THE FLOW OF CONTROL DATA WITHIN
THE ANALOG CONCENTRATOR OF THE SYSTEM IFS

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ABSTRACT

This paper presents a study on the flow of control
data within the microprocessor controllea analog
concentrator of the future integrated communi-
cation system IFS, developped in Switzerland.

After a short description of the structure and
operating mode of the concentrator, models for
simulation and calculation resp., are derived.
The evaluation procedures and their results will
be discussed in detail. They lead to interesting -
insights into the traffic behavior of the con-
centrator control , taking into account the net-
work structure, into which the concentrator is
imbedded.

1. THE IFS CONCEPT

IFS (Integriertes Fernmeldesystem) stands for
"Integrated Telecommunication System". This PCM
system is jointly developped in Switzerland by
the PTT administration and its three manufac-
tures of public telephone exchanges. As a SPC-
switching system with centralized control, this
communication system shall provide switched tele-
phone and data service.
Transmission,switching and control are based on
the 32 channel PCM System.

Fig. 1 shows the IFS network configuration of
one plane. Five different areas are to be distin-
guished:

o The peripheral field
It consists of analog and digital subscriber sta-
tions together with their interconnecting lines,
as well as analog or digital trunks.

o The concentration field
performs the traffic concentration (analog con-
centrator AKT and digital concentrator DKT) of the
subscriber lines, analog to digital conversion by
means of the terminals T.

The concentrators perform functions for call es-
tablishment and clearing which are discussed later.

o The switching network
performs the interconnection of 64 kbps PCM
channels by means of the digital switching units
(DE).

o The processor field
consists of the central processors (ZS) and so-
called telegram units (TE) for control data inter-
change with all controlled units.

The register unit WE is for the processing of
signalling information.

o The service field is for maintenance and opera-
ting functions.

To secure operation and to achieve a high degree
of availability the so called multi-plane
principle (Fig. 2) is introduced.

This principle means, that 4 planes, one of which
shows Fig.1 are completely equipped and are working
according to a load sharing mode with respect to
originated calls. Therefore each concentrator is
connected to these 4 planes.

More details about IFS can be found in /1-7/.

This paper presents a study on the flow of control
information and the performance of the control of
the analog concentrator AKT of this system IFS.

2. STRUCTURE AND OPERATING MODE OF THE CONCENTRATOR

2.1 STRUCTURE OF THE AKT

Fig.3 shows the basic structure of the concentrator
and its environment.

Subscribers are connected to the analog switching
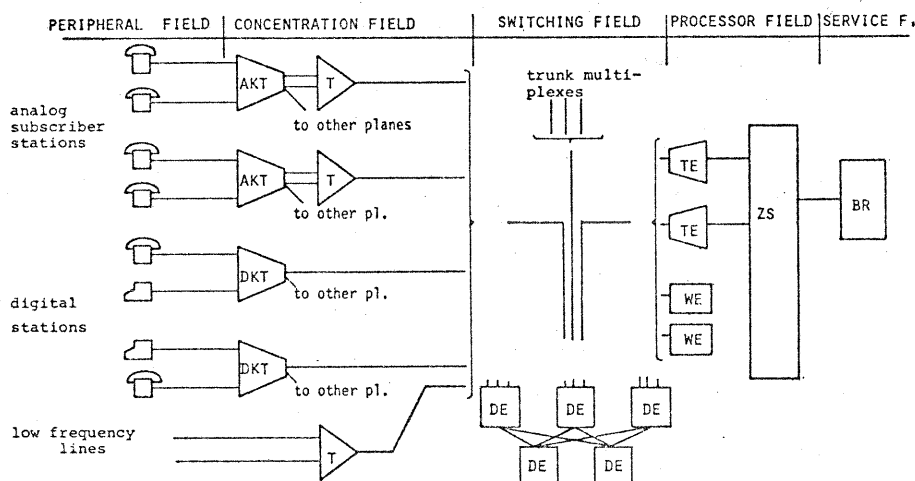array via subscriber circuits (SC). The switching

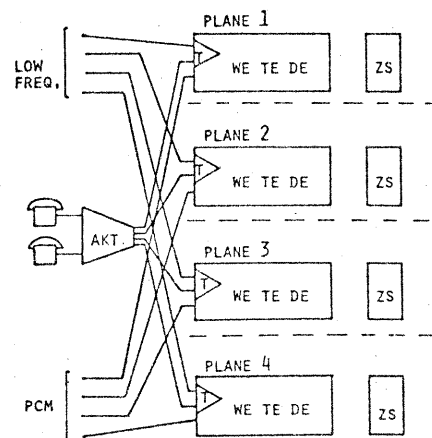FIG. 1: IFS NETWORK STRUCTURE OF ONE PLANE

FIG. 2: THE MULTIPLANE STRUCTURE OF
THE SYSTEM IFS

+ Dr. Kraemer is now with IBM Laboratories, Böblingen

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Beitrag des Instituts für
Nachrichtenvermittlung und Datenverarbeitung der
Universität Stuttgart zum 9th International Teletraffic
Congress Torremolinos vom 17.-24. Oktober 1979

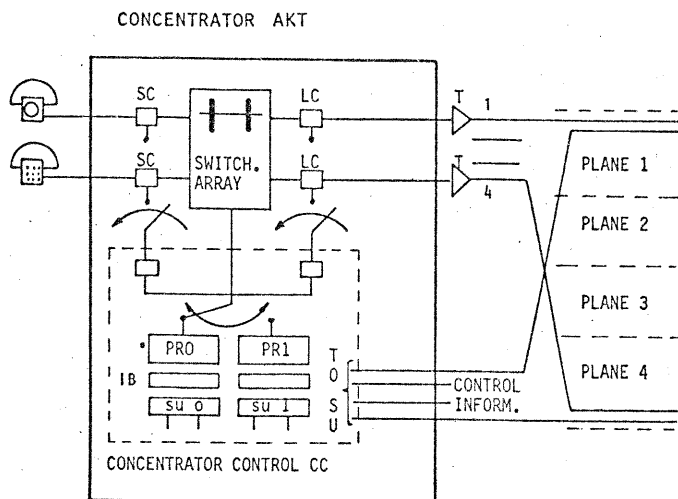WIZGALL / KRÄMER / MAYER-1

CONCENTRATOR AKT

FIG. 3: BASIC STRUCTURE OF THE CONCENTRATOR AKT

array performs a concentration of the subscriber lines to the outgoing trunks, which are connected to the switching array via line circuits (LC). The trunks are partitioned into four groups, leading to four switching fields within the four planes of the system IFS.

