OUTLINE OF THE FRENCH METEOROLOGICAL OPERATIONAL SYSTEM

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1) THE GENERAL COMPUTER CONFIGURATION

1.1 Transmission system

In the Global Transmission System , Paris is a Regional Transmission Center , and consequently , has national and international responsibilities. In order to assume this role , the Central Meteorological Service is endowed with a Transmission system called COMETE , the achitecture of which is shown in figure 1.

1.1.1) Description of the COMETE system and evolution

The COMETE system is distributed on 3 MITRA 225, mini-computers respectively dedicated to the management of the alphanumeric links (computer C3), of the facsimile links (computer C2) and to the bulletins management and their supervision (computer C1).

The elementary information received on COMETE is the bulletin (set of identical messages).

Bulletins containing syntactic errors are sent for supervision.Thus, operators can perform manual corrections on alphanumeric terminals.

After syntax correction bulletins are stored in a Data Base, containing the information for the last 18 hours (it represents a volume of about 26 million bytes).The correct bulletins are then queued and sent to recipients listed in a directory. Among the recipients there are in particular:

- a server-computer managing an Aeronautic Data Base, available, for consultation in real time, from French meteorological stations, airlines or users linked to the Aeronautic Fixed Telecommunication Network.
- the meteorological pre and post-processing computer (Cyber 835)

The main alphanumeric links also connect COMETE to World Weather Watch correspondents and to French Regional Meteorological Services.The facsimile

links connect COMETE to the Cyber 835 computer and to French Regional Meteorological Services receiving the products elaborated on the Cyber 835.

In order to ensure a sufficient reliability to COMETE, each MITRA is backed up by a second one.

Because of the saturation of the current COMETE system and increasing needs, the analysis of a new transmission system called TRANSMET is in progress.

1.1.2) The current transmission network

The current network (figure 2) connects the six French Regional Meteorological Services to the Central Service in Paris.Each Regional Service is itself connected to the other Meteorological stations of the same region by multipoint links.This kind of network presents several drawbacks:

. It requires heavy bulletin management by COMETE system (COMETE having to transmit information as many times as there are multipoints)

. All the stations linked to the same multipoint receive the same information even if they do not have the same needs.

. Link rate is low from the multipoints.

. The network uses specialised (and rather expensive) links leased from the PTT (French Post and Telecommunication Service).

But these disadvantages should soon be suppressed as a new transmission network called RETIM (Meteorological Teleinformatique Network) is to be introduced.

1.1.3) The future RETIM network

This network will use the joint services of the national transmission network TRANSPAC and the satellite TELECOM1.The figure 3 shows the progress of the meteorological information through this network :

- the data concentration in the Central Service in Paris : each meteorological station sends its messages directly to the Central Service through the TRANSPAC network.

- the dissemination from Paris : the Central Service disseminates its products and bulletins to the meteorological stations through the TELECOM1 satellite. Each recipient station is equipped with a receiving aerial connected to a selector on which are programmed the wanted products.

The six specialised links connecting the Central Service in Paris with the six Regional Services will remain for extra needs (like contrentation of radar observations).

The independence of each station will overcome most of the current drawbacks.

1.2 The meteorological processing computer CDC

1.2.1) General configuration and evolution

The figure 4 shows a simplified configuration of the meteorological computer center, which is at the moment equipped with two CDC computers:

- a Cyber 835 : dedicated to operational processing and thus used and supervised 24 hours a day
- a Cyber 175 : dedicated to development jobs, climatology, remote batch processing, all jobs having lower priority.

The characteristics of these computers are given below for comparison:

	Cyber 175	Cyber 835	Cyber 860
Central Memory Size (in K words)	256	1024	2000/4000
Word size (in bits)	60	64 (60 used)	64
Internal Code	DISPLAY	DISPLAY	ASCII
CPU (in Mips)	8	3	8
Disk volume (in G bytes)	9,6	1,8	

The two computers run the same operating system and communicate through two shared disks (which represents 1,2 giga bytes).

In case of extended failure on the operating computer, it is possible to run the operational processing on the Cyber 175, at the expense of other users.

Within six months the Cyber 175 and 835 will be replaced by two Cyber 860 (whose characteristics are described above).

1.2.2) Links between CDC computers and the outside

As shown on figure 4 Cyber 835 main links are the following:

. with the COMETE transmission system : in order to receive bulletins and to send out elaborated products

. with the CRAY-2 computer which is described below : in order to run the forecast models

Cyber 175 main links are with the CRAY-2 computer (to allow users to develop applications) and with ECMWF.

Each Cyber is moreover connected to some peripheral equipment (such as Versatec plotters, output tables, alphanumeric or remote batch terminals ...).

1.3 The CRAY-2 computer

1.3.1) Presentation of the users group

The French forecast models run on a CRAY-2 shared between the French Meteorological Office and other scientific partners, most involved in research activities.French Meteorology uses 25 percent of the computer time.
To satisfy the special constraints (reliability, respect of schedule) imposed by meteorological needs, the operational models have a higher priority during their running on the CRAY-2.

1.3.2) Characteristics and configuration

The CRAY-2 is a vector multiprocessor computer running an operating system based on the UNIX operating system (UNICOS).Figure 5 describes its general configuration.

