RIO : AN OPERATIONAL NETWORK IN 6 SUB-SAHARIAN COUNTRIES OF AFRICA AND THREE SOUTH PACIFIC ISLANDS*

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ABSTRACT* Africa is probably the continent least served by computer networks, especially the sub-Saharian area.
ORSTOM has set up a network which presently links 17 places in intertropical countries. On the one hand, this experience is the only one in French-speaking African countries, on the other hand it has been carried out by an atypic scientific institute which specialises more in food, the environment and health than in computer technology. At the beginning, the RIO network project was a respond to the needs of ORSTOM researchers. It is now becoming a tool used by other scientists and non governmental organizations (NGO's) working on development.

Electronic communication networks offer a cheap and reliable solution to develop north/south relationships. They also contribute to the emergence of necessary transversal links for establishing a scientific community of southern countries.
The RIO network links LAN (Ethernet, TCP-IP, NFS), of Unix workstations and of PC (DOS & Mac), set up in ORSTOM and some of its partners'premises. It is intended for researchers working on fields of development (health, food, environment). Very simple ergonomic interfaces have been developed tenable them to be use by people who know little about computers. It uses available telecommunications links (dialup lines, switched packet networks) with Internet and UUCP (g & f) protocols.

KEY WORDS Data-processing networks, electronic communication, developing countries, Africa, scientific research, cooperation, Internet, UUCP.

1. INTRODUCTION

In West Africa we can note that until now very few initiatives undertaken by the academic sectors have succeeded [MAL92]. This situation is specific to the African continent, for in most South American countries the number of projects have increased during the last few years.
This situation must be studied in order to decide :
- which partners will carry out the development of the networks ?
- which are the applications for which the needs are most urgent ?
- who will provide the technical implementation ?
- who will provide the financing ?
Several projects are being developed. They are undertaken by international organisations (UNESCO, UNDP) or NGO's (Fidonet...). However these projects are encounterring difficulties in associating local institutes.
The RIO project has proceeded in a different way. Using ORSTOM premises and equipment, we first set up Unix Workstations for scientific computing and graphic use. Then we link them together.

2. THE SITUATION OF THE ACADEMIC SECTOR

We must differentiate between on the one hand the universities and on the other hand research institutes and engineering schools. The former have very limited resources, a lack of qualified staff and are prone to the political and social crisis that affects many African countries. The latter are more well off and often benefit from the support of foreign partners.
Nevertheless, the first aim of research is the vital needs of the population : food, health, education. These organizations have very few technical staff competent in computer sciences. Their equipment, gifts from foreign organizations, is often not adapted. The lack of specialists is made up for by the recruitment of young volunteers for

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cooperation (VSO-Voluntary Service Overseas) who have little experience and only stay 2 years in the country [WOR91].

3. A DESCRIPTION OF THE NEEDS

In northern countries, networks have been created thanks to the need for sharing powerful computers, array-computer and connexion machines. Thanks to the setting-up of Bitnet and Internet, they became a means of encouraging collaboration between research teams working in fields of high technology.
These needs, linked on the one hand to fundamental research, and on the other to the fierce competition between industrial nations to be the leader in terms of technological development, do not exist in very poor countries.
In developing countries, long distance communications are a rare commodity. The goal of networks is not to preserve or to gain first place in the technological race, but it is to set up the logistical tools necessary to win the race for food and health self-sufficiency.
Electronic communication represent a great opportunity. The techniques of error correction allow us to compensate for the weakness in telecommunication infrastructures ; while the increase of modem speeds involves very competitive operating costs, which in turn allows this means of communication to spread further.
We must be aware that at present the isolation of engineers and researchers may be the biggest disadvantage, more so than the lack of computing resources. Access to a telephone line or a telefax line is very difficult because the communication costs are very high and discourage even the most well-equiped African teams [ANT91].
Relationships with top scientific institutes, information centres, documentation centres and equipment manufacturers are necessary and sometimes essential [NDI 91].

