

BSSE System and Software Engineering

Call data Acquisition and Distribution Integrated System

(CADIS)

System Overview

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Dr. Rainer Gerlich
Auf dem Ruhbuehl 181
D-88090 Immenstaad
Tel.: +49/7545/91.12.58
Fax: +49/7545/91.12.40
e-mail: gerlich@t-online.de
www: <http://home.t-online.de/home/gerlich/>

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1. INTRODUCTION

CADIS (Call data Acquisition and Distribution Integrated System) is a highly configurable system for continuous (24h/24h) and automated data acquisition, processing and distribution of call data. CADIS can be adapted to customer's needs based on a building-block approach and parameter files. The call data are generated by a base station/master exchange (MX) and need to be forwarded to a billing system. CADIS covers the link between the base station/MX and the billing system by

- acquisition and storage of the call data received from a base station by a local link (like RS232 or LAN/Ethernet), this functionality is covered by CADIS DLD (Data Logging Device),
- acquisition, pre-processing, storage and analysis of the call data, this functionality is covered by CADIS DAD (Data storage and Analysis Device),
- automated collection of call data from all base stations (which may be distributed over a wide area), conversion of data into the billing system format and data archiving over a given time period by a central processing facility (CPF).

Retrieval and analysis of call data and of system status data is supported by a highly performant data base and a graphical user interface (GUI). All the different features can either be provided by a distributed, multi-processor CADIS system or partially or fully integrated into one CADIS system and processor respectively. The actual configuration depends on a customer's needs.

A distributed system configuration for automated data acquisition is shown by Fig. 1-1: a number of CADIS DAD or DLD systems (shown in the upper part, for details see Figs. 1-2 and 1-3) acquire data locally (decentralised) from base stations. The central CADIS system CPF (which is shown in the middle and lower part) - acquires such data according to a predefined schedule and brings them into a format readable by the billing system. The data archiving facility allows to analyse the data over the legally allowed time period e.g. for fault analysis or traffic analysis either on DAD or CPF according to the configuration. The data analysis facility based on the highly performant data base system provides enhanced evaluation and visualisation capabilities and can be integrated into each customer-tailored CADIS system.

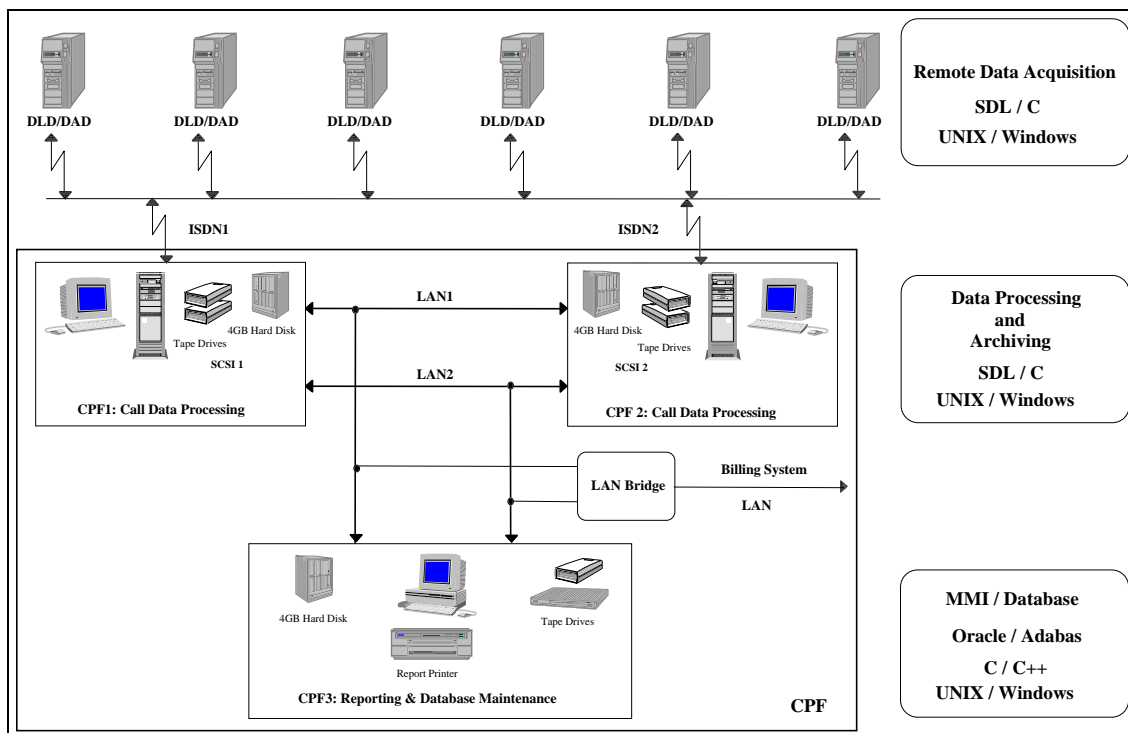


Fig. 1-1: Overview on an Example CADIS DAD/DLD-CPF-Configuration

A DAD/DLD represents an instantiation of CADIS as data acquisition front-end, CPF its instantiation towards centralised data processing and evaluation. Due to the highly flexible configuration capabilities of CADIS the following configurations (the enumeration is non-exhaustive) may be provided according to a customer's needs:

1. decentralised data acquisition and centralised data processing and analysis as shown by Fig. 1-1, single-processor DAD/DLD and triple-processor, one-fault-tolerant CPF,
2. single-processor integrated DAD//CPF (upgrade of DAD towards CPF),
3. fault-tolerant integrated DAD//CPF (upgrade of CPF towards DAD)
4. simple data acquisition and storage with WAN/ISDN capability for automated data acquisition (one processor DAD/CPF).

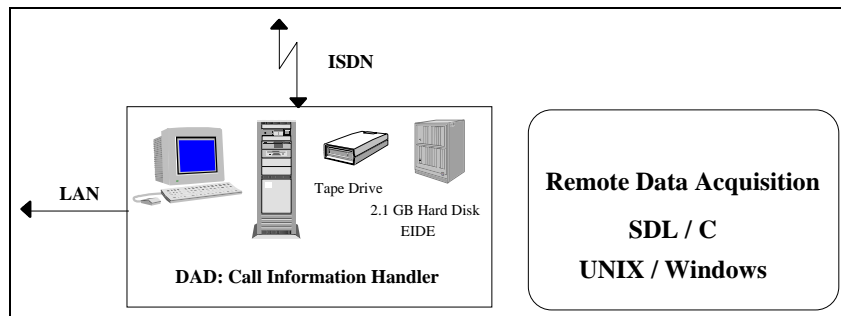


Fig. 1-2: Overview on CADIS DAD-Configuration

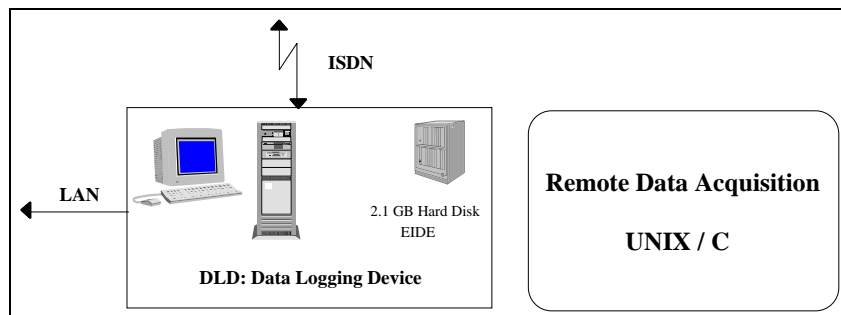


Fig. 1-3: Overview on CADIS DLD-Configuration

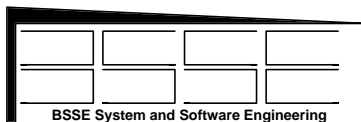
2. MEETING CUSTOMER REQUIREMENTS

2.1 Flexibility of System Configuration

CADIS provides a number of capabilities by which it best can meet specific customer requirements. Such capabilities are: flexibility of configuration, fault tolerance and ease of maintenance by support of remote maintenance. Moreover, CADIS brings to a user an optimum of capabilities for data evaluation, system analysis and (remote) system control.

The properties of a CADIS component are driven by data, which easily can be updated if needed. Hence, it is possible to modify immediately the properties of a system without recompilation.

The explaining text, e.g. of the menus or status messages, can easily be adapted to the customer's native (European) language.



In addition to the numerical presentation of data base queries by a user-friendly GUI (Fig. 2-1)¹, report preview (Fig. 2-2) and periodic (or sporadic) printing of comprehensive reports, data base contents is presented as spreadsheet (Fig. 2-3).

Display of CADIS status messages is done by the same GUI (Fig. 2-4) which is used for data base queries and report generation. System activities are controlled by menus for which the ISDN menu (Fig. 2-5) or the job control menu (2-6) are examples. By jobs activities are initiated like daily generation and printing of reports or periodic data transfer to the billing system. Also, sporadic activities can be executed like data base start or stop. The ISDN menu allows a user to control the automated data acquisition via WAN/ISDN and to define the data needed to initiate and execute the transfer.