Central Memory Size (in million words)	256
Word Size (in bits)	64
Internal Code	ASCII
Number of processors	4
Clock Period (nano seconds)	4 for vector calculation, 8 otherwise
Number of connected front-end computers	20

2) METEOROLOGICAL DATA PRE-PROCESSING ON THE CDC

2.1 The monitor

An important aim of the Meteorological Service is to elaborate forecasts and to provide internal and external users with data, either in raw form (as observational data) or in elaborate form (such as forecast results). Such jobs have to run generally in a repetitive way and in similar conditions.Morever the number of such tasks is very large (about 500 per day) and is increasing regularly.So it was necessary to computarize their management and a "monitor" was developed to assure automatically this function.It offers the following possibilities:

- conditional execution of jobs: at stated times, on request of another job , on quantifiable resources (for example when there is a given number of files available) or by manual action of the operator.
- periodical repetition of a job or a group of jobs

- communication between jobs: two tasks can communicate by sending files or messages to each other. In this case, the monitor plays the role of a "postman".

The program of the monitor consists of a set of routines continuously in the calculator. Regularly it consults tables describing the launching conditions as well as the internal watch of the computer, tests if some conditions are realized and starts the corresponding tasks.

There are two main sorts of tasks managed by the monitor:

- the tasks always in the computer, and generally having a high priority, like: the tasks managing the communication with the COMETE system, or the tasks of data pre-processing ...
- the tasks running punctually, at given times, like: making graphical products, or preparing the observational data used later by the analysis, ...

2.2 The data pre-processor

The transmission system, COMETE, dispatches permanently new available bulletins to the Cyber 835. On that computer, data contained in the bulletins will be used by numerous tasks. Therefore they are to be put in an accessible way available for all tasks.The program called "pre-processor" performs that role. It is composed of two processing levels:

- a main program executing the processing, common to all kinds of bulletins
- a set of subroutines (one per kind of bulletin), dynamically loaded when necessary, and achieving, for each message of a bulletin: the decoding, the meteorological quality control and the storage into a data base called Meteorological Data Base (BDM).

The "pre-processor" is always in the computer. It becomes active as soon as a bulletin arrives. When it detects an anomaly in the coding or in the meteorological content of a message, instead of storing it into the BDM, it sends the non valid message (put into a bulletin) for supervision.Thus an operator can manually correct the rejected bulletins from an alphanumeric terminal. The corrected bulletins are then sent back to the "pre-processor".

2.3 Description of the Meteorological Data Base (BDM)

From a logical point of view the BDM is structured as follows:

- the information is divided into groups, each group containing 12 successive hours data (from 9 UTC until 21 UTC, and from 21 UTC until 9 UTC)

- each set of 12 hours data is shared into 2 parts: located and unlocated data
- in each of these two last parts the data are classified according to geographical zones. The size of each geographical zone depends on the density of data available in that time interval.

Physically the BDM is a set of six files, each file being concerned with data observed during a 12 hours interval.
The logical and physical structures of the BDM are unknown by the using tasks. Indeed, the tasks access the data through interfaces executed by a subsystem managing the Data Base.

The current implementation of the BDM provides ON-LINE access to the 3 latest days data (which represents a volume of about 65 millions bytes). The previous data have been archived on tapes for two years.

2.4 Observatinal data extraction for analysis

The logical description of the BDM implies that the access by geographical domain is more efficient than any other one. This is precisely the type of access performed by the tasks preparing the observational data for the analysis. The logical structure of the BDM was in fact chosen in order to optimize these extraction tasks.
Indeed, as it will be described below, the analysis models start about 3 hours after the initial conditions time. Thus the preparing tasks are to run as quickly as possible in order not to delay the start of the models.

Practically there is one extraction task per analysis type. Its role consists in extracting data from the BDM, putting them under a succinct check and storing them in a format suitable for the analysis. If "T" is the time of analysis initial conditions, this task extracts surface data observed at T+-30 minutes and upper air data available at T+-3 hours.
Currently the minimal cut-off to run an hemispheric model is stated 2 hours and 45 minutes after the initial conditions time. The begining of each analysis and forecast on the CRAY-2 is involved by the end of the corresponding extraction task.

3) THE OPERATIONAL SUITES RUNNING ON THE CRAY

3.1) Models features

The analysis-forecast system used operationally in France comprises two main models. Each one performs a data assimilation and a forecast :

- An hemispheric large scale analysis and forecasting system : EMERAUDE

-A fine mesh model on a limited area : PERIDOT

The different specifications of the two models are the folowing :

	EMERAUDE	PERIDOT
Integration domain	Northern hemisphere (soon global)	Polar stereographic projection domain covering France
spatial discretisation method	spectral	grid points
levels	15 (hybrid)	15 (sigma)
mesh	Lat-Long	35 km on the latitude of France
time integration	20 mn	4 mn
data assimilation cycle	6 hours	12 hours
maximum range of forecast : from 00 UTC data from 12 UTC data	 72 hours 48 hours	 36 hours (soon 60) 12 hours (soon 48)
post processing frequency	every 6 hours every 12 hours from 48 UTC to 72 UTC	every 3 hours

The hemispheric model results are used by PERIDOT for boundary conditions.

Planned change : EMERAUDE will soon be a global model and the maximum range of PERIDOT will be 60 hours on 00 UTC data and 48 hours on 12 UTC data.

3.2) General outlook of the suites

The operational suite consists of :

- the data assimilation cycle for EMERAUDE
- the operational suite on 00 UTC data
- the operational suite on 12 UTC data.

