binary coded digits and transmitted to the concentrator processor - SLAVE for further processing.

The busy tone generator (BTG) is able to insert busy tone, in a digital form, to each time slot of the incoming HW, to supply the connected subscribers. This is controlled by the concentrator processor , too. The busy tone insertion is one of the autonomous functions of the concentrator, described below.

Data subscribers (DTE) using interface protocols according to CCITT X.20 or X.21 are connected via DCE's to data subscriber circuits DSC (Fig.4). The DSC's perform for synchronous data subscribers (X.21) bit- and envelope synchronisation . For asynchronous data subscribers (X.20) asynchronous to synchronous conversion, ITA No.2 to ITA No.5 conversion and signalling procedure adaption is performed.

The subchannel multiplexer (SCM) works according to CCITT X.51 with 80 subchannels per time slot, each with a bit rate of 600/750 bps . Each subchannel is dedicated for the use of socalled (8+2) envelopes, where 8 information bits (one ITA No.5 character) are preceded by a status and a framing bit. These subchannels are allocated permanently to DSC's. The number of subchannels per DSC depends on the bit rate e.g. for 600/750 bps one subschannel, for 2400/3000 bps four subchannels. In contrast to the telephone subscribers notraffic concentration. is performed for data subscribers, they are only multiplexed by the SCM.

The remote concentrator is controlled by a "concentrator processor SLAVE" which itself is remote-controlled by the "concentrator processor-MASTER" within the exchange. Part one of this double processor configuration, denoted as SLAVE is a microprocessor control that performs all standard and routine functions like
- scanning
- connecting and disconnecting devices
- collecting and transmitting of digits etc.

Microprocessor two of this configuration denoted as MASTER, ist located within the exchange and connected with the SLAVE via the concentrator signalling units (CSU) and time slot 16 of the PCM transmission system between RC and PSA.
Each MASTER-SLAVE pair is responsible for one concentrator and performs autonomously a certain part of the switching functions for telephone connections. The following functions are stand alone functions of the MASTER:
- Allocation of PCM channels and digit receivers to calling subscribers, path search in the digital concentrator network and providing of dial tone for the calling subscriber.
- Digit pre-interpretation with respect to the facilities, the internal or external calls and to the assembling of digits to digit blocks as far as possible. This facilitates the digit translation within the common switching processor (CSP).
- Disconnecting of ringing tone if the called subscriber goes off hook
- Disconnecting of dial tone after the calling subscriber has dialled the first digit
- Clearing of connections for calling subscribers, e.g. release of the DCN, disconnection of the DR, disconnection of audible tones
- Setting the inhibit bit IB if all PCM channels and/or all digit receivers are busy.

The following functions of the MASTER are activated by commands of the CSP:
- Connect through the DCN for called subscribers, this includes connection of ringing tone and setting of bit No.3 in the TSC memory
- Release of connections for called subscribers
- Connect and disconnect busy and ringing tone
- Switch over a subscriber line from TSC to DSC.

The MASTER has an own memory for temporary data and the program. It has access via the central bus interface (CBI) and the central bus (CB) to the common switching processor and via the central bus controller (CBC) and memory bus to the central memory modules (CCM). The CCM hold all relevant informations concerning the state of subscribers and connections, subscriber related data etc.
The structure of the local concentrator is similar to that of the remote concentrator. The two parts of the concentrator control, MASTER + SLAVE, are combined to the concentrator processor (CP).

4.2. The PCM Switching Array

The PCM 30/32 systems to and from the concentrators carry both-way traffic in the four-wire transmission mode. Connections between all subscriber-HW's must be possible, even internal ones, from and to the same HW. From this follows a switching array whose principle is shown in Fig.7. The incoming speech direction of all HW's terminate on one side of the switching array, without regard to their traffic direction. Consequently, all outgoing speech directions start from the other side.
For one four-wire connection one has to switch both speech directions from the left to the right hand side through the same switching array.