Communication between the CADIS components is transparently done through the whole network: locally on the same processor or by LAN or between local and remote processors by WAN. In fact, there is no difference from an operational point of view whether a function is executed locally or remotely. It is even possible to attach a second instance of a CADIS system without disturbing the first one while it is still operational. This can be done remotely across a WAN connection, e.g. to test a new version of the software or the data base with real data, to run the second system in debugging mode etc.

The graphical figures 2.8 -2.16 show more details about the CADIS user interface and the menus for transparent network operations.

2.2 Hot-Billing

Hot-Billing is the capability to continuously provide to clients information about their billing account. CADIS supports hot-billing in the CPF or in an integrated DAD/DLD-CPF configuration. For a given set of clients all call records referring to hot-billing subscribers will be stored into a file either separately or in addition to the usual billing information. A hot-billing file will periodically be forwarded to the customer's billing system as defined by an entry in the job menu. Of course, this data transfer can also be performed either by LAN/Ethernet or WAN/ISDN. It can also be initiated manually.

2.3 Record Formats and Contents

The binary frames received from a base station may be converted into different formats: into C- and G-record format, into R028/R029/RC3-format, into AMA-format or into a format for data analysis as described in section 2.7. All formats may be stored into the database for refined data analysis based on queries, reports and spreadsheet diagrams. CADIS generates also detailed information on fleets so that a refined analysis on fleet interaction can be performed.

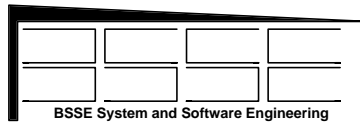
2.4 Fault-Tolerance

CADIS systems are designed to be operated continuously 24 hours of a day. If a fault occurs the system itself identifies the impact and reconfigures (as far as system resources are available to compensate the fault). In case of a fault-tolerant CADIS version (like the CPF three processor system) the processor and the data links are redundant. Each hardware component is provided twice (see CPF in Fig. 1-1). The processors continuously perform selftests, exchange status data and decide what to do according to the overall system state. This prevents e.g. duplication of data delivery to the billing system and double charging of clients. If a CPF processor is lost its function can be substituted by one of the remaining processors by manual intervention.

The data links are continuously monitored and re-established if the hardware link or the partner processor is again available. If a link fails the system takes automatically the redundant link if it is still working correctly.

Although the software is thoroughly and duly tested, sporadic errors may still occur. When the system is aborted it will restart automatically and continue to provide the service, keeping all the data acquired before. Cases which require manual intervention are permanent faults like loss of a hardware component

¹ Figs. 2.1 - 2.16 are added at the end of this document starting by page 6.



or an abort of the operating system. CADIS includes self-protection mechanisms to prevent CPU overload or a full disk.

When restarting a processor of the double-processor system it will exchange information with its partner processor in order to update its own database. and to achieve again full redundancy of data.

By implementing a combination of UNIX/Linux with Windows which can even run together on the same processor an optimum solution was found to cover user needs: the highly reliable parts are running on UNIX/Linux and the graphical user interface (GUI) is running on MS-Windows providing an appropriate environment for graphical presentation of data.

2.5 Maintenance

Maintenance of CADIS components like CPF or DAD/DLD can be done remotely through a LAN or WAN network. This is also true for fault diagnosis. So - except replacement of hardware - everything concerning maintenance can be done by remote operations. It is even possible to continue with data acquisition when replacing the data processing part of a CADIS system.

In case of the CPF double-processor system one branch can be switched off if needed e.g. for hardware maintenance. Then the other processor executes the tasks as usual. When coming into operation again the second processor will update its own database by communication with the partner processor. So after maintenance the same procedure is applied as after occurrence of a permanent fault.

2.6 Time Mangement

A CADIS CPF supports centralised management of time: it may be equipped with a DCF77² time device by which all the peripheral devices like DAD or DLD are synchronised. Then the DCF77 time is taken to update the timestamp which a call data frame gets from a MX. In consequence, within a CADIS network all call data will be correlated to a unique time reference irrespectively of the possible deviations of time between a number of MX. Moreover, corrections needed to adapt to MET in autumn or to MEST in spring are automatically handled by CADIS components.

2.7 Addon's for Data Analysis

In addition to the functions needed to acquire, process, evaluate and present the data CADIS provides a number of additional tools which visualise what is going on at the interface to the base station. Such tools are:

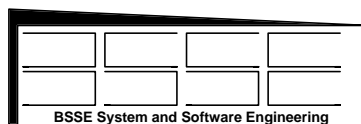
- **Moni232**

which logs all data flowing over a Rx- and/or Tx-line and optionally assigns a time stamp to such data for refined timing analysis. On request, BSSE provides a hardware box which allows to trace Rx and Tx lines simultaneously.

- **FrameAnalyser**

which documents in an ASCII-file the data which have been acquired from a MX or logged by Moni232. It prints (as shown by Fig. 2-7) the frame number (as assigned by FrameAnalyser), the time stamp (if available), the type of the data/message frame, the number of bytes of the frame and in hexadecimal format the frame itself. In case of Alive- and Time-frames the corresponding mode is printed.

² DCF77 is a radio station operated by the "Physikalisch-Technische Bundesanstalt" in Braunschweig (Germany) which continuously provides exact timing information.



- **MXscope**

which is a program for graphical visualisation of frames over time (if the time stamp is available). It provides zooming and partitioning of larger files. Fig. 2-7 lists the contents of the data of Fig. 2-8. When a user clicks on one of the events a window opens and displays the formatted contents of each record.

- **MXtime**

which evaluates the timing behaviour of the frames. It determines the time difference between the frame types and writes them into a file either in QuatroPro or Excel-Format. Then histograms on the frames' timing can be generated.

- **MXsimul**

is a software simulator of a base station (MX). At both RS232 lines (or one line only) it provides all the data which are usually issued by a MX and it follows the same protocol. This allows to simulate all activities during data acquisition from initial handshake to disconnection including generation of faulty states on the line(s) and line switching. In addition, MXsimul can trace the incoming and/or outgoing data which can be evaluated by Moni232.

Point of Contact

For further information or in case of any questions please contact:

Rainer Gerlich
BSSE System and Software Engineering
Auf dem Ruhbuehl 181
D-88090 Immenstaad
Germany

Phone: +49/7545/91.12.58
Mobile: +49/171/80.20.659
Fax: +49/7545/91.12.40
email: gerlich@t-online.de
www: <http://home.t-online.de/home/gerlich/>

On the web-page you will find files for download and more information about BSSE.