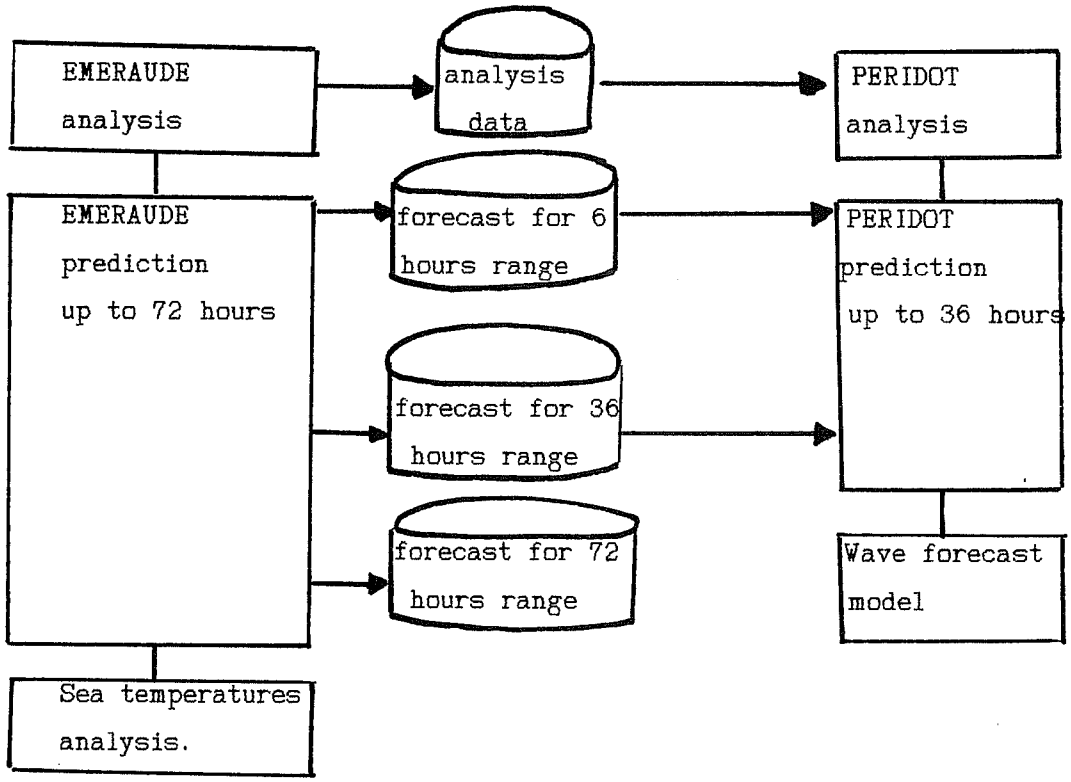
3.2.1) The data assimilation cycle for EMERAUDE

It consists of four cycles of successive analyses and six hours forecasts. The analyses are respectively made on 0, 6, 12 and 18 UTC data from the day before. These forecasts provide a guess for the following analyses. So, at the end of these cycles, the operational 00 UTC analysis guess is ready.

3.2.2) The operational suite on the 0 UTC data

The two systems EMERAUDE and PERIDOT are started up simultaneously and run at the same time.

The maximum range of forecast is 72 hours for EMERAUDE and 36 hours for PERIDOT (this maximal range will soon go up to 60 hours).



As PERIDOT needs EMERAUDE results for its boundary conditions, a synchronisation mechanism had to be set up : PERIDOT must wait the completion of an analysis or forecast file produced by EMERAUDE.

Some other models run after EMERAUDE and PERIDOT : a sea surface temperature analysis used by EMERAUDE analysis the next morning and a wave forecast model using EMERAUDE predicted surface winds.