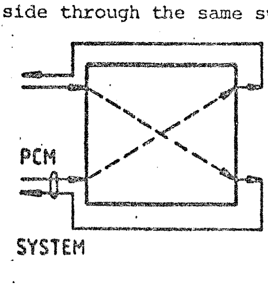

FIG. 6: CONNECTION OF THE HIGHWAYS TO THE PCM SWITCHING ARRAY

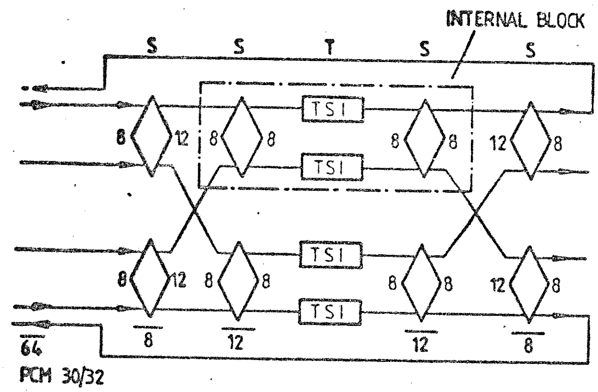

FIG. 7: FIVE STAGE PCM SWITCHING ARRAY SSTSS

Another criterion for the design of the switching array is the desired maximum number of PCM 30/32 sys. that have to be connected to. The exchange has a maximum of 16 concentrators, each having one or two HW's leading to the switching array. An adequate number of highways from and to other exchanges has to be connected to the switching array too. Therefore about 64 PCM 30/32 systems as a maximum have to be provided.
The dimensioning of the network can now be done under the condition that the POINT-to-POINT LOSS (PPL) should, for instance, be less than 1^{o}/oo for a prescribed carried traffic per inlet of 0.8 Erl.
The costs for the whole switching array should naturally be as small as possible. This leads to the 5 stage structure SSTSS shown in Fig.7. Its calculated PPL for the prescribed traffic per inlet and for the 1st attempt is 0.1^{o}/oo and the costs are the lowest among all suitable systems of the type STS, TST, TSST, TSSST, STSSTS and TSSSST (under the assumption of a cost ratio 5:1 between the costs per gate and per storage bit, peripheral costs included).
The switching array is controlled by a switching array processor, responsible for conjugated path searching and switching.

A blockwise extension of the switching array from e.g. 8 to the maximum of 64 HW's is easily possible, Fig..7.

Another two arrays are discussed in the Annex. In particular a five stage array is shown having a three stage core, which is exactly nonblocking. This allows an elegant path searching algorithm by means of a multiprocessor configuration.

The way how such low cost systems can be designed and how their probability of loss can be calculated /4/, will be published in a paper to be presented at the 9th International Teletraffic Congress 1979, Spain.

4.3 The Data Switching Unit

The data switching unit (Fig.8) performs functions for data connections similar to those of the concentrators and the PCM switching array for telephone subscribers.

The novel features of this new unit are:
- One stage non-blocking time switch for subchannels with (8+2) envelopes .
  The switching capacity amounts to 4800 subchannels (600 bps + 150 envelope bit/s each), equal to an overall bit rate of 3.6 Mbps and a maximum of 4800 simultaneous connections (in case of 600 bps each).
- Common subscriber signalling processing unit for up to 4800 connections working according to a time sharing principle, for detecting and preprocessing call requests, clear requests and signalling.
- Microprocessor control for establishing connections
- Interface between microprocessor and common switching processor.

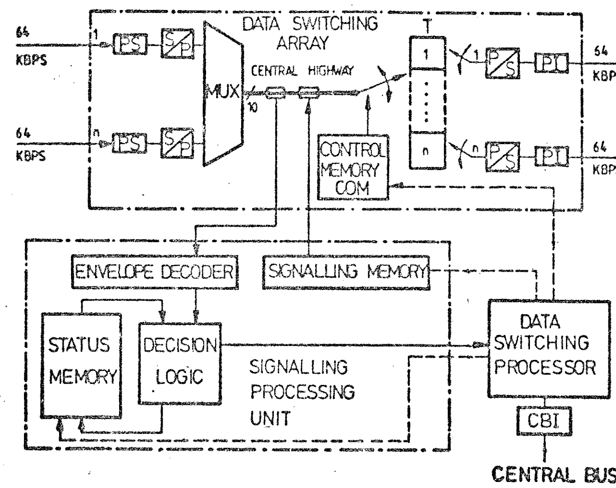

FIG. 8: THE DATA SWITCHING UNIT

According to these points, the unit can be subdivided into three parts:
- The data switching array (DSA)
- The signalling processing unit (SPU)
- The data switching processor (DSP).