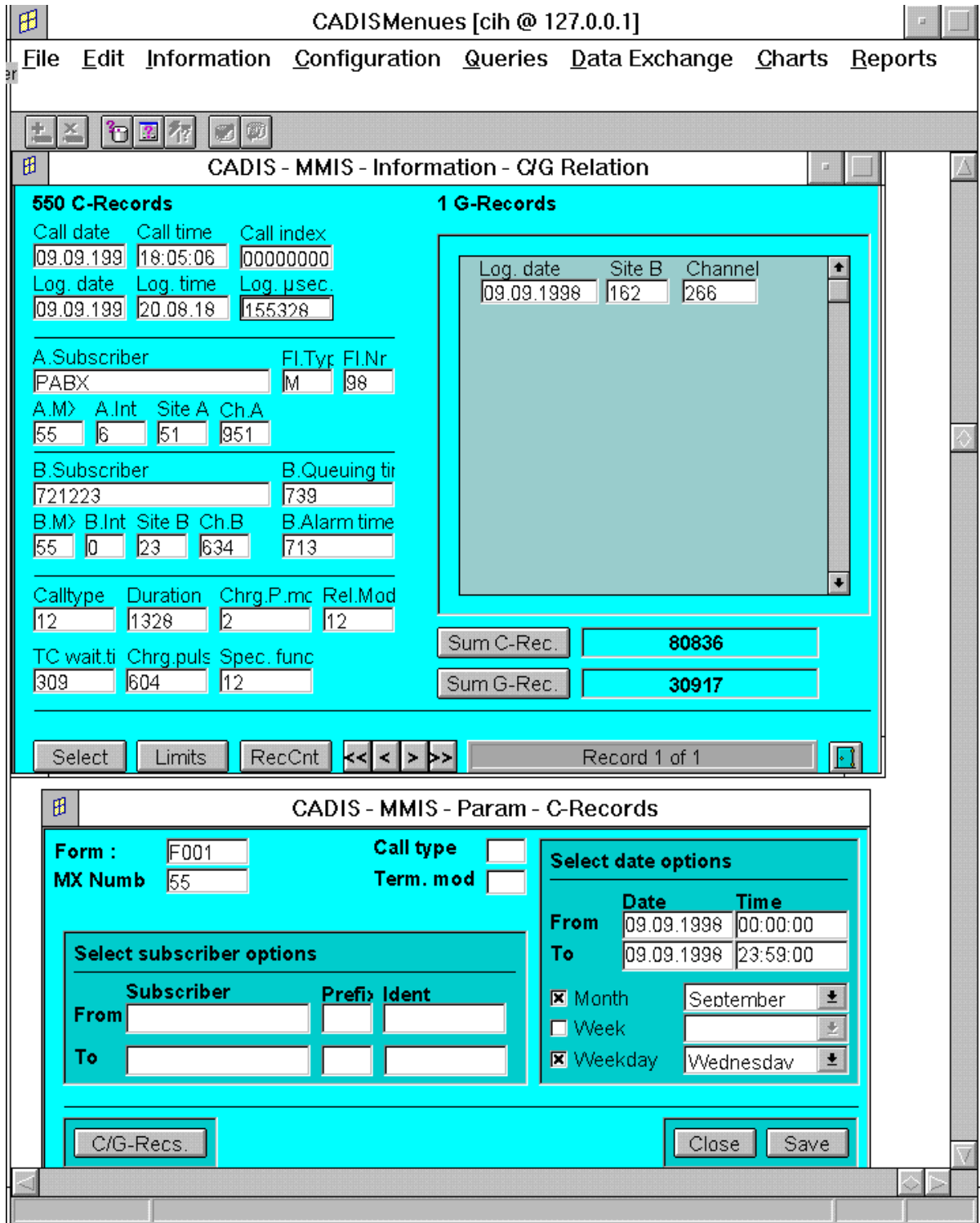


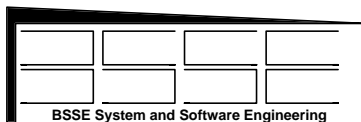
Fig. 2-1.1 (upper part): Presentation of Query Results: C Record and Associated G Records (more information about C record, e.g. fleet information, is opened on button-click)

Fig. 2-1.2 (lower part): Definition of Selection Criteria

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Hour	Q00	Q15	Q30	Q45	Calls / Hour
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	34	0	0	34
15	0	0	0	93	93
16	316	0	432	0	748
17	0	0	0	0	0
18	0	0	50	0	50
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
Total	316	34	482	93	925

Fig. 2-2-1: Preview of Report on Busy Times



Page 1

Calltype	No. calls	% of total	% succeeded
0	EMERGENCY speech	7	1,03 % 100,00 %
1	EMERGENCY data	17	2,49 % 100,00 %
2	EMERGENCY spec speech	27	3,96 % 100,00 %
3	EMERGENCY spec data	16	2,35 % 100,00 %
4	SIMPLE CALL speech	20	2,93 % 100,00 %
5	SIMPLE CALL modem	13	1,91 % 100,00 %
6	SIMPLE CALL prio speech	15	2,20 % 100,00 %
7	SIMPLE CALL prio modem	20	2,93 % 100,00 %
8	DATA CALL	21	3,08 % 100,00 %
9	SIMPLE CALL include speech	19	2,79 % 100,00 %
10	GROUP CALL include speech	19	2,79 % 100,00 %
11	GROUP CALL Bspeech	23	3,37 % 100,00 %
12	GROUP CALL broadcast	19	2,79 % 100,00 %
13	GROUP CALL local Bspeech	18	2,64 % 100,00 %
14	GROUP CALL local broadcast	25	3,67 % 100,00 %
15	GENERAL CALL Bspeech	17	2,49 % 100,00 %
16	GENERAL CALL broadcast	18	2,64 % 100,00 %
17	GENERAL CALL local	18	2,64 % 100,00 %
18	GENERAL CALL broadcast	19	2,79 % 100,00 %
19	OPEN ChCALL	27	3,96 % 100,00 %
20	SIMPLE CALL short data	20	2,93 % 100,00 %
21	GROUP CALL short data	23	3,37 % 100,00 %
22	SIMPLE CALL status	26	3,81 % 100,00 %
23	GROUP CALL status	23	3,37 % 100,00 %
24	SIMPLE CALL xdata	21	3,08 % 100,00 %
25	GROUP CALL xdata	20	2,93 % 100,00 %
26	ACTIVATION div	17	2,49 % 100,00 %
27	GROUP CALL exec speech	24	3,52 % 100,00 %
28	GROUP CALL exec broadcast	15	2,20 % 100,00 %
29	GROUP CALL high prio speech	17	2,49 % 100,00 %
30	GROUP CALL high prio broadcast	24	3,52 % 100,00 %
31	GROUP CALL exec local speech	22	3,23 % 100,00 %
32	GROUP CALL exec local broadcast	21	3,08 % 100,00 %
33	GROUP CALL high prio local speech	14	2,05 % 100,00 %
34	GROUP CALL high prio local broadcast	17	2,49 % 100,00 %
		682	