The subscriber and line circuits are scanned by the concentrator control.

All switching and control functions within the concentrator are performed by the concentrator control CC, which consists for reasons of reliability of two microprocessors (PRO,PR1) and two signalling units (SUO,SU1), also microprocessor controlled, for control information interchange with the central control units in the processor fields of the four planes.

2.2 OPERATING MODE OF THE CONCENTRATOR

The concentrator control handles three different types of requests, which are listed in order of priority:

- Connect requests (CN)
For call attempts, who need a connection to a called (B) subscriber, connected to the considered concentrator, the central control unit, responsible for this call, sends control information (connect request) via the control information channel to a SU. For the following it is assumed, that signalling unit SU1 is responsible for control data channels from planes 1+2, and SU2 for planes 3+4. The SU preprocesses this information and fills it into the storage location of the input buffer (IB) of the considered plane.

The CC tries to find a path through the switching array from the free SC of the called subscriber to a free trunk (LC) leading to the appropriate plane.

The connect request is acknowledged either positive if the throughconnection is possible or negative if congestion occurs.

- Clear requests (CL)
Clear requests are generated if a connection terminates and the occupied paths and trunks have to be released. The clear request is indicated within the LC and detected by means of scanning the LC under control of the CC.

The mechanism for scanning LC's can be seen in Fig 4. If a clear request has been detected during the last scan cycle at LC x, scanning starts at LC

x+1. Assume that at LC y the first clear request with respect to the scan direction is waiting, then the scanning stops at the LC y. The next scan-cycle will then start at y+1. Therefore the time needed by the CC for scanning, which is a linear function of the scan-distance (in this case $(N+y-(x+1)+1)_{modN}$, is not constant.
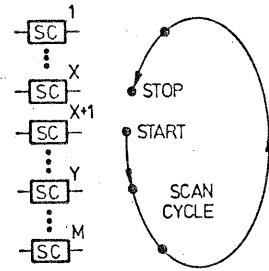
- Call requests (CA)
Call requests are generated by subscribers, connected to the considered AKT, which want to place a call. The call request is indicated within the SC and also detected by means of scanning.

The mechanism for scanning SC's can be seen in Fig.5. This mechanism is very similar to that of the LC scanning, but the scan distance, and therefore also the scan time is constant, as always all SC are scanned. This is necessary for technical reasons. The first detected call request is stored for later processing.
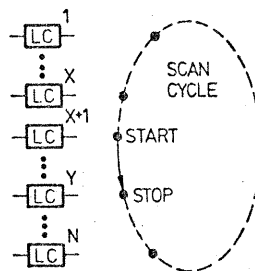
X: LAST DETECTED REQUEST
X+1: START NEXT SCANNING
Y: FIRST WAITING REQUEST
SCANNING STOPS AT LC Y
SCAN-DISTANCE Y-(X+1)+1

X: LAST DETECTED REQUEST
X+1: START NEXT SCANNING
Y: FIRST WAITING REQUEST
SCANNING STOPS AT SC X
SCAN-DISTANCE M

FIG. 4: PRINCIPLE OF LC SCANNING

FIG. 5: PRINCIPLE OF SC SCANNING

The CC tries similar as in the case of connect requests to find a path and a free outgoing trunk. In contrast to the case of connect requests, the trunk can be choosen arbitrarily from all trunks connected to the AKT. By cyclic testing the trunks a balance of occupied trunks to all planes can be achieved.

2.3 THE CONTROL CONCEPT OF THE AKT

2.3.1 THE PRINCIPLE OF THE CONTROL PHASE

Each of the two processors of the concentrator control can be in an "active" or "passive" control phase (Fig.6). If one processor is active, the other has to be passive. Access to the switching array is only possible within an active control phase.

During an active control phase a sequence of tasks, as described in chap. 2.3.2 is performed. The other processor, being in the passive status looks for connect requests in his input buffer IB. This mode of operation with two working processors,

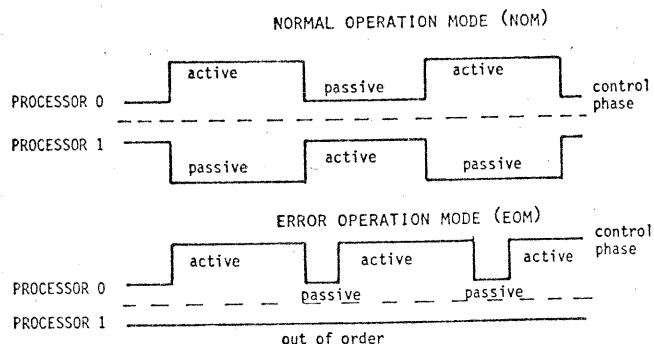NORMAL OPERATION MODE (NOM)

ERROR OPERATION MODE (EOM)

FIG. 6: THE CONTROL PHASE PRINCIPLE

will be denoted as normal operation mode (NOM).
In this mode processor 0 (PRO) is, as assumed
previously, only able to process connect requests
from planes 1+2, PR1 from planes 3+4.

In case of failure of one processor, the error
operation mode (EOM) is set up.