The following tasks are performed:
- Detection of call requests; sending of "proceed to select" signal to the subscriber,providing of digit receivers.The transmission of call requests from the SPU to the DSP can be blocked by means of an inhibit bit, similar to the strategy within the concentrator. This is a part of the overload protection mechanism. Also the number of data subscribers, that are allowed to be simultaneously in the selection phase can be restricted.
- Detection of selection signals (digits)
- Detection of clear request
- Sending of signal "incoming call" to a subscriber caused by a command of the SSP
- Switching of subchannels caused by a command of the SSP.

The incoming 64 kbit/s PCM channels used for data traffic are linked via a padding bitsuppressor and a serial to parallel converter to the multiplexing stage of the DSA. The output of this multiplexing stage, i.e. the central highway is supervised to detect envelopes with status bit set (signalling envelopes) by the envelope decoder. The contents of the signalling envelope is decoded and transmitted to the decision logic together with that contents of the status memory belonging to the subscriber. The status memory contains information about the status of each subscriber, e.g. ready, call request. The decision logic decides what to do with the signalling envelope and hands it over to the data switching processor if necessary. A detailed description of this unit can be found in /3/.

4.4 The Interoffice Signalling Unit (Fig.3)

Common channel signalling will be used for telephone as well as data connections. The basic signalling functions are done by the signalling processor. The interoffice signalling interfaces (ISI) perform time consuming and time critical standard functions of the signalling system, e.g. parity bit generation and testing.
It is intended to use the new CCITT common channel signalling system No.7.

4.5 The Common Switching Unit

The central and common part of the switching system is the common switching unit (Fig.3). It consists of
- the central bus system (CB) with its bus control (CBC)
- the duplicated common switching processor (CSP)
- the memory bus (MB) with the memory bus control (MBC) and the central memory modules (CMM).

The central bus transfers the main control information. Three modes of operation have to be distinguished which are listed in order of their priority:
- Peripheral unit recovery mode (failure mode)
- Clocked information transfer mode } normal
- Memory access mode for peripheral units} mode

In case of failures, the normal operation mode of the bus is blocked for a certain time and a permanent channel is switched between the faulty unit and the CSP or the central memory modules, respectively, to check and recover the unit. In the normal operation mode, information transfer between the peripheral units, i.e. concentrators, PCM switching array, data switching unit, interoffice signalling unit is done according to a clocked mode of operation. At each clock pulse (typical 10 msec) one message and one command can be transferred between each peripheral unit and the switching support processor.
The CBC connects also the peripheral units according to a FIFO strategy to the memory bus if a memory access is requested.

The two common switching processors are working in a special mode of the socalled active stand by mode. The CSP No.0 performs normally some common switching functions, specified later on. The other processor, CSP No.1 performs standard routine test functions and man machine communication. In case of a failure of the active processor No. 0, a switch over is performed to the processor No. 1.
Both processors have access to the necessary software being resident in the common memory modules.

In case of system overload a special form of load sharing is performed by both processors. Processor No. 0 has access to the peripheral devices and performs switching functions. Processor No. 1 performs all time consuming functions which do not require access to the peripheral devices, like charging / billing, digit translation etc. The communication between the processors is, in this case, done in the same way as between the CSP and a peripheral device, namely clocked via the CB.

The central memory modules serve first as the working storage for the two CSP's. Program and data of the common switching processors are stored here. Both processors use in the normal case different memory bus systems and different memory modules to avoid access problems.

Secondly they serve as memories for common data. One of the modules contains all data used by the peripheral units and the CSP, e.g. data about
- busy PCM channels
- busy digit receivers etc.

Another module contains queues for data transfer from the CSP No 0 via the central bus to and from the peripheral devices and to and from CSP No 1.

All relevant data are stored in two modules for safety reasons.

The main functions of the CSP are
- to store and handle subscriber related data
- to perform digit translation
- to perform time supervision
- to supervise connections
- to perform all special facilities and special operating modes
- to perform charging/billing
- to process interoffice connections .

The following special operating modes are possible
- possibility of waiting if PCM systems to and from the concentrators are blocked
- automatic recall in case of subscriber busy
- overload control strategy including special absolute priority for a restricted number of important subscribers in case of catastrophic events.