Fig. 2-2-2: Preview of Report on Call Type Distribution

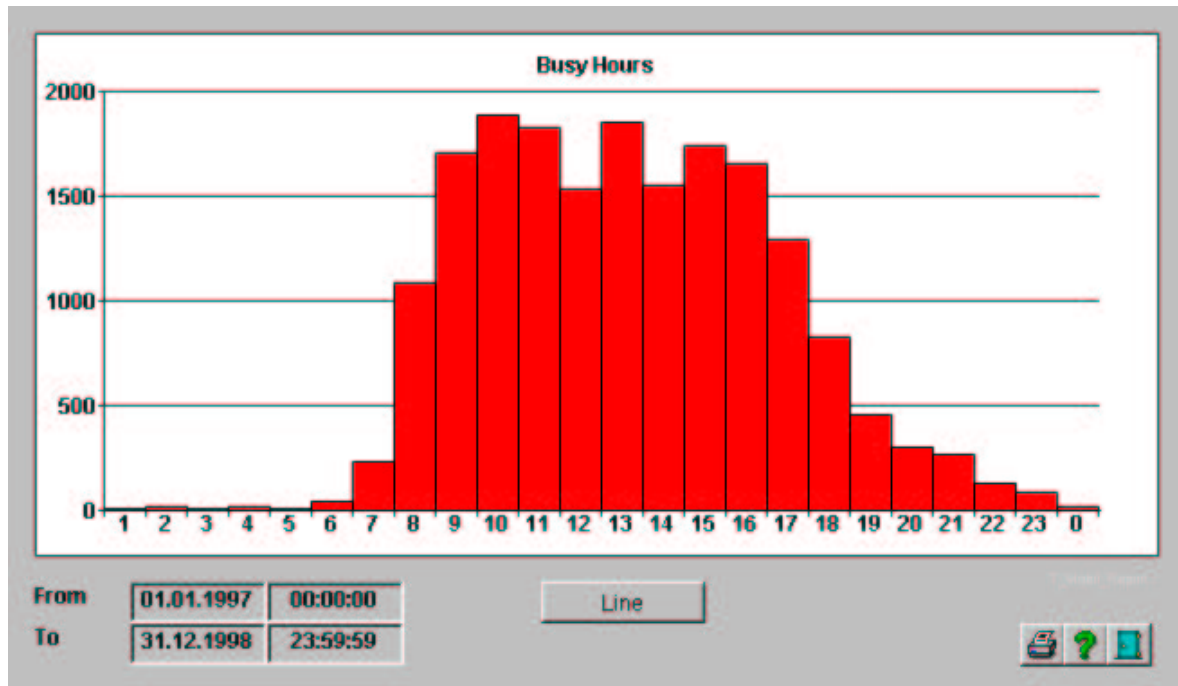


Fig. 2-3: Histogram on Busy Times

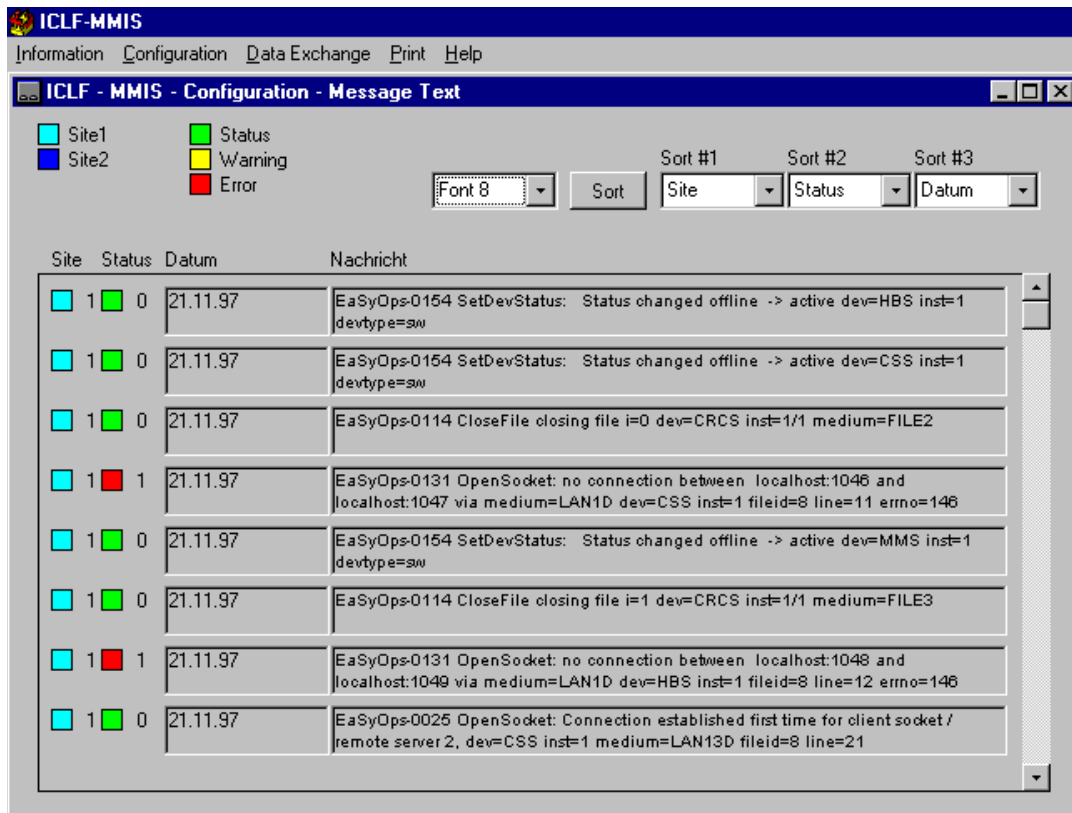


Fig. 2-4: Display of Status Messages

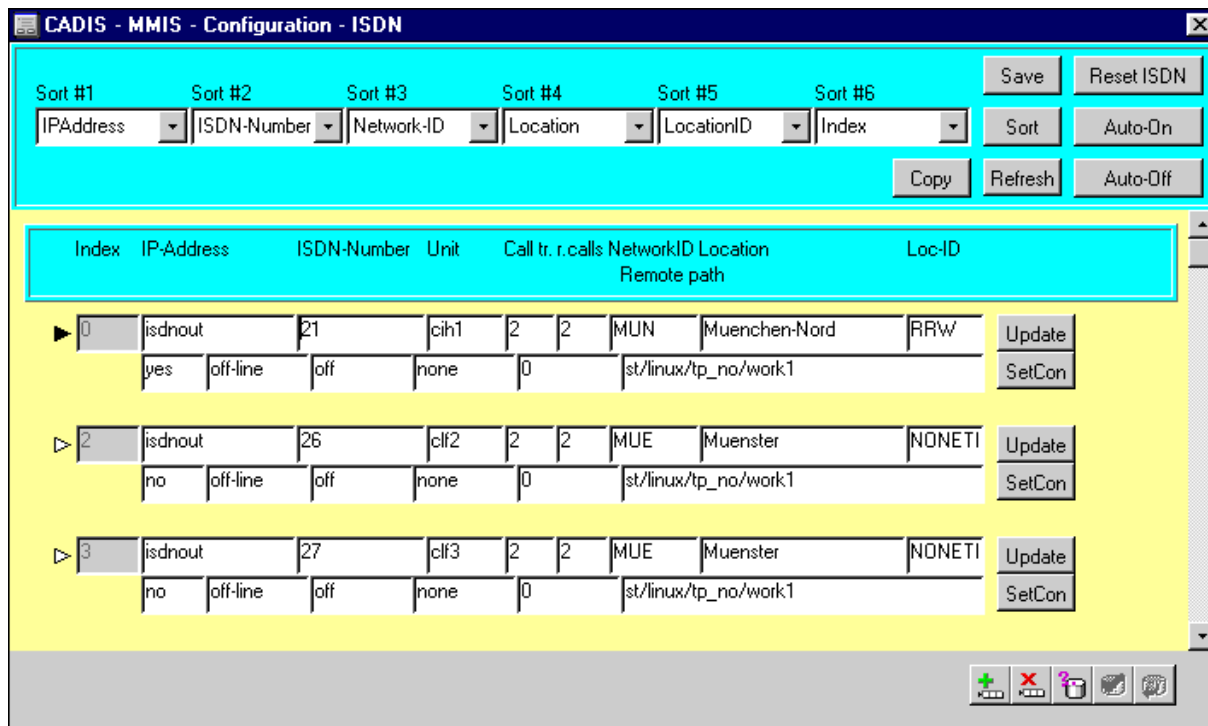
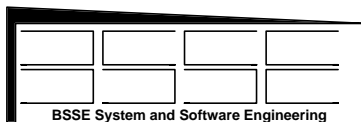