The error-free processor (PRO in Fig.6) performs
the normal functions during his active control
phase . The next active control phase starts after
the end of the preceding control phase, plus a
short constant time , during which the processor
is set into the passive status. In this passive
phase the processor tests, among others, if con-
nect requests are waiting in the IB. Furthermore
the working processor can now serve connect re-
quests from all planes, as control data channels
from the 4 planes are switched to this processor.

2.3.2 THE DIFFERENT TYPES OF ACTIVE CONTROL PHASES

Four types of control phases have to be distin-
guished according to the tasks to be performed
(Fig.7). Each control phase starts with a self-
testing program (T), this lasts t_T. Then subs-
criber circuit scanning (SS) takes place, lasting
t_{SS}.

a) If a connect request from one of the two planes
for which the active processor is responsible is
waiting, this request will be served. During the
time t_{PS} a path search program is running. This
program is finished with an acknowledgement
(positive or negative) which is sent to the cen-
tral processor. This acknowledgement enables the
central processor to send a new request if neces-
sary. Therefore not more than one request per
plane can waite.

If the path searching (PS) has been successful,
the switching function for the connect request
takes place during t_E. This type of control phase
is denoted as type "CN".

b) If no connect request is waiting (or if the
path search for a connect request has not been
successful) line circuit scanning (LS) takes
place during t_{LS}.

b1) If a clear request is detected, that clear
request is processed during t_C. The type of this
phase is denoted "CL".

b2) If no clear request is detected, it is tested
if during the SC scanning a call request has been
detected. In this case a path and trunk searching
starts (PS) and afterwards a throughconnecting
takes place (time t_E) or in case of congestion

FIG. 7: THE DIFFERENT TYPES OF ACTIVE CONTROL
PHASES

the control phase is terminated. This control
phase is denoted "CA".

c) If no request has to be served, an overhead
phase is performed. This is necessary for tech-
nical reasons and causes, that an active phase
is not shorter than a given minimal time. This
phase is denoted "NOP".

These different types of active control phases
will be further clarified in the following.

3. INVESTIGATIONS BY MEANS OF SIMULATION

3.1 THE SIMULATION MODEL

Fig. 8 shows the model of the concentrator control
as a queuing model. As in the normal operation
mode NOM only one processor is active during a
control phase, only one processor has been depicted

This processor represents
- for the NOM the momentarily active processor
- for the EOM the only active processor.

The already mentioned tasks of the processor
are represented by square boxes in Fig. 8.

Furthermore the 4 control channels to the cen-
tral processors of the 4 planes are modelled.
The model of one control channel consist of an
output buffer into which connect requests from
the central processor are filled with rate $\lambda_{CN,i}$.
The transmission delay of control information
from the output buffer to the buffers IB of the
concentrator is modelled by means of the constant
delay time t_{TD}. Only one request is allowed to
wait in the buffers IB for each plane until an
acknowledgement is sent to the central processor
of the pertinent plane via a backward control
channel. This acknowledgement has also the
constant delay time t_{TD}.

The operation of the control within the model is
in accordance to that described in chap. 2.3.

LC and SC scanning is modelled in detail.

In contrast to the real system, only the trunks
are modelled with respect to free or busy, having
holding times of t_h after each seizure. The
switching network is assumed to be non blocking
and has therefore not to be modelled here.

3.2 The SIMULATION PROGRAM

The simulation program has been written in Algol
and comprises 13k statements and appr. 1k data
array, together about 42 kbyte main store. The
program uses code procedures for time consuming
simulation functions. Run time is about 1 hour
CPU time on a computer with a typical execution
time for a statement of 6 μsec for a large num-
ber of test calls.

3.3 DEFINITION OF CHARACTERISTIC TRAFFIC PARAMETERS

The aim of the investigation is to obtain
characteristic traffic parameters of the control.
The following values, among others are obtained.

Waiting Times
$t_{w,CN}$: Mean waiting time of all connect requests
This time starts with entering of a request into
input buffer IB and ends with sending the acknow-
ledgement.