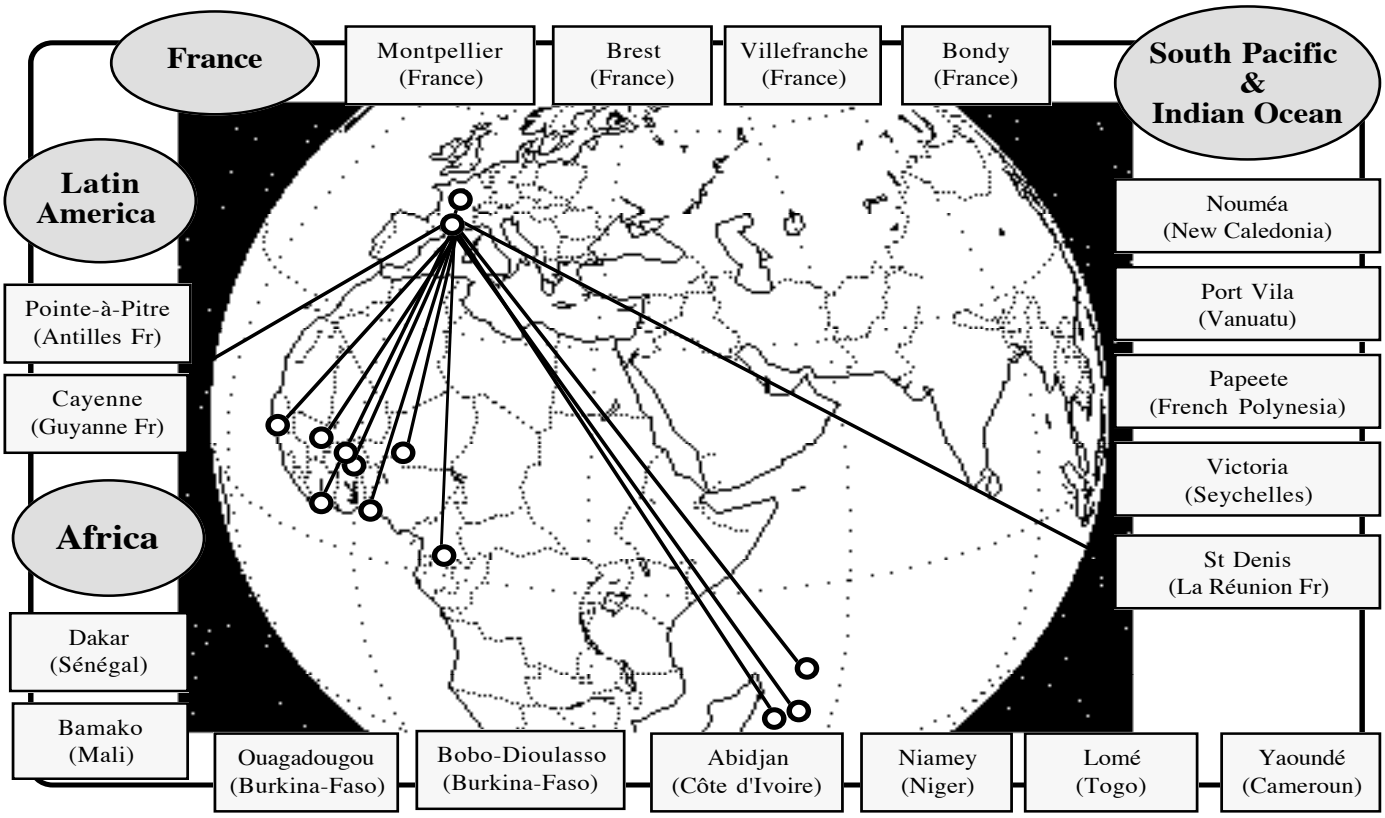
To the North/South communications we must add the strategic aspect of regional South/South communication. We can see the "transnational" nature of various agricultural, hydrological or epidemiological problems. Many teams in South America, Africa or Asia have to solve similar problems and would improve their research with regular electronic transmissions.
The aim of the collaboration between southern researchers goes beyond mutual assistance. It favours the formation of an autonomous scientific community, independent of the technological metropolis [REN91].

4. THE CONTEXT OF ORSTOM EXPERIENCE

ORSTOM is a French Public Institute of Scientific Research, whose task is to collaborate with organisations in tropical countries. Its financing (90 %) comes from the French Ministry of Research.
Its policy concerning data-processing equipment is based on various ideas :

- to provide to African researchers technical tools similar to those found in France.
- to create around data-processing some "meeting places" between different disciplines : data-processing workshops.
- to favour the transfer of technical knowledge to our African partners, providing them with up-to-date technical tools and the reception of trainees.
- to favour the links between teams working in developing countries and the international scientific community.
- finally, to improve the communication within an organisation present in 30 countries and on 4 continents.