Fig. 2-5.1: ISDN Menue to Control Data Acquisition

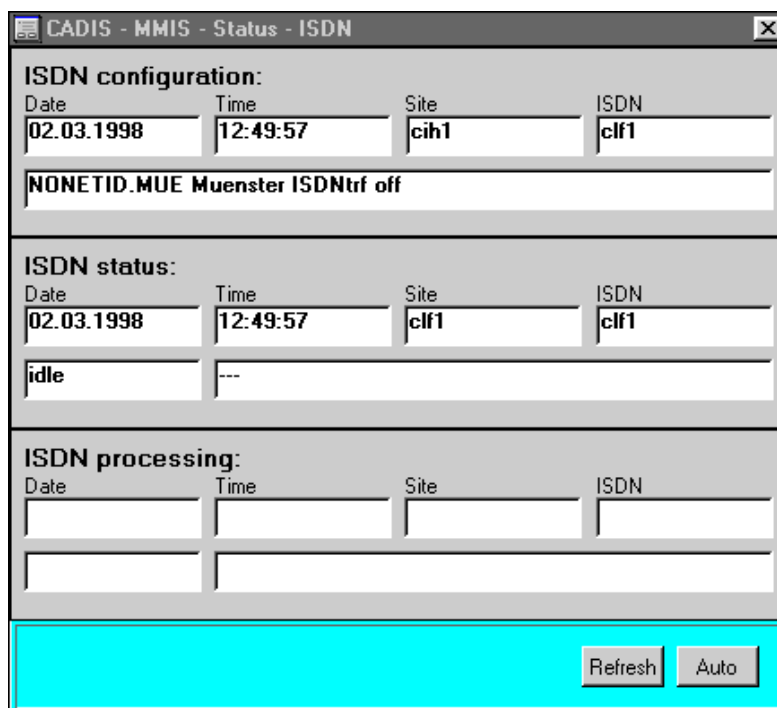


Fig. 2-5.2: ISDN Status Menue

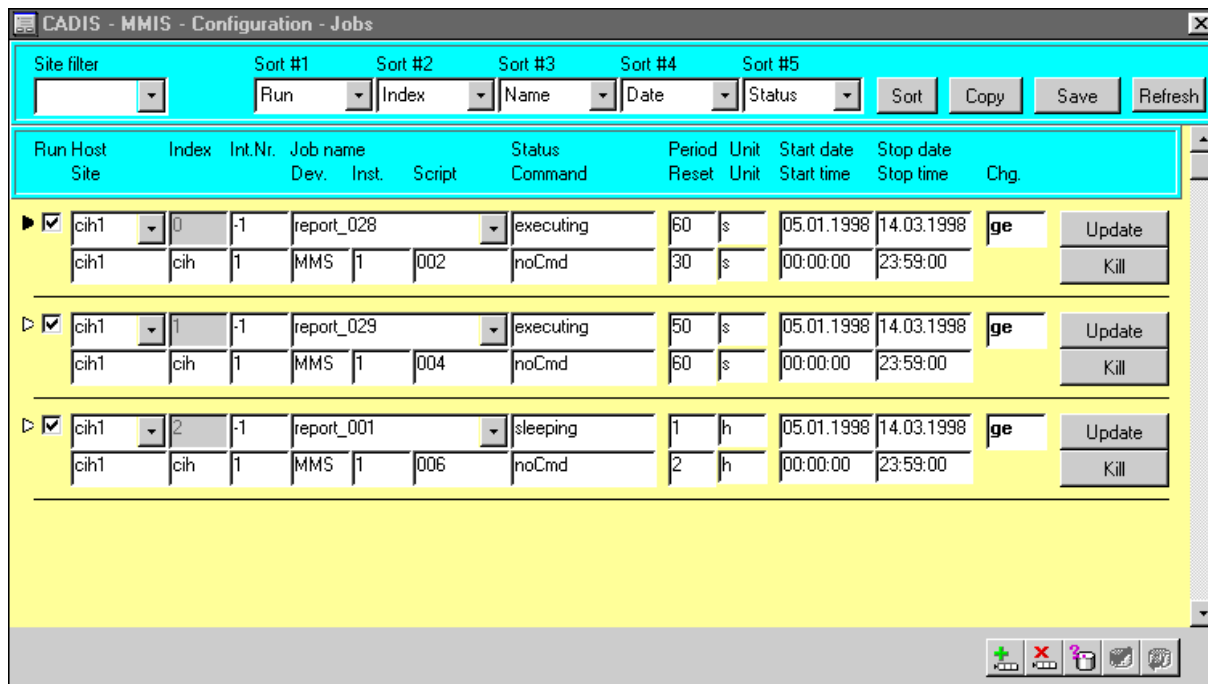


Fig. 2-6: Job Menu

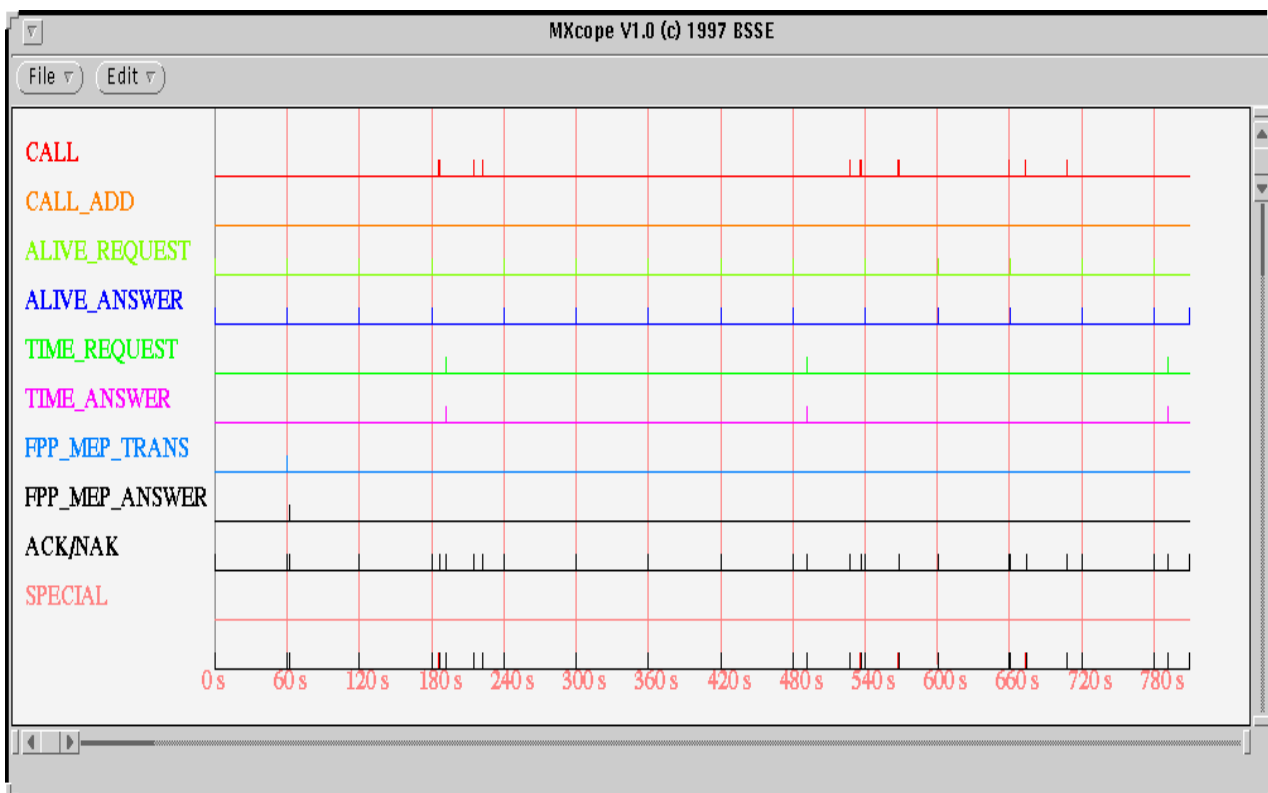
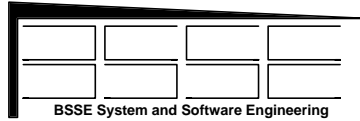


Fig. 2-8: Graphical Visualisation of Time-Stamped Frames: Frames vs. Time

When a user clicks on an event related to a certain frame a window opens and displays the formatted contents of the frame.



Frame	0	at relTime=0.000000 s	Length= 7	ALIVE ANSWER	
			f00003390601f1	DXD: FIRST WAKE UP	
Frame	1	at relTime=0.000359 s	Length= 1	ACK	f2
Frame	2	at relTime=0.019702 s	Length= 12	ALIVE REQUEST	
			f0320839060158020802	20f1	MX: FIRST WAKE UP
Frame	3	at relTime=0.079678 s	Length= 1	ACK	f2
Frame	4	at relTime=60.009783 s	Length= 12	ALIVE REQUEST	
			f0330839060258020802	20f1	MX: UPDATE PARAMS
Frame	5	at relTime=60.059727 s	Length= 1	ACK	f2
Frame	6	at relTime=60.059830 s	Length= 7	ALIVE ANSWER	
			f00103390602f1	DXD: PARAMS RECEIVED	
Frame	7	at relTime=60.089680 s	Length= 1	ACK	f2
Frame	8	at relTime=60.089773 s	Length= 73	FPPMEP TRANS	
			f034455e06020140ff33	34ffffffffffffffffffff	
			ffffffffffffffffffa0ff	ffffff55ffffffffffffff	
			ffffffffffffffffffffff	ffffffffffffffffffff34	
			ffffffffffffffffffffff	fffffl	
Frame	9	at relTime=60.289683 s	Length= 1	ACK	f2
Frame	10	at relTime=60.289778 s	Length= 73	FPPMEP TRANS	
			f035455e06020240ffff	ffffffffffffffffffffff	
			ffffffffffffffffffffff	ffffffffffffffffffffff	
			ffffffffffffffffffffff	ffffffffffffffffffffff	
			ffffffffffffffffffffff	fffffl	
Frame	11	at relTime=60.589680 s	Length= 1	ACK	f2
Frame	12	at relTime=62.579795 s	Length= 7	FPPMEP ANSWER	
			f002035f0601f1	DXD: OK	
Frame	13	at relTime=62.580021 s	Length= 1	ACK	f2
Frame	14	at relTime=120.175450 s	Length= 12	ALIVE REQUEST	
			f0360839060000000000	00f1	MX: NOT USED
Frame	15	at relTime=120.292433 s	Length= 1	ACK	f2
Frame	16	at relTime=120.292533 s	Length= 7	ALIVE ANSWER	
			f00303390600f1	DXD: NOT USED	
Frame	17	at relTime=120.292739 s	Length= 1	ACK	f2
Frame	18	at relTime=180.355192 s	Length= 12	ALIVE REQUEST	
			f0370839060000000000	00f1	MX: NOT USED
Frame	19	at relTime=180.386755 s	Length= 1	ACK	f2
Frame	20	at relTime=180.386854 s	Length= 7	ALIVE ANSWER	
			f00403390600f1	DXD: NOT USED	
Frame	21	at relTime=180.387114 s	Length= 1	ACK	f2
Frame	22	at relTime=186.579794 s	Length= 54	CALL	
			f0383202062020161640	98041719881e197eleff	
			ffffffffffff00000004	015f00015f00ffff0000	
			06001000000000000005	000320f1	
Frame	23	at relTime=186.729679 s	Length= 1	ACK	f2
Frame	24	at relTime=191.999783 s	Length= 13	TIME REQUEST	
			f0390960060100000000	0000f1	MX: CHECK TIME
Frame	25	at relTime=192.039680 s	Length= 1	ACK	f2
Frame	26	at relTime=192.039775 s	Length= 13	TIME ANSWER	
			f0050961060100000000	0000f1	DXD: TIME IS CHECKED
Frame	27	at relTime=192.069949 s	Length= 1	ACK	f2
Frame	28	at relTime=192.199757 s	Length= 13	TIME REQUEST	
			f03a0960060009171617	0498f1	MX: SET TIME
Frame	29	at relTime=192.239694 s	Length= 1	ACK	f2
Frame	30	at relTime=192.239791 s	Length= 13	TIME ANSWER	
			f0060961060009171617	0498f1	DXD: TIME IS SET
Frame	31	at relTime=192.269939 s	Length= 1	ACK	f2
Frame	104	at relTime=809.599861 s	Length= 7	ALIVE ANSWER	
			f01503390603f1	DXD:MANUAL DISCONNECTION	
Frame	105	at relTime=809.600715 s	Length= 1	ACK	f2
#F5=0 #ACK=53 #NAK=0 #CALL=9 #ADD=0 #AliveRQ=14 #AliveAnsw=15 #TimeRq=6 #TimeAnsw=6 #FPPTrans=2 #FPPAnsw=1					

Fig. 2-7: Textual Visualisation of Time-Stamped Frames

The following figure shows a histogram about "Busy Times": it gives the number of calls active at a certain quarter of an hour over 24 hours. By the lower part (as shown by Fig. 2-9) a user specifies the criteria on which the report shall be built: MX number (in case the database includes data from different MX), G records to be included (optionally), time period in terms of date and time, prefix and ident. If a criterion is specified the data are selected accordingly, if not all values of this criterion will be considered. For the time period a user may specify larger durations such as days (Monday, ..., Saturday, weekend), calendar weeks and months. This will speed up the search in the database.

Two types of reports are provided: type A counts all calls which are on-going, started or terminated within the respective quarter of an hour, type B only counts such calls which have been started.

The upper part of Fig. 2-9 shows a graphical representation of the report on "Busy Times" (for the textual representation please refer to Fig. 2-2.1). The legend for the quarters can be placed interactively at each of the four corners of the figure or may be switched off. Three modes may be selected for generation of the graphics: line, multi-bar and stacked bar. For Fig. 2-9 the "stacked bar" mode has been selected.