$t_{w,CL}$: Mean waiting time of all clear requests.
This time starts with the originating of a clear
request within the LC and ends with the release
of the LC. The time from going on hook until the
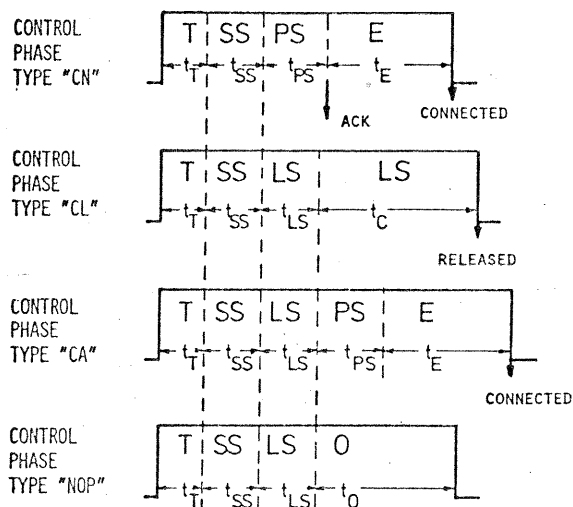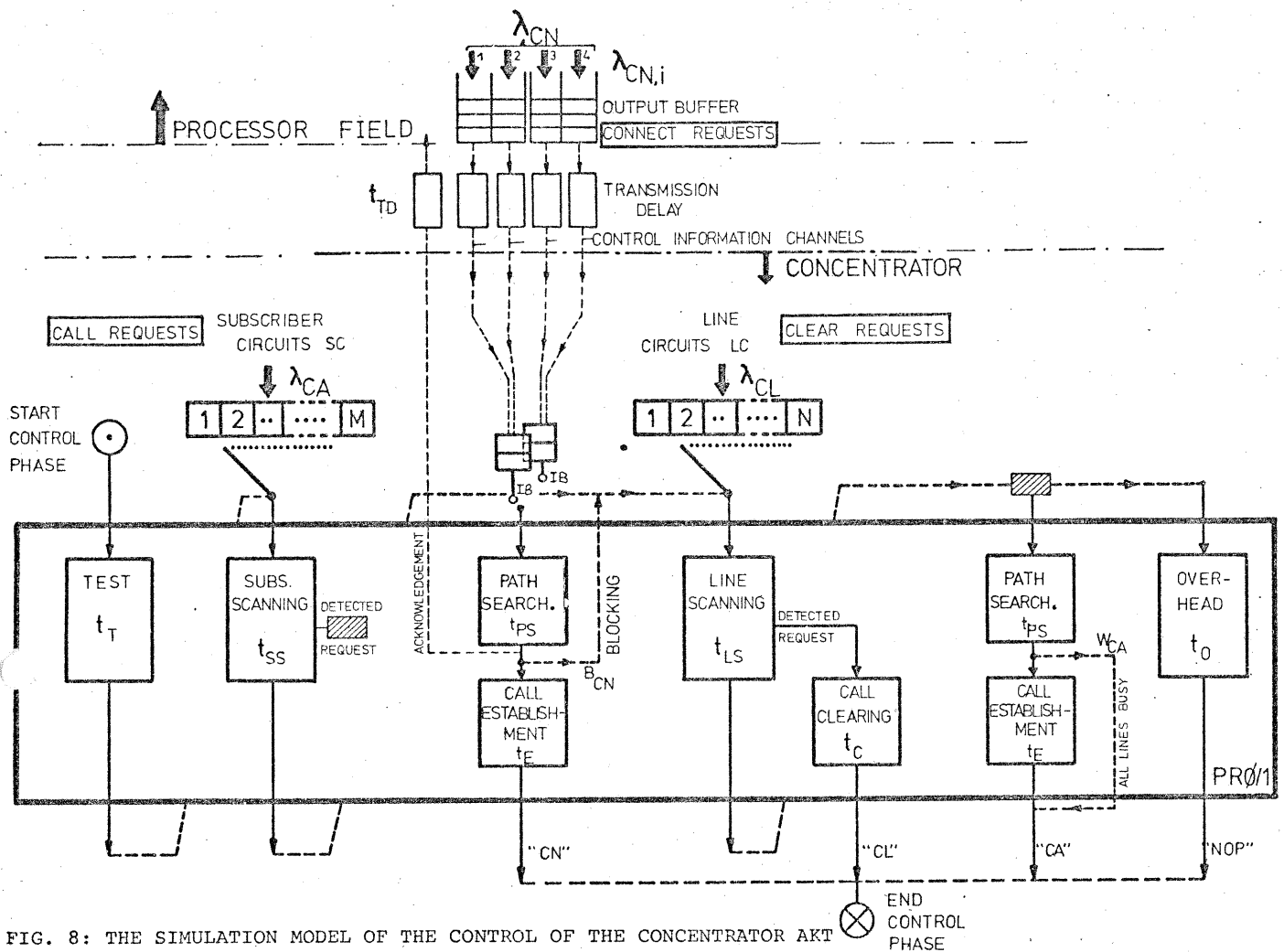clear request is generated within the LC is $t_{D,C}$.

FIG. 8: THE SIMULATION MODEL OF THE CONTROL OF THE CONCENTRATOR AKT

This time can be considered as constant. The release of the SC, belonging to this connection has to be done during a SC-scan routine. For technical reasons this is only possible after a time $t_{RS,MIN}$. The actual time between release of LC and release of the pertinent SC is t_{RS}. Therefore the total time from being on hook until LC and SC are released is

$$t_{D,R} = t_{D,C} + t_{w,CL} + t_{RS}.$$

$t_{w,CA}$: Mean waiting time for call requests. This is the time, a SC is occupied until a path to a free LC is throughconnected. This time may enclose several unsuccessful attempts of the control (in case that no idle trunk (LC) is available).

With these waiting times and their pertinent rates $(\lambda_{CN}, \lambda_{CL}, \lambda_{CA})$ the queue length or the mean number of simultaneously waiting requests can be calculated according to the formulae

mean queue length $= \lambda \cdot t_w$.

Occupancy
The load of the processors PO and P1 is of special interest.

It depends on the rates $\lambda_{CN}, \lambda_{CL}, \lambda_{CA}$ and on the following parameters, which are determined by the number of trunks and their carried traffic load:

B_{CN} : Probability of loss for connect requests

W_{CA} : Probability, that the control has to perform another attempt to serve a call request (due

to all trunks busy). It is assumed, that call attempts wait until they are served.

In the stationary case it holds

$$\lambda_{CL} = \lambda_{CA} + (1-B_{CN}) \cdot \lambda_{CN}$$

The mean number of unsuccessful attempts to serve a single call is

$$\frac{W_{CA}}{1 - W_{CA}}$$

If t_{DC} denotes the mean duration of an active control phase, then $1/t_{DC}$ is the (a priori unknown) rate, with which control phases are started. Therefore the rate of LC-scanning is

$$\lambda_{LS} = 1/t_{DC} - (1-B_{CN}) \cdot \lambda_{CN}$$

because call establishment for connect requests (rate $(1-B_{CN}) \cdot \lambda_{CN}$) excludes LC-scanning within the same control phase

The rate with which a control phase of the type CA occurs is

$$\lambda_{CA,TOT} = (1/(1-W_{CA})) \cdot \lambda_{CA}.$$

Therefore the number of control phases of the type NOP within a given time is

$$\lambda_{NOP} = \lambda_{LS} - \lambda_{CL} - \lambda_{CA,TOT}$$

The occupancy Y of the processor is defined as the processor time necessary for a certain task related to the length of an active control phase