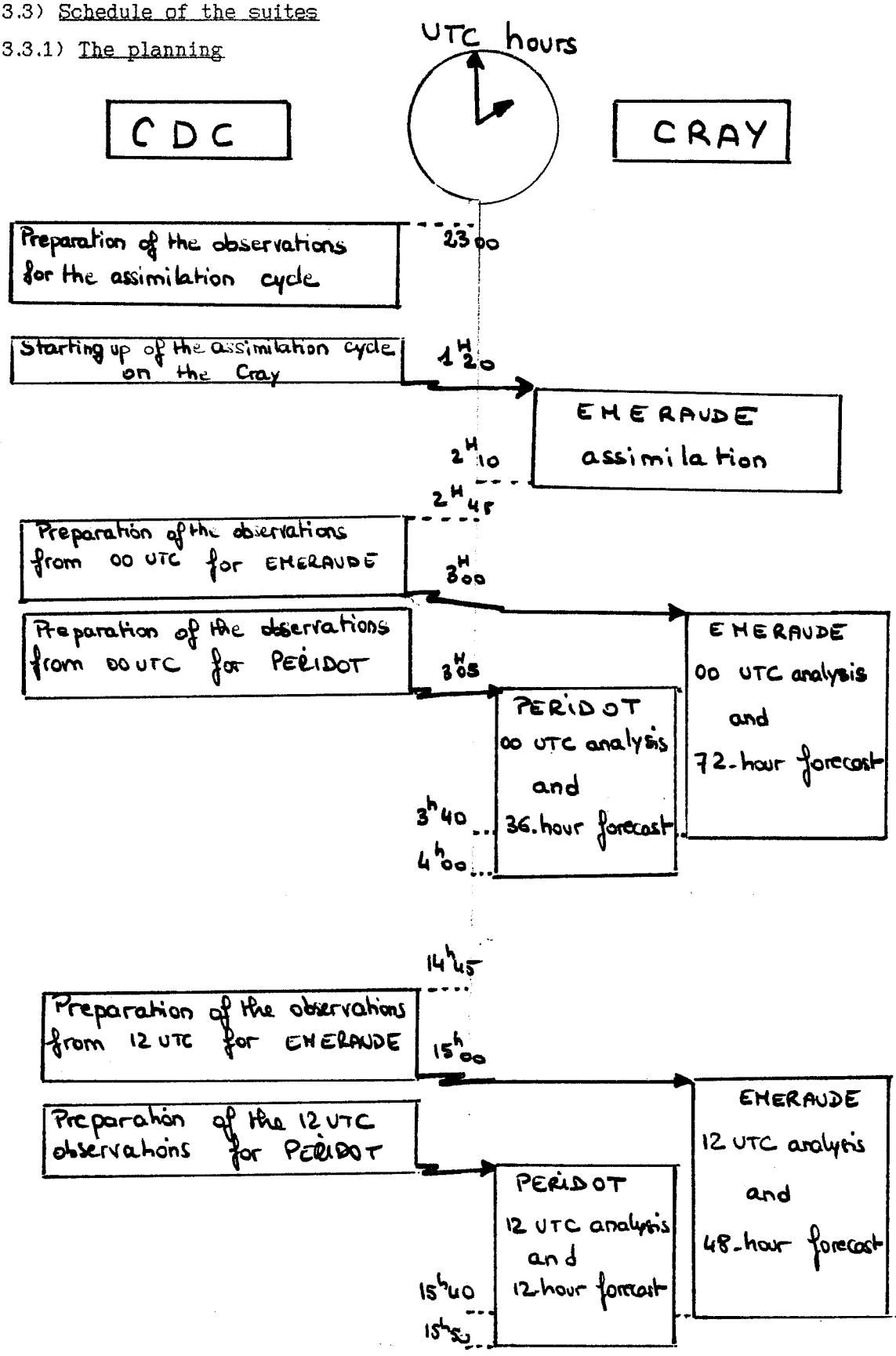
3.2.3) The operational suite on the 12 UTC data

EMERAUDE and PERIDOT analyses use observed 12 UTC data and a 12 hour forecast guess from the morning operational suite.

The maximal range of forecast is 48 hours for EMERAUDE. At the moment, PERIDOT from the operational suite only makes 12 hour forecasts which provide a guess for the PERIDOT next night analysis. But this range will soon be extended to 48 hours in order to supply charts to forecasters.

3.3) Schedule of the suites

3.3.1) The planning



3.3.2) Constraints due to sharing the CRAY2

The EMERAUDE assimilation cycle runs at 1h20 UTC. Why does the assimilation have to run so late whereas the usefull data are available since 22h UTC ? This constraint is due to the CRAY sharing with other users : the running hours of the meteorological operational jobs have been chosen to minimize the inconveniences for other users. The best compromise solution was to run the operational jobs in a single slot. That is why a locking mechanism had to be set up to avoid a possible overlapping between the assimilation cycle and the operational suite. Consequently, the start of the morning operational suite depends also on the end of the assimilation cycle and can sometimes cause delays in the availability of the results.

The length of the assimilation and of the operational 00 UTC suite is usually steady. However, due to the more important overload of the CRAY, significiant delays can be experienced in the afternoon. This problem is currently under further investigation.

3.4) Transfers of results towards the CDC

The post-processing is performed on the CDC 835. That is why it is necessary to send analysis and forecast results as soon as they are available. The frequency for the post producing history files is :

- for EMERAUDE : every six hours for forecasts from 0 to 48 H, every twelve hours for forecasts from 48 to 72 H.
- for PERIDOT : every three hours.

The transfer of results is made by a task running simultaneously with the models in order not to delay them. This task sends to the CDC the files produced on the CRAY as soon as they are available.

4)POSTPROCESSING ON THE CDC

4.1) The analysed and forecast data base : BDAP

The results sent "on line" from the CRAY feed a data base (called BDAP) on the CDC. The BDAP is a set of files ; each one contains the results for each model (EMERAUDE or PERIDOT) and from the 0 UTC and 12 UTC initial conditions

- either of analyses
- or for forecasts for a given range

The number of days stored depends on the range. Besides, a special file is used as a repertory to describe the contents of the BDAP.

The jobs using results stored in the BDAP access these data through basic programs making the physical organisation of the data base transparent for users.

The volume of this data base is about 230 M characters.

4.2)Feeding the BDAP

As soon as some results are transmitted from the CRAY to the CDC a special task is launched on the CDC. This task has to feed the data base with the last results. It lasts about 1mn30 for EMERAUDE results and starts every four minutes (average time between the availability of two EMERAUDE results).

A data link problem between the CRAY and the CDC or an overloading on the CDC can provoke an accumulation of the feeding data base tasks. To prevent them from running at a random order a synchronisation between jobs has been set up.

In practice, these tasks can only run in chronological order of ranges.

4.3) The graphical products

4.3.1) general points

The results are stored in the BDAP if the forecast range is a multiple of 6 hours for EMERAUDE and 3 hours for PERIDOT. However, charts are produced only for the most significant ranges.