These are the reasons why ORSTOM took the decision to buy SUN workstations (Unix Operating System) and set-up the RIO Network.



5. THE TECHNICAL CHOICES

The technical choices made for the RIO network are a direct result of the ideas cited above.

We had first to ensure the transmission of short messages (on average 1 page) over a long distance at low cost, and this whatever the quality of the telecommunication infrastructures.
The users, mainly researchers in natural, medical and human sciences are far from being computer experts. Therefore we had to provide simple, easy-to-use tools, requiring only basic knowledge [KOR90]. For the great majority the electronic mail system was their first contact with a computer.
Finally, the reliability of the system is an essential point. An unreliable system of communication leads to misunderstandings and tends to damage relations rather than consolidating them, and sometimes it even puts off the more serious users.

We concentrated our attention on 3 main points :
• The low cost of transmission : to be competitive with the postal service. Presently, the UUCP protocol offers the best results. We are studying the Telebit modem on UUCP/g and X400 on X25.
• The installation of easy-to-use user interfaces (taking into account the French accents). 3 interfaces have been developed :
- NFS-MESSOR running under MS-DOS in a PCNFS LAN
- UU-MESSOR the same one running on a single PC with UUPC (DOS emulator of UUCP)
- POP-MESSOR running with MAC-TCP[1]
- PC-MESSOR, a terminal emulator under MS-DOS;
• The reliability of the system. A thorough check is made by the person in charge of the network and its technical aspects . Technical advice and orders are often given to the people in charge of the local network. Any cut in the service above 24 hours results in direct contact, by telefax or telephone, with the broken node.
The X25 lines are generally prefered to dial-up lines. The switched packet networks set up by "France Cable et Radio"[2] in many African countries is very secure [SHE91].

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[1]Adapted from POP-Mail of Farhad Auklesaria & Georges Gonzales, Microcomputer and workstations network center, University of Minesota.

[2]FCR, subsidiary of France-Télécom)

6. THE SETTING-UP CONDITIONS

The setting-up of a network node in Africa requires engineering expertise, a financial and administra-tive dossier that must be well prepared.
Running costs must be met (telephone, electricity, minor repairs, rental of premises...). The conditions of delivery of the equipment, the preparation of the building (furniture, adequate electrical current), the identification of the person in charge of the delivery (clearance of goods, verification of the parcels) and the working conditions must also be considered.
The order is done in France, components (hardware and software) are integrated and tested before being send to Africa. It will be virtually impossible to find a missing part there. An experienced engineer is sent to the site to carry out the installation. He will train the person in charge of the system and the first users.

7. THE USERS

Presently 700 persons are using the RIO network in 10 countries and most of them are working in developing countries

We can note a penetration in the network per speciality. Some scientific disciplines are fully connected (100%), others, with the same technical conditions are not aware of this means of communication. Those who use the networks most are the researchers who publish in international congresses or who are leading international collaborations with the North America and Europe.

Our African partners working with the ORSTOM system are very interested, and train to use the electronic mail system. Nevertheless, they communicate mainly with researchers they have met, having few contact with foreign institutions.