Testing $Y_T = t_T/t_{DC}$

Subscriber scanning $Y_{SS} = t_{SS}/t_{DC}$

Connect requests
$$Y_{CN} = \lambda_{CN} \cdot (B_{CN} \cdot t_{PS} + (1-B_{CN}) \cdot (t_{PS}+t_E))$$

Clear requests $Y_{CL} = \lambda_{CL} \cdot t_C$

LC scanning $\quad Y_{LS} = \lambda_{LS} \cdot g \cdot t_{LS}$. $\quad g \cdot t_{LS}$ is the traffic dependent mean time for LC-scanning

Call requests $Y_{CA} = \lambda_{CA} \cdot (t_E + (1+W_{CA}/(1-W_{CA})) t_{PS})$

In contrast to that, the overhead phase is not considered as real load, so that the effective load of an active processor during a control phase is

$$Y_{PR} = Y_T + Y_{SS} + Y_{CN} + Y_{LS} + Y_{CL} + Y_{CA} = 1 - \lambda_{NOP} \cdot t_O = 1 - Y_O$$

After having described the structure and operating mode of the model, the stochastic characteristics of the arrival and service processes have to be characterized.
It is assumed, that all service and transmission times are constant, excluding the time for LC-scanning, which is calculated within the simulation program by means of the scan distance.

The arrival process for call requests is assumed to be a poissonian process with rate λ_{CA}.

The arrival process for connect requests is also assumed to be a poissonian process with rate

$$\lambda_{CN} = \sum_{i=1}^{4} \lambda_{CN,i} \quad \text{with} \quad \lambda_{CN,1} = \lambda_{CN,2} = \lambda_{CN,3} = \lambda_{CN,4}$$

The arrival process for clear requests (rate λ_{CL}) is also a poissonian process because the holding times of the trunks are also negative exponentially distributed .

The momentary rate $\lambda_{CL,MOM}$ is a function of the momentarily occupied trunks Z:

$$\lambda_{CL,MOM} = Z \cdot 1/t_h$$

with t_h = mean holding time of a trunk after seizure.

The carried traffic on the trunks is

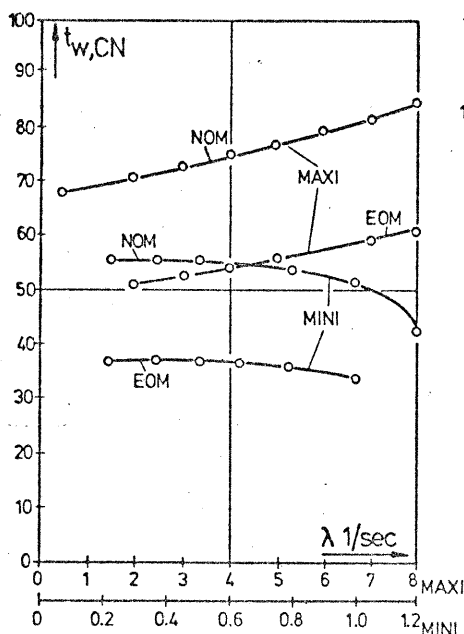$$Y_{TR} = (\lambda_{CA} + (1-B_{CN}) \cdot \lambda_{CN}) \cdot t_h.$$

Fig. 10 gives a list of the input parameters together with values for two sizes of the concentrator (MAXI,MINI).

3.4 RESULTS

Waiting times (Fig. 11,12,13)
Fig. 11 shows the mean waiting times for connect requests $t_{w,CN}$ for the concentrator sizes MAXI and MINI (see Fig. 10) as a function of the request rate for call establishments

$$\lambda = \lambda_{CN} + \lambda_{CA} \quad \text{with} \quad \lambda_{CN} = \lambda_{CA}$$

Fig. 12 and Fig. 13 show the mean waiting times for clear requests $t_{w,CL}$ and the mean waiting times for call requests $t_{w,CA}$, resp.

As expected, the waiting times increase for the size MAXI with the request rate λ. Due to the priorities for the different kinds of requests, the waiting times for connect requests (CN) are the lowest, whereas the waiting times for call requests (CA) are the highest due to their lowest priority.

INPUT PARAMETER	MAXI	MINI
Number of subs. circuits M	8192	1024
Number of line circuits N	2048	128
Mean holding time t_h	150 sec	150 sec
Time for testing t_T	5 msec	5 msec
Time for scan. all SC t_{SS}	15 msec	3 msec
Time for path search t_{PS}	8 msec	8 msec
Time call establishm. t_E	25 msec	25 msec
Time for scan. all LC, t_{LS}	8 msec	1 msec
Time for clearing t_C	26 msec	26 msec
Overheadtime t_O	12 msec	31 msec
Time to set clear req. $t_{D,C}$	178 msec	178 msec
Min. time to rel. SC $t_{RS,MIN}$	50 msec	50 msec
Mean transfer time t_{TD}	16 msec	16 msec
Time for passive phase in case of EOM	1 msec	1 msec

FIG. 10: LIST OF INPUT PARAMETERS

FIG. 11: MEAN WAITING TIME FOR CONNECT REQUESTS

FIG. 12: MEAN WAITING TIME FOR CLEAR REQUESTS

FIG. 13: MEAN WAITING TIME FOR CALL REQUESTS

The difference between the waiting times for connect requests $t_{w,CN}$ in the normal operation mode (NOM) and the error operation mode (EOM) is due to the fact, that in the NOM each processor can only serve half of the connect requests(PRO the requests from plane 1+2, PR1 from plane 3+4), whereas in the EOM each processor can serve each connect request.

Fig.14 shows the distribution function for waiting times for call requests $P\{T_{w,CA} \leq t\}$ for the rates $\lambda=1,4,7$ for the size MAXI.

In the case of the concentrator size MINI, the waiting times for connect and clear requests are decreasing with λ.