The figure shows the results of different acquisition runs up to 36,000 single and group call records (ratio 3:1) of which only the single call records for interface types 0-0 (mobile-mobile) are included.

A user may restrict the display of data to certain interface types by the button at the right lower corner. When pressed it shows all combinations of interface types which are included in the data and a user may select the desired combination from the menu.

For all following reports and corresponding charts the principal user operations are the same.

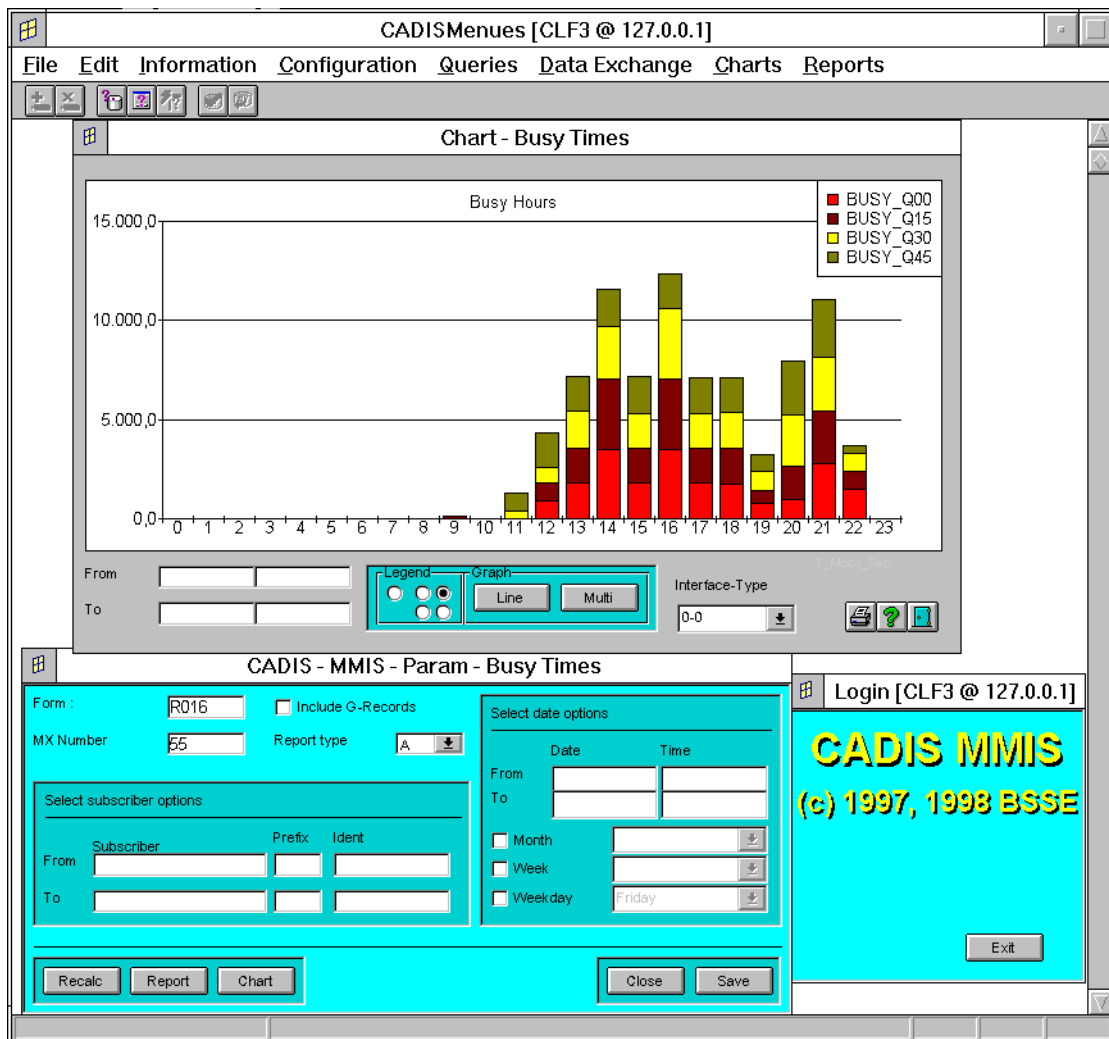


Fig. 2-9: Busy Times

Fig. 2-10 gives an overview on "Queuing Times" for all hours and quarters of a day over the specified time period. For Fig. 2-10 the "multi bar" mode has been selected for the histogram and the legend has been switched off. A user may select out of three different report types A, B and C (considering different combinations of A subscriber and B subscriber interface types) and may ask to include group calls or not. He also can specify explicitly which interface type shall be considered for the report.

In case of type A at least one subscriber number (subscriber A or B) belongs to the local or specified basestation/MX. Type C considers all basestations/MX and all other interface types. Type B is similar to type A, but allows to exclude/include certain interface types (see the menu in the left part of the select form).

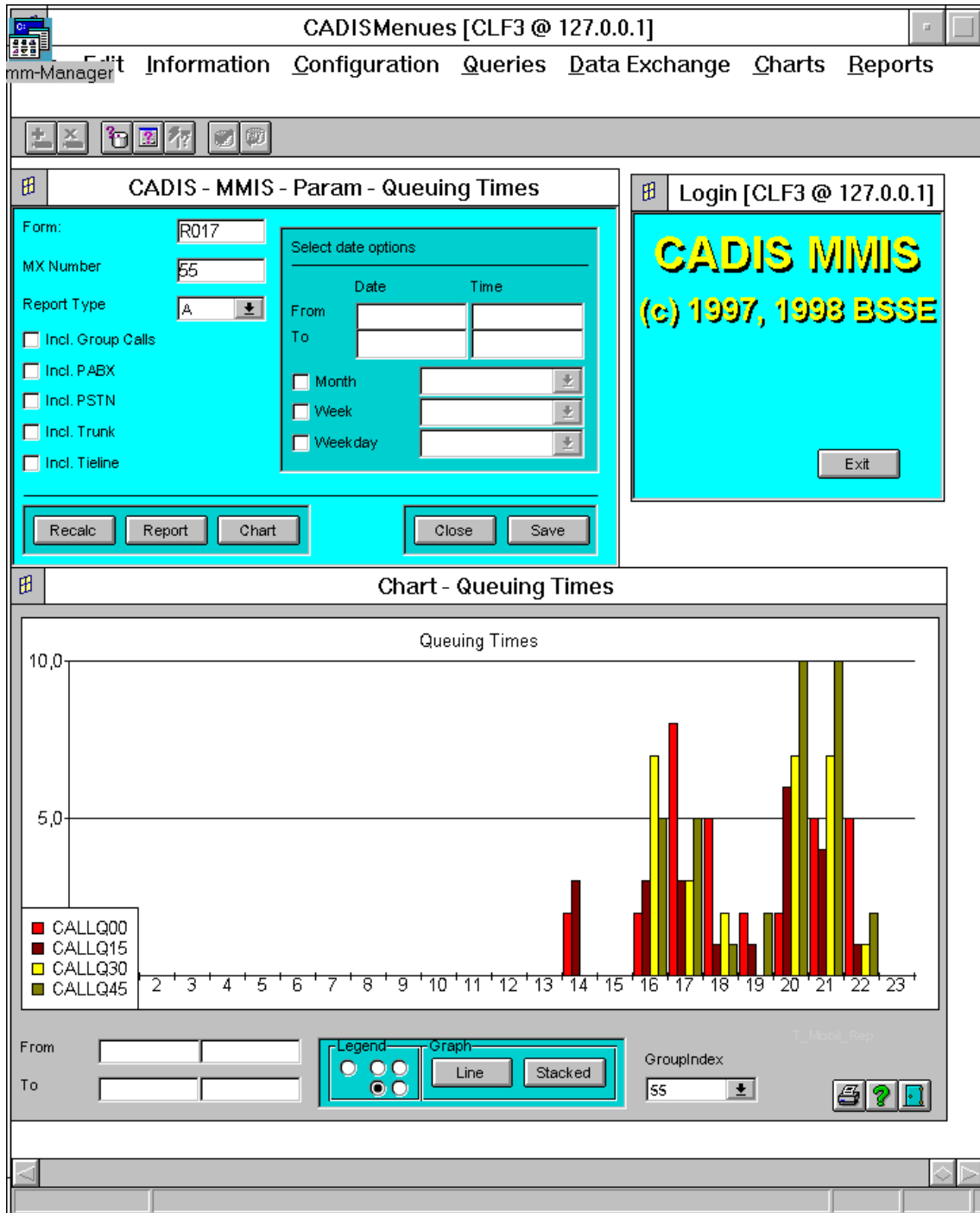


Fig. 2-10: Queuing Times

The following Fig. 2-11 shows the "Call Type Distribution". In addition to the usual criteria it allows to specify a criterion for fleets.