The software structure of the CSP can be characterized by the use of functional blocks (FB) for clearly defined functions. They can be linked according to the task to be performed. The FB's are

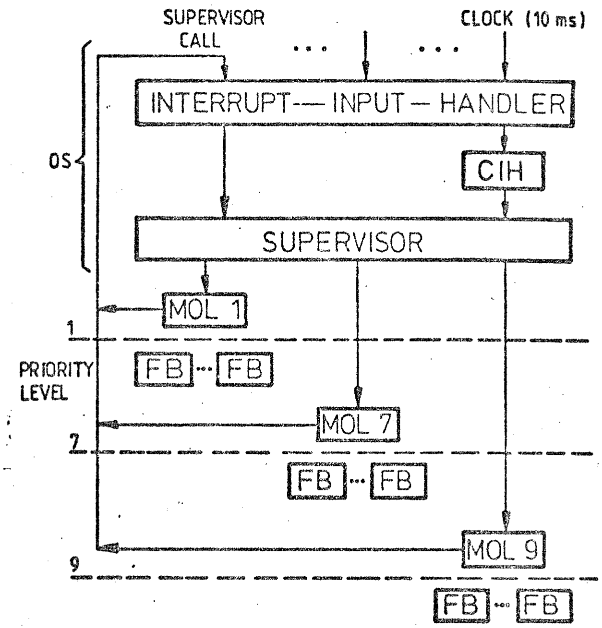

FIG. 9: SIMPLIFIED SOFTWARE STRUCTURE OF THE COMMON SWITCHING PROCESSOR

selected by the monitor on its related priority level (MOL) using decision tables. The MOL is activated by the supervisor and the interrupt handler of the operating system. Fig. 9 shows the simplified structure. The interrupt input handler processes all interrupts in the system, e.g. the supervisor call (SVC) and the clock interrupt of the CBC for clocked information transfer.

As an example, the processing of a message from a peripheral device is described.
The CBC fills all messages from peripheral devices and from the CSP No. 1 into the input buffer (IPB), see Fig.10, within an CMM and transfers all commands from the output buffer (OPB) to the devices.
The clock interrupt handler (CIH) examines all messages in the IPB and decides which monitor is responsible for the different kinds of messages.

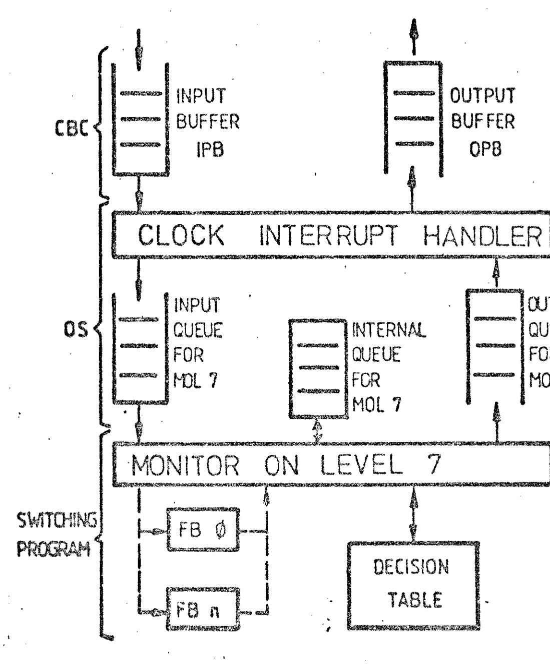

FIG. 10: STRUCTURE OF THE PROCESSING OF MESSAGES BY THE COMMON SWITCHING PROCESSOR

The supervisor activates the MOL according to its priority. The MOL on priority level 7 is responsible for the switching functions (MOL7). It decodes the message and activates the appropriate FB using a decision table. If the task to be performed requires another FB, a command is written into the internal queue which is served with priority to activate an - other FB.
This concept allows functions to be performed by means of software (FB) within the CSP or by peripheral units, just by changing internal commands to external commands.
Another advantage of this software concept is that further software functions can easily be implemented and added.

5. Conclusion

The combined local switching system for voice and data was designed for local areas, where separate data exchanges are uneconomic. It is part of the telephone network. Furthermore it has data links to and from one or more data networks.

Separate switching arrays for telephone and data enable local telephone as well as data connections. Data subscribers of the telephone network (having modems) can be crossconnected to data subscriber using DCE's as well as to the linked data networks and vice versa.

The system is controlled by decentralized processing units and a common switching processor.

The presented local switching system is under development (hardware as well as software) as a laboratory model at the Institute of Switching and Data Technics (University of Stuttgart).

Investigations on the traffic performance of the decentralized and the common control units are under way.

Acknowledgement:
The authors would like to express their gratitude to Professor Dr.-Ing. A.Lotze, Head of the Institute of Switching and Data Technics, University of Stuttgart, for supporting their work.

REFERENCES:

The following references represent, because of the lack of space, only a few publications out of the large number of valuable and interesting studies published in the recent years.