To explain this phenomena, Fig. 15 shows the probability of loss for connect requests (B_{CN}) and the probability that a call request is not served (W_{CA}) resp. for the size MINI.

For values of λ higher than 0.5 the probability of all trunks busy increases rapidly. Due to this fact, the mean duration of an active control phase decreases.

It should be mentioned however, that the engineered values for λ are 4 in case of MAXI and 0.5 in case of MINI.

Fig. 16 shows the occupancy of the processor Y_{PR} as a function of λ for the sizes MAXI, MINI. The occupancy of the processor is for $\lambda=0$ according to the definition and the fact, that only control phases of type NOP are performed

$$Y_{PR} = \frac{t_T + t_{SS} + t_{LS}}{t_T + t_{SS} + t_{LS} + t_0}$$

that is for the size MAXI $28/40 = 0.7$
and for the size MINI $9/40 = 0.225$.

As for the size MAXI and the considered values of λ, B_{CN} and W_{CA} are equal to 0, Y_{PR} is a linear function of λ.

Furthermore the total load Y_{PR} is split into the different parts due to the different tasks of the processor to be performed (see chap. 3.3)

4.INVESTIGATION BY MEANS OF CALCULATION

4.1 MODEL 1

The first model to calculate interesting parameters is a single server queuing model (Fig.17) with

- one class (type) of requests, served accord. to a FIFO strategy
- poisson input, rate λ'
- infinite buffer
- clocked service with generally distributed clock periods, with mean τ and coefficient of variation v

To take into account the priorities of the requests in the real system (see chap. 2.2), a constant factor p is introduced. p is identified with the probability, that in the considered clock period no request with higher priority has to be served. Therefore p is the probability that the first waiting request within the queue may begin service at the next clock instant.

If the service starts, it will be finished in any case before the next clock instant, having a constant service time t_s (Fig. 17).

The probability p has to be calculated for the three different types of requests in the system (CN,CL,CA) (see Fig.18).

The following parameters can be calculated

- Probability, that the queue length Q just before a clock instant is greater than 0

$$P(Q>0) = \lambda'\tau/p$$

- Mean queue length E(Q) just before the clock instant

$$E(Q) = \frac{\lambda'\tau(2-\lambda'\tau(1-v^2))}{2(p-\lambda'\tau)}$$

- Mean waiting time t_w. (The waiting time of a request starts with inserting the request into the buffer and ends after the service of this request)

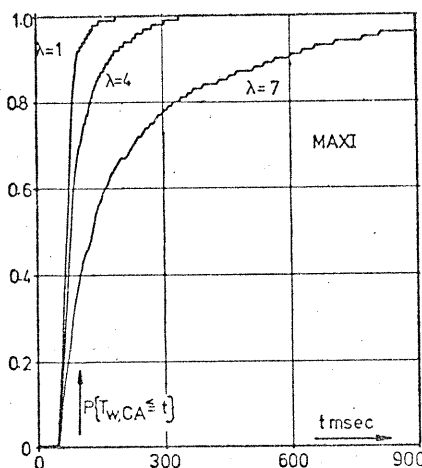$$t_w = \frac{\tau(2-p(1-v^2))}{2(p-\lambda'\tau)} + t_s$$
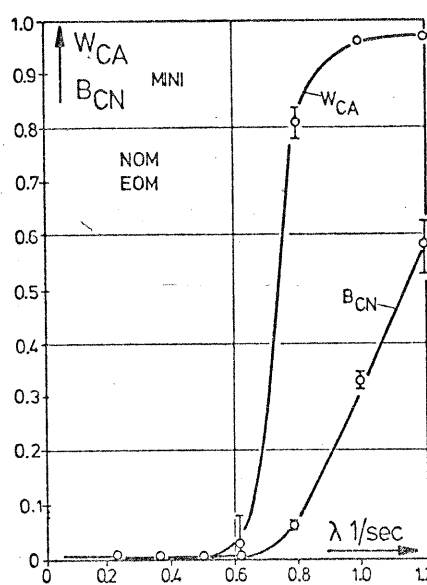

FIG. 14: DISTRIBUTION FUNCTION OF THE WAITING TIMES FOR CALL REQUESTS

FIG. 15: PROBABILITY OF LOSS AND PROBABILITY OF REPEAT FOR CONNECT AND CALL REQUESTS, RESP.
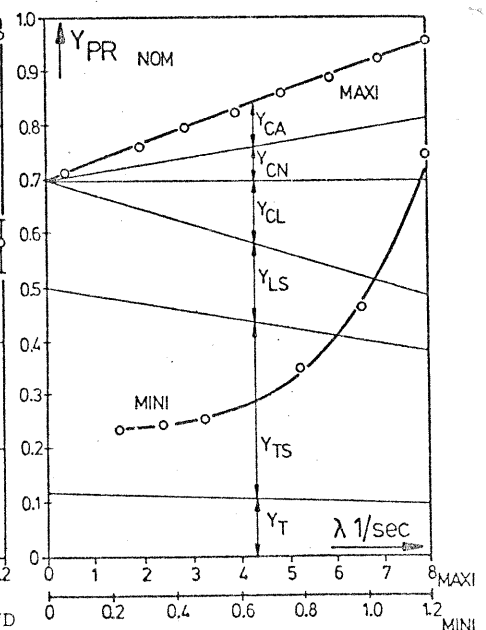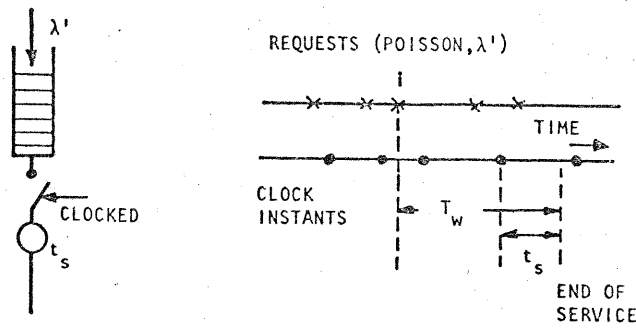
FIG. 16: OCCUPANCY OF THE CONTROL

FIG. 17: MODEL ONE FOR CALCULATION

To calculate the parameters for the concentrator control, the following relations are assumed for t_s (see Fig 7+10)

- for CN-requests $\quad t_{s,CN} = t_T + t_{SS} + t_{PS}$
- for CL-requests $\quad t_{s,CL} = t_{LS}/2 + t_C$
- for CA-requests $\quad t_{s,CA} = t_{SS} + t_{LS} + t_{PS} + t_E$

The coefficient of variation is neglected in the following.