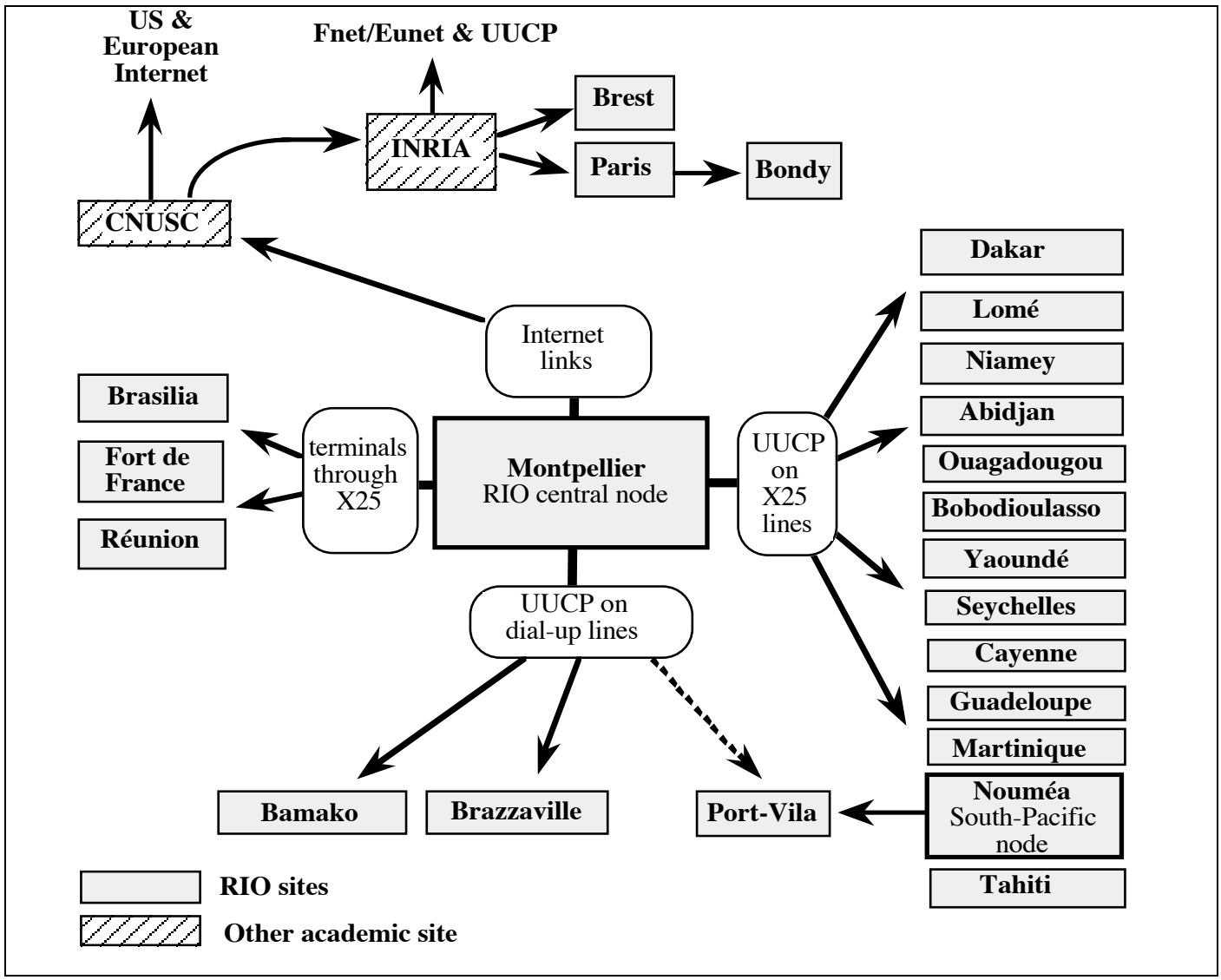
Presently, we are working to associate scientific communities of African countries to the development of the network. Several projects consist in linking multi-nationals organizations:

- CORAF: (Conference des responsables de recherche agronomiques africain/ Conference of African agronomic research directors). It has 14 African member countries. Our project consists in linking members of each countries through RIO network.
- UNCED: (United Nations Conference for environment and development. We distribute preliminary papers and we propose to organizations the possibility to communicate with their delegation through RIO network.
- OCCGE: Organisme de coordination et de coopération pour la lutte contre les grandes endémies en Afrique de l'Ouest (organization of cooperation and coordination for struggle against the great diseases). We plan to study the setting up of networks which will link between different members.

8. THE NETWORK CENTRE IN MONTPELLIER (FRANCE)

The site of Montpellier (orstom.orstom.fr) deals with all the international traffic.
It provides the data routings towards others sites and most of the access in terminal mode (MINITEL[3] or PC-Modem). A SUN workstation (Sparc station 2) carries out all these services (gateway, router, MTA), managing the following protocoles :
- X400 with Atlas-400[4] (an X400 router is being installed on the main node of Montpellier).
- Internet (IP) with ORSTOM's French centres and other academic networks (Fnet, Easynet). The links are made on X25 with SUN workstations (SunNet X25).
- UUCP/f on X25 for intercontinental links towards sites equiped with switched packet networks (programmes "Consult X25-UUCP" and SunNet X25).
- UUCP