When the BDAP feeding tasks for these ranges are completed they initiate, through the monitor, a job which makes the graphical products. It lasts, on average, between 1 hour and 1 hour 30 to obtain all the charts for a given range. But we have seen that the BDAP feeding jobs were started every 3 minutes for EMERAUDE and simultaneously every 5 minutes for PERIDOT. Therefore, without supervision, many jobs which are making charts could run at the same time and overload the computer.

In order to obtain reasonable delays for the availability of charts a priority order has to be set.

4.3.2) Other information

About one hundred and fifty charts are available for the forecasts (made by the two models) based on 0 UTC data.About half of them are for the SCEM and the others are sent to local weather centers by fac simile.

The charts used by the central service (SCEM) are printed out on a Versatec.

4.4) Other jobs reading in the BDAP.

The BDAP contents are not only used to produce charts : other products have been developed :

- to supply results to outside organisations.
- to provide GRID messages sent on the international network.
- to make statistics and to check the forecasts' validity.

4.5) Back up products in case of failure.

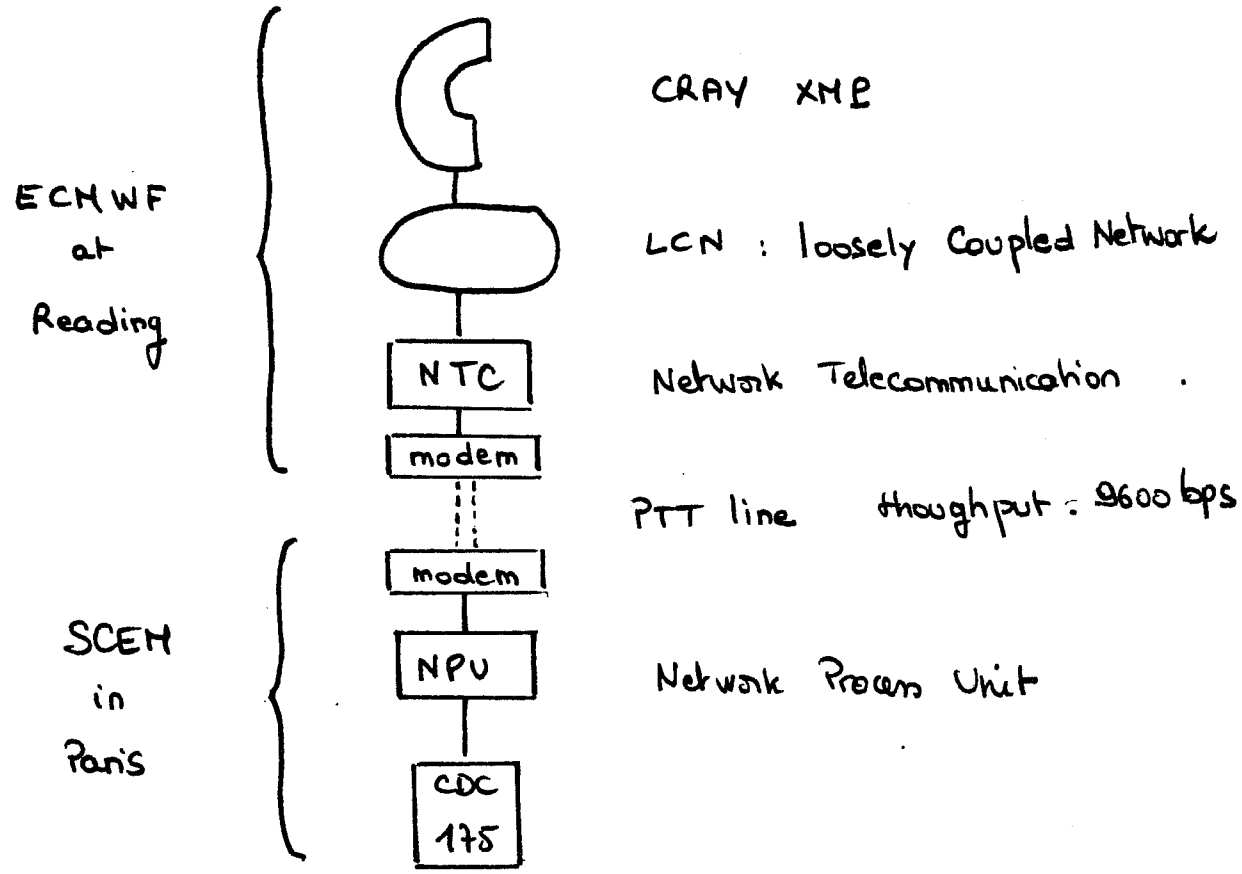
When the results are not available, Bracknell forecasts, received as GRID messages, are used as back ups.

There are less charts and these are only provided for ranges under 48 hours.

The ECMWF results are also available and used every day, up to 156 hours forecast range.

5) USE OF ECMWF RESULTS.

5.1) Link between ECMWF and the SCEM.



This link has two different uses :

- to transfer ECMWF results from Reading to the SCEM in order to be processed.

- to submit jobs to the CRAY XMP. These jobs are research and development ones.

As this second use is the more common one, the link has been switched on to the development computer (CDC 175).

5.2) The results processing.