Fig. 18 shows the formulae to calculate the parameters for the three types of requests, CN,CL,CA.

Fig. 19,20,21 show the calculated values (solid lines) together with the simulated values (circles) for the waiting times $t_{w,CN}, t_{w,CL}, t_{w,CA}$.

The chosen values for the mean duration of an active control phase (t_{DC}) are also shown.
The diagrams show the good accordance between calculated and simulated values.

4.2 MODEL 2

The second model for calculation (Fig. 22) is a standard priority model with 4 (non-preemptive) priority classes.
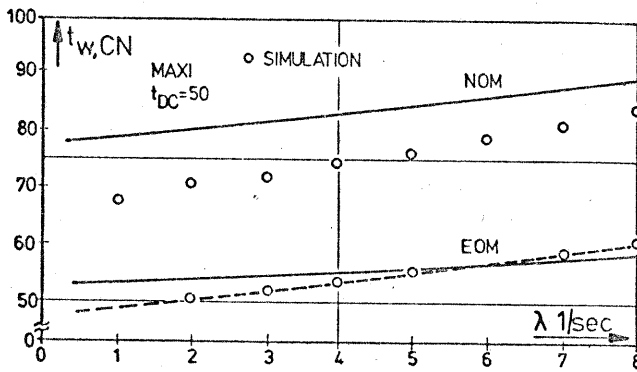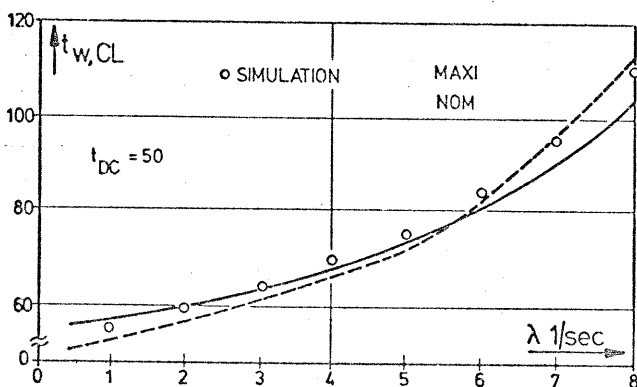
TYPE OF REQUEST	OPERAT. MODE	PARAMETER				CHARACTERISTIC VALUES FROM EQU.
		λ'	τ	t_s	p	
CN	NOM	$\frac{\lambda}{4}$	$2t_{DC}$	28	1	$P(Q>0)=P_{CN}=\dfrac{\lambda\, t_{DC}}{2}$
						$t_{w,CN}=\dfrac{t_{DC}}{1-\lambda t_{DC}/2}+t_s$
CN	EOM	$\frac{\lambda}{2}$	t_{DC}	28	1	$P(Q>0)=P_{CN}=\dfrac{\lambda t_{DC}}{2}$
						$t_{w,CN}=\dfrac{t_{DC}}{2(1-\lambda t_{DC}/2)}+t_s$
CL	NOM	λ	t_{DC}	30	$1-P_{CN}$	$P(Q>0)=P_{CL}=\dfrac{\lambda t_{DC}}{1-\lambda t_{DC}/2}$
						$t_{w,CL}=\dfrac{t_{DC}(1+\lambda t_{DC}/2)}{2-3\lambda t_{DC}}+t_s$
CA	NOM	$\frac{\lambda}{2}$	t_{DC}	56	$(1-P_{CN})(1-P_{CL})$	$P(Q>0)=P_{CA}=\dfrac{\lambda t_{DC}}{2-3\lambda t_{DC}}$
						$t_{w,CA}=\dfrac{t_{DC}(1+3\lambda t_{DC}/2)}{2(1-2\lambda t_{DC})}+t_s$

FIG. 18: FORMULAE FOR CHARACTERISTIC VALUES
(Size MAXI, times in msec)

This model has in comparison to the comprehensive simulation model the following characteristics:

It takes fully into account the
- variable length of an active control phase
- priorities
- traffic dependent overhead phases

It approximates
- the variable (traffic dependent) time for LC-scanning
- different arrival processes for CN,CL,CA requests.

It neglects the effects due to all lines busy in case of CN and CA requests

Each of the 4 classes of the priority model has a poissonian input process with rate λ_i, mean service time h_i, a coefficient of variation c_{Hi}, and an offered traffic $A_i = \lambda_i \cdot h_i \quad i=1..4$.