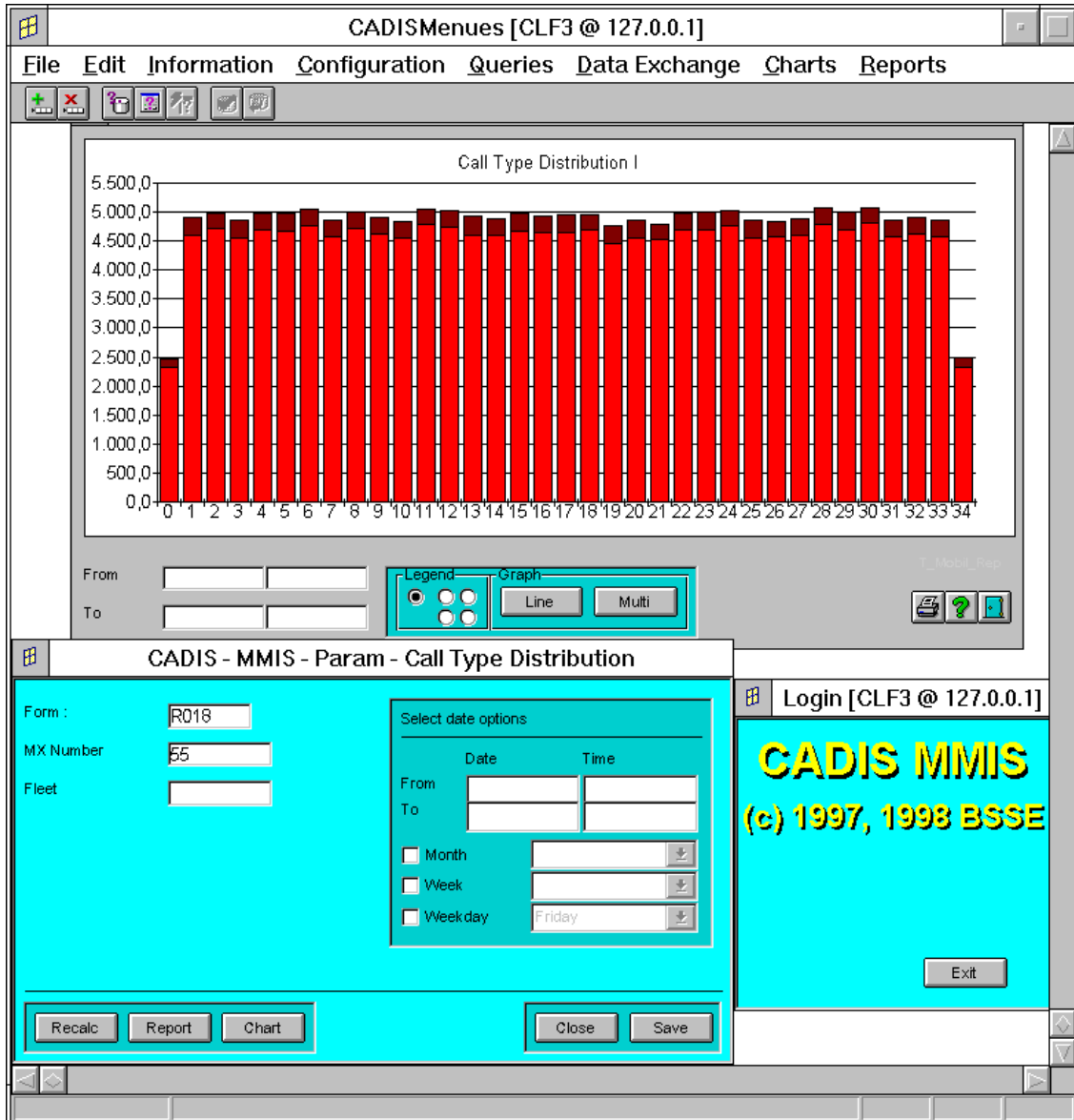


Fig. 2-11: Call Type Distribution

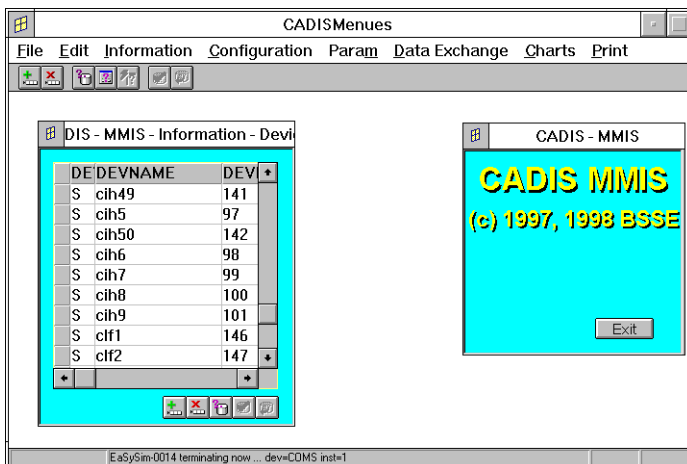


Fig. 2-12: Overview on Devices

Fig. 2-12 shows the menu which informs a user about the devices / processors and sites which are available in the network

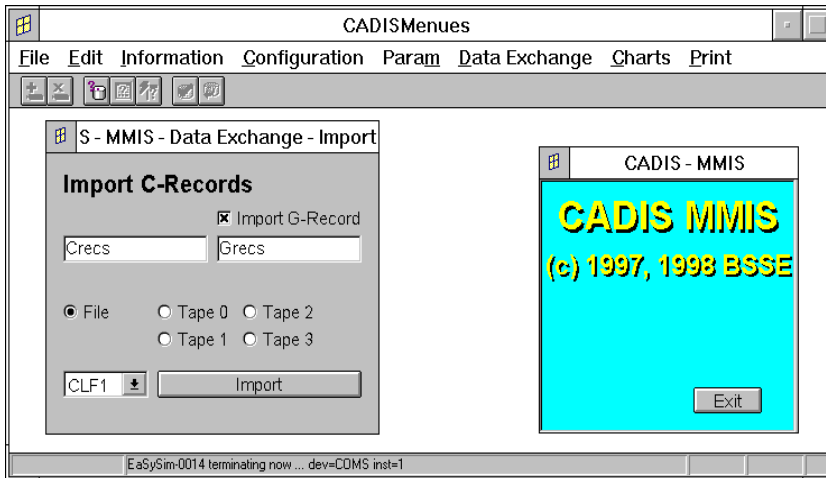


Fig. 2-13: Import of C Records

Fig. 2-13 gives the menu by which a user may import C records. Similar menus are available to import G records and to export C and G records. If G records are imported the corresponding C records must have been imported before.

A user may select the medium (file or tape drive X) from which the data shall be imported and the network device where the import shall take place.

It is even possible to initiate a transfer between two different processors from a third processor within the LAN/WAN network.

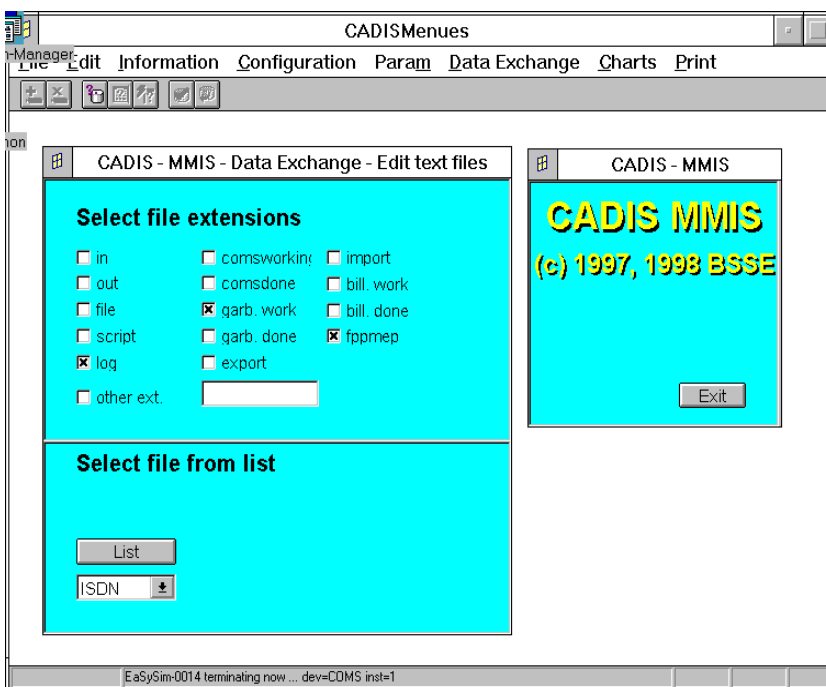


Fig. 2-14: Listing and Accessing Files Network-Wide

A user has full access to all resources available within the LAN/WAN network. Fig. 2-14 shows how files can be accessed. First, a user can select a certain file type which fixes the extension and the directory, or he can type in an arbitrary directory and name pattern (without '*' because the '*' will be added automatically). When pressing the LIST button he will get a file list for the desired pattern. Then he can select the desired file out of this list by a mouse-click.

The processor in the network on which the file is searched for is selected by a menu: it may be either one of the local processors (up to three) of a site or a processor which is accessible by the current ISDN/WAN connection.

The following Fig 2-15 shows by a "stacked bar" representation the distribution of call durations. There are six predefined duration classes. By the menu for specification of the filtering options (appearing at the lower part of the figure) a user can select data out of the database according to the specified criteria.