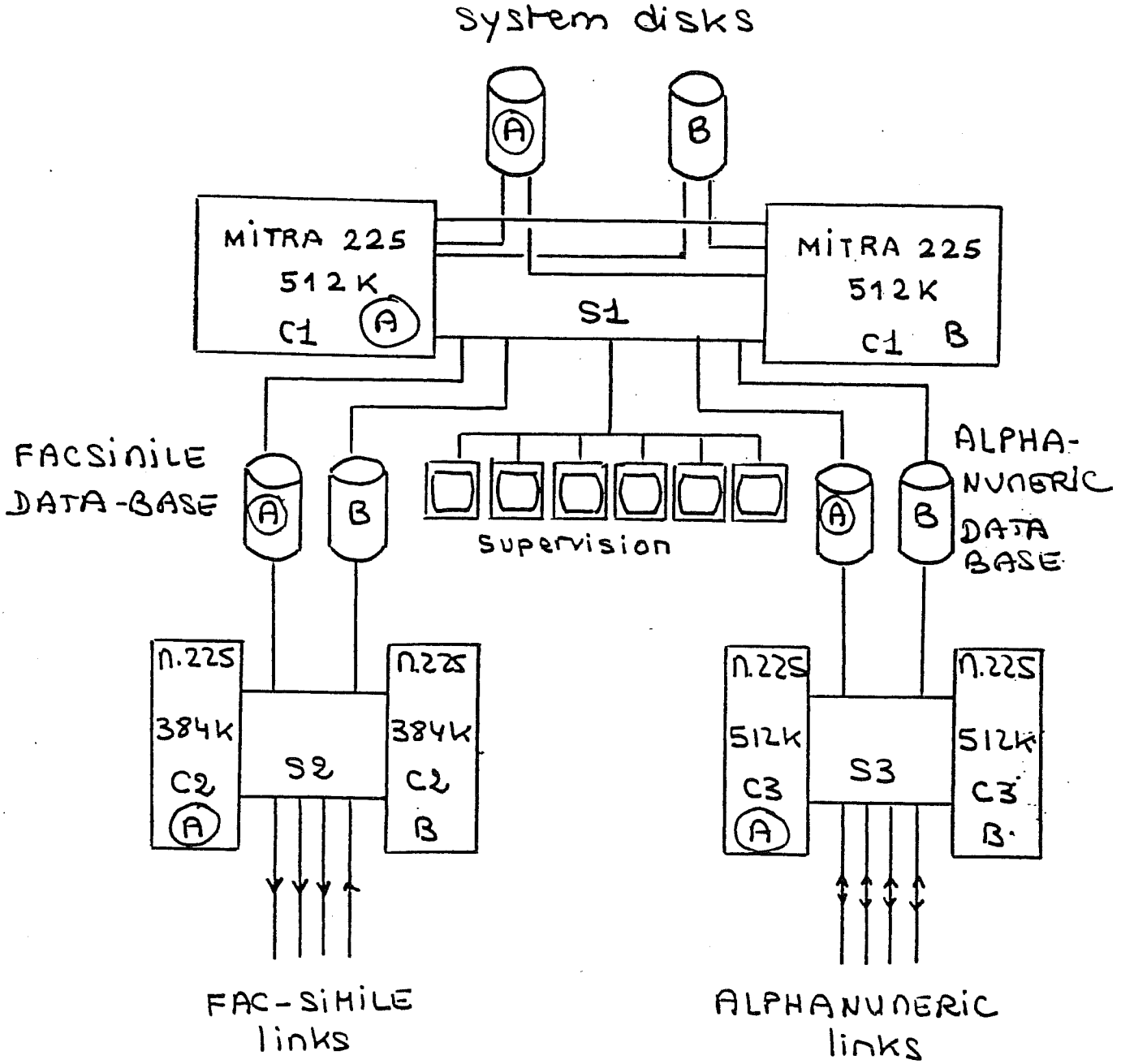
Every night, from 23 UTC to 2 UTC ECMWF results files are received (one per forecast step) on the Cyber 175. On this computer, an application which handles the telecommunication, enables the storage of these files on a shared disk.

The post processing of these files is an operational job and therefore has to run on the CDC 835.

On this computer, a task starts at specific hours (0H30, 1H40, 2H15, 7H30 UTC). For each file coming from ECMWF this job has to :

- restructure its contents.
- store the results in a file which gathers all the fields for all ranges.
- launch for the last range taken into account, a task which will produce the graphical output.

About fifty charts are produced every day with ECMWF results.Thirty of them are for the SCEM and about twenty of them sent to local weather centers.