Fig. 19: MEAN WAITING TIME FOR CONNECT REQUESTS

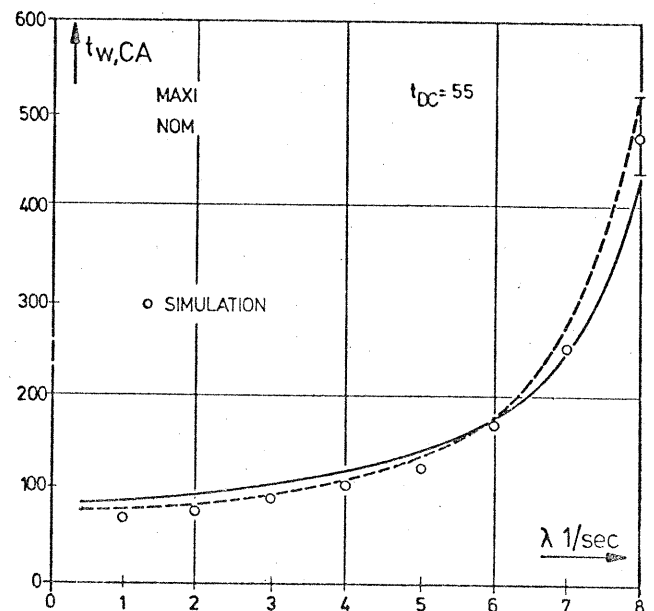FIG. 20: MEAN WAITING TIME FOR CLEAR REQUESTS

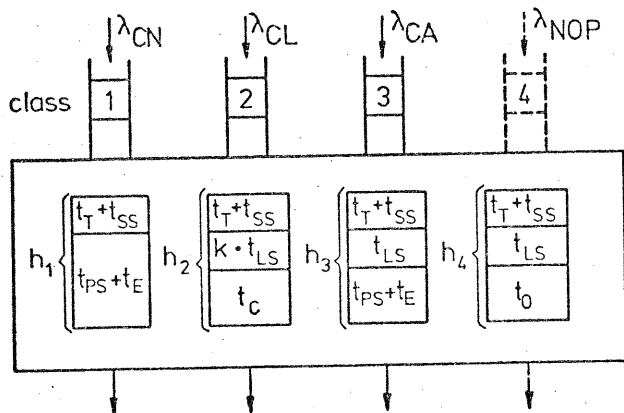FIG. 21: MEAN WAITING TIME FOR CALL REQUESTS

FIG. 22: MODEL TWO FOR CALCULATION

It holds (Fig.22) $\lambda_1 = \lambda_{CN}$ $h_1 = t_T + t_{SS} + t_{PS} + t_E$

$\lambda_2 = \lambda_{CL}$ $h_2 = t_T + t_{SS} + k \cdot t_{LS} + t_c$

$\cdot t_{LS}$ (k≤1) represents the mean time for LC-scanning. It is known that k=0.5 for $\lambda \to 0$. Assuming that under normal conditions the probability that more than one request is waiting is low, k is chosen to 0.5 for the general case

In case of an active control phase type CA, the time for scanning is t_{LS}, therefore

$\lambda_3 = \lambda_{CA}$ $h_3 = t_T + t_{LS} + t_{PS} + t_E$

The additional, fictive class 4 (NOP requests) models the phases with overhead. According to the mechanism described, λ_4 has to be choosen in such a way, that the processor is permanently occupied, therefore

$A = \sum_{i=1}^{4} A_i = 1$ or $A_4 = \lambda_4 h_4 = 1 - (A_1 + A_2 + A_3)$

Therefore $\lambda_4 = \lambda_{NOP}$ $h_4 = t_T + t_{SS} + t_{LS} + t_O$

From these formulae, the maximum rate of successful call establishments, being processed by the concentrator control, for stationary operation can be calculated:

$\lambda_4 = 0$ or $A_1 + A_2 + A_3 \lessgtr 1$

As it is assumed that $B_{CN} = W_{CA} = 0$, $\lambda_{CL} = \lambda_{CN} + \lambda_{CA}$.

Therefore

$\lambda_{CN}(t_T + t_{SS} + t_{PS} + t_E) + (\lambda_{CA} + \lambda_{CN})(t_T + t_{SS} + t_{LS}/2 + t_c)$
$+ \lambda_{CA}(t_T + t_{SS} + t_{LS} + t_{PS} + t_E) = 1$

For the size MAXI: $\lambda_{CN} \cdot 103$ msec $+ \lambda_{CA} \cdot 111$msec $= 1$
or for $\lambda_{CN} = \lambda_{CA} = \lambda/2$ $\lambda_{MAX} = 9.35$ call establ./sec

Therefore 33660 BHC are possible in the stationary border line case.

According to COBHAM /8/ the mean waiting times (expectation values, without service times) are

$$T_{W1} = \frac{\sum_{i=1}^{4} A_i (1 + c_{Hi}^2) h_i}{2(1 - A_1)} \quad T_{W2} = \frac{T_{W1}}{1 - A_1 - A_2}$$

$$T_{W3} = \frac{1 - A_1}{1 - A_1 - A_2 - A_3} T_{W2}$$

As the service times are constant, it holds $c_{Hi} = 0$. Furthermore B_{CN} and W_{CA} are assumed to be equal to 0 and $\lambda_{CN} = \lambda_{CA}$.

Therefore $\lambda_{CN} = \lambda/2$, $\lambda_{CL} = \lambda$, $\lambda_{CA} = \lambda/2$.

The determination of the characteristic traffic parameters from the waiting times of the model must reflect, for each type of request, up to which time within an active control phase, it can be served in reality

o Mean waiting time $t_{w,CN}$ for CN-requests is according to the definition

$t_{w,CN} = T_{W1} + t_T + t_{SS} + t_{PS}$

o Mean waiting time $t_{w,CL}$ for CL-requests.

The request CL is detected in the real system during the LC-scanning.

$t_{w,CL} = T_{W2} + t_{LS}/2 + t_c$

o Mean waiting time $t_{w,CA}$ for CA-requests. Similarly holds

$t_{w,CA} = T_{W3} + t_{SS} + t_{LS} + t_{PS} + t_E$

The calculated values are printed in Fig. 19-21 with dashed lines for the size MAXI.

5. CONCLUSION

This paper presented a study on the performance and the flow of control information of the concentrator control within the analog concentrator of the system IFS.

One simulation and two calculation models have been developped and the results of the investigations have been presented and discussed.

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