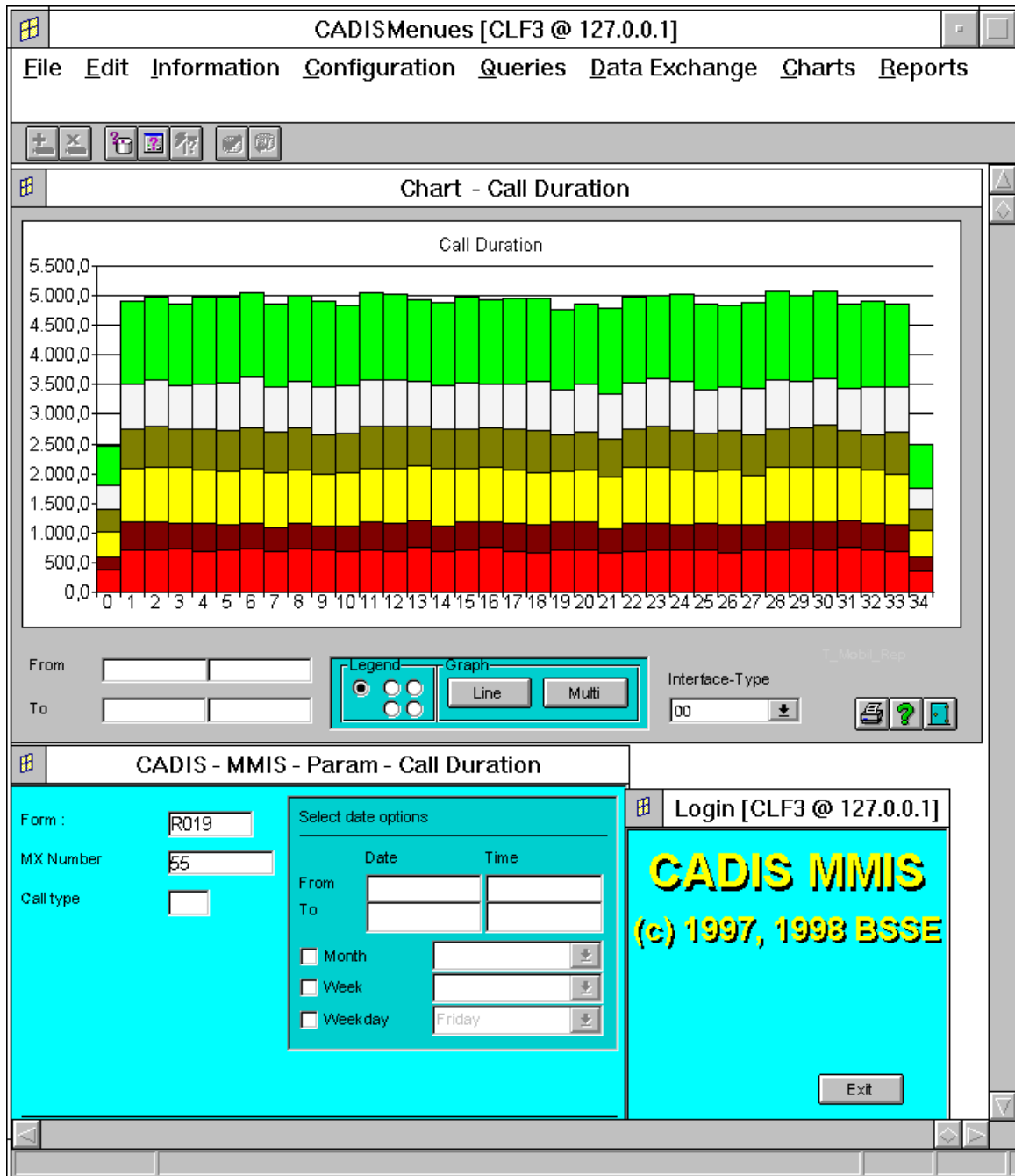


Fig. 2-15: Call Duration

Information about the health status of CADIS components and the utilisation of CADIS internal buffers is shown by Fig. 2-16. In the upper left part the status of all the local components (up to three per site) are shown. In case of a single processor system the second component is always disabled - as shown here. The third component is the one which displays the menus. It may run on a separate processor (the third processor in case of a fault-tolerant processor set) for performance reasons or on the same processor. So as far as this menu is displayed this piece of software is always active and therefore the status is defined as "AUTO". The text of these system states are entries in a file and may be changed by a user, if desired.

The upper right part informs about the status of the CADIS daemons. Depending on the desired configuration such daemons complement the functionality of the CADIS kernel. The command daemon

accepts commands from file and forwards them into the CADIS kernel, the hardware daemon monitors the hardware and manages the time, and the RS232 daemon acquires data from the RS232 serial data line(s).

The next lower part shows the states of the LAN connections, the redundant partner processor (in case of a fault-tolerant system) and the command input window. An "External Activity", e.g. delivery of billing data to a billing system, may be enabled or disabled. In case of a fault-tolerant system only the active component delivers such data, the redundant component must not deliver data. The permission to execute such an activity is shown by the "Ext. Activity" field and relates to the processor on which this menu is displayed.

CADIS has a number of internal buffers of which the utilisation is given by a pair of numbers and the length of bars. The status of these buffers is displayed at the lower part and on the next menu page (not shown here). A full set is displayed for each of the two redundant processors. The actual set is selected by the "site" sub-menu. The left number and the blue bar gives the actual utilisation of a buffer, the right number and the orange bar the maximum utilisation. Red colour means "no data available", e.g. in this case the hardware daemon is disabled and does not deliver data.

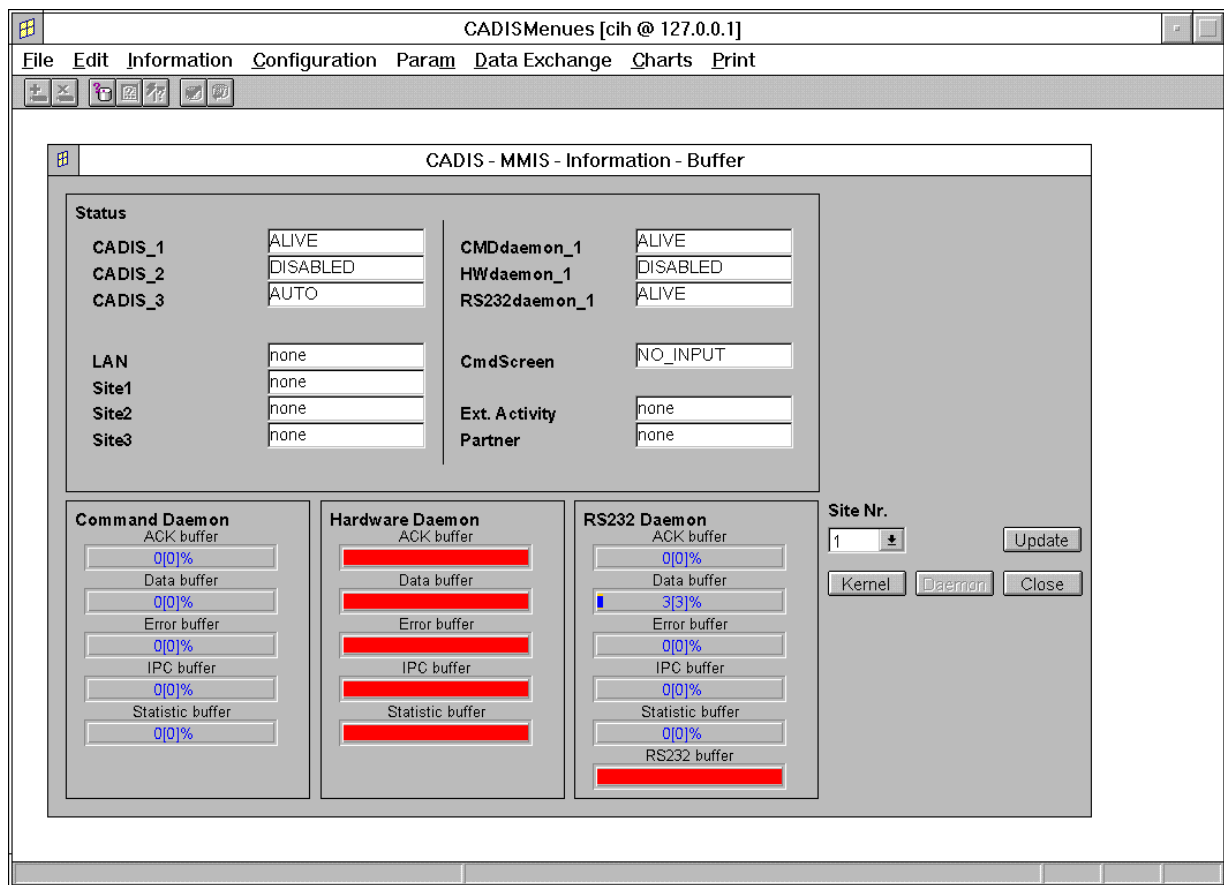


Fig. 2-16: Health and Resource Monitoring