Ⓐ = opérational configuration

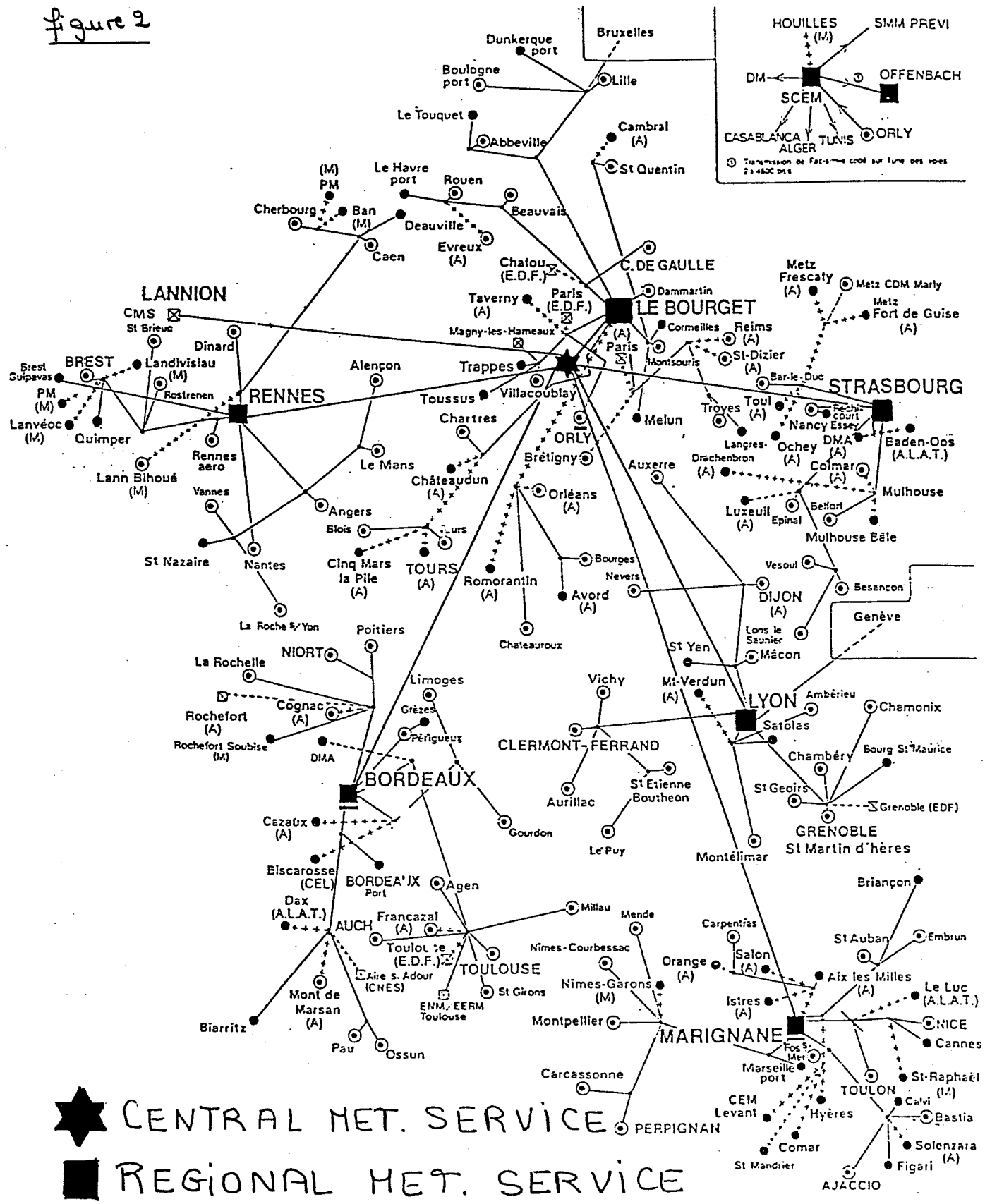
B = back up configuration

S1, S2, S3 = Switches

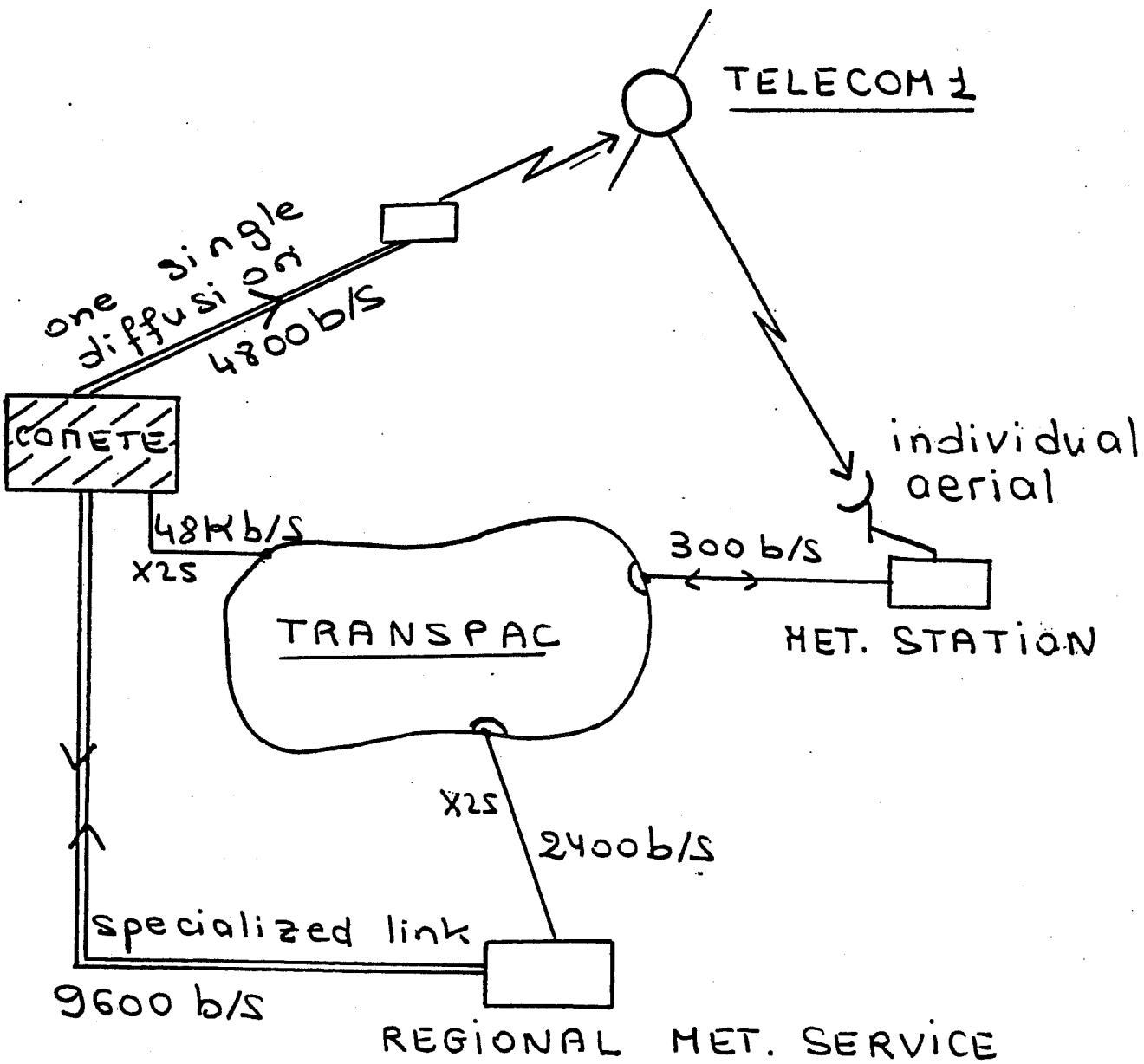
COMETE CONFIGURATION : figure 1

CURRENT TRANSMISSION NETWORK