/1/ Recommendation CCITT X.51
Orange Book , 1976, Vol. VIII

/2/ KATZSCHNER,L., WIZGALL,M.,
Problems of Signalling in Integrated Switching Systems for Voice and Data.
ISS Kyoto 1976, Proc. pp 413-4/1-8

/3/ SCHELLER,R., WEISS,W., WIZGALL,M.,
A Data Switching Unit with Microprocessor Control
ISS'79, Paris 1979, Proc.

/4/ LOTZE,A., RÖDER,A., THIERER,G.,
PPL- A Reliable Method for the Calculation of Point-to-Point Loss.
8th ITC, Melbourne 1976, Proc. pp 547/1-14

/5/ BOCKER,P.,
Data Traffic in Communication Networks.
World Telecom. Forum, Genf 1975,Proc. pp 2311/8.

/6/ BOTHNER-BY,H.,
Architecture of a Digital Service Integrated Telecommunications Network.
Eurocomp 1978, London, Proc. pp 313-329.

/7/ HOLM,R.K.,
No. 3 EAX System Description.
ICC'77, Chicago 1977, Proc. pp 27.1-194/198.

/8/ LUCAS,P.,
Les progrès de la commutation électronique dans le monde..
Commutation et Electronique,No.59, Oct.1977.

/9/ REVEL,M., FICHAUT,J., GOUTTEBEL,R.,
Concentration des lignes d'abonnés en commutation électronique temporelle.
Commutation et Electronique,No.55, Nov. 1976.

/10/ ROSS,M.J.,TABBOT,A.C., WAITE,J.A.,
Design Approaches and Performance Criteria for Integrated Voice/Data Switching.
Proc. IEEE, Vol 65, No.9, Sept.1977.

Annex

1) Switching Array TSSST

Another example for a possible 5-stage structure is drawn in Fig.11. It is a TSSST configuration having the same traffic capacity and grade of service like the SSTSS structure.
Depending on the cost ratio gate-price/bit-price it will be slightly cheaper or more expensive than the switching array shown in Fig.7.

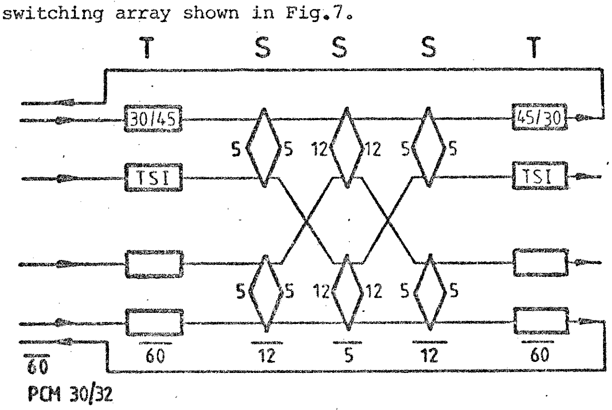

FIG. 11: FIVE STAGE TSSST SWITCHING ARRAY

2) 5-stage Switching Array with a Nonblocking 3-stage Core

In the SSTSS switching array according to Fig. 7, a 5-stage path search algorithm is necessary. If the internal 3-stage block is extended such that it be - comes a CLOS system that is strictly nonblocking, one can apply a more efficient path search algorithm, Fig.12. Each internal 3-stage block gets a block switching processor of its own, only responsible for switching paths through this block. The 5-stage path search algorithm can now be divided into two parts.
In the first part two idle paths from the two inlets to an internal block and from this block to the corresponding two outlets have to be found. This corresponds to a three stage path search algorithm. The second part of path-searching and connecting-through within the internal - full access - block is done autonomously by the block switching pro - cessor.

The costs for the whole switching array increase, however, as the different block processors work in parallel the path-searching becomes faster.

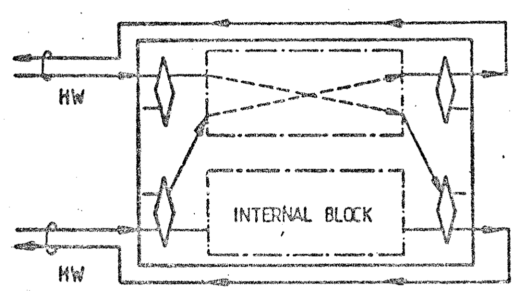

FIG. 12: FIVE STAGE SSTSS ARRAY WITH A NONBLOCKING THREE STAGE CORE