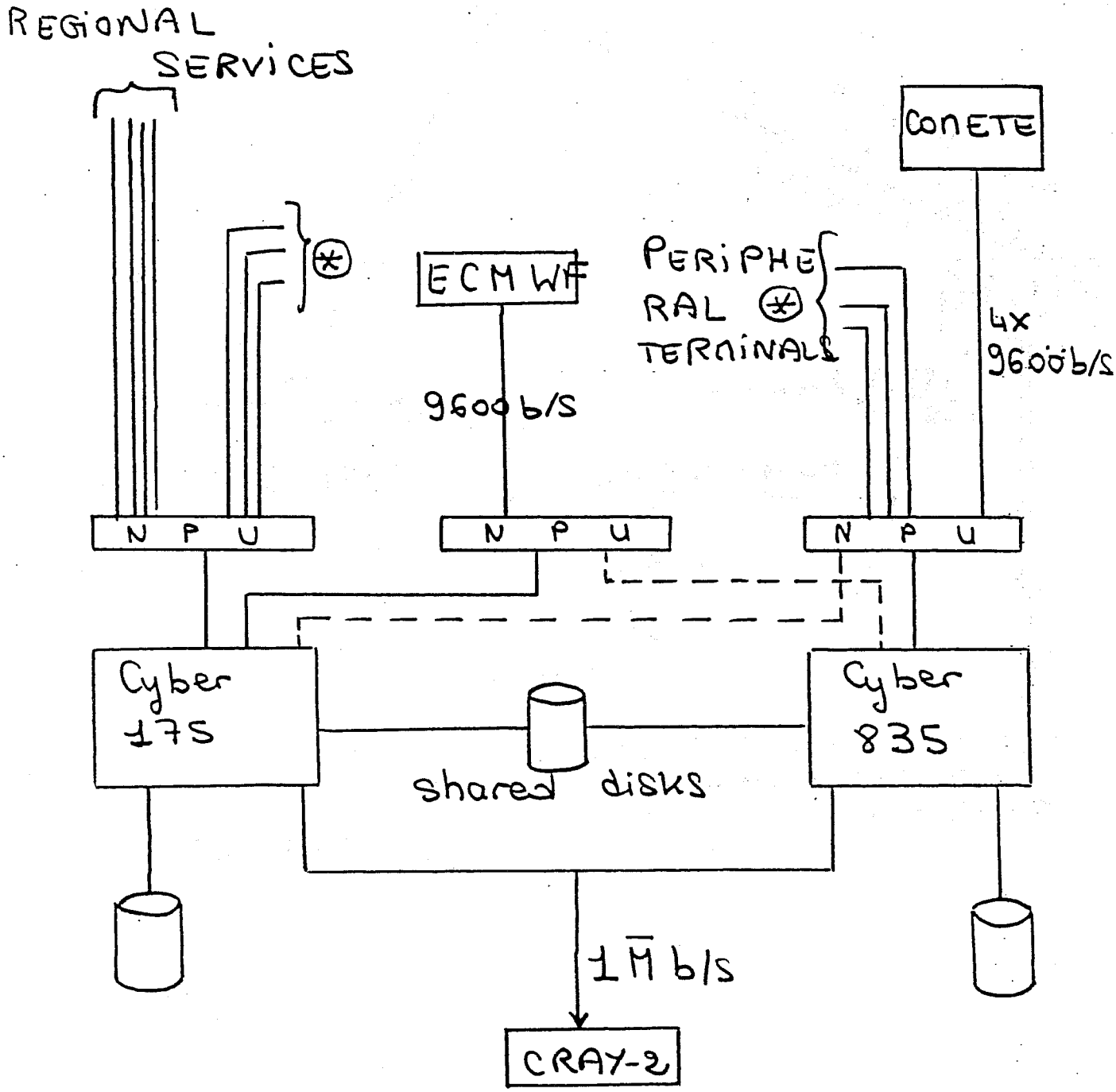
Figure 2



FUTURE RETIM NETWORK : figure 3



CDC CONFIGURATION : figure 4



NPU : NETWORK PROCESSOR UNIT

--- : Back up links

OUTLOOK OF

CRAY-2

ENVIRONMENT

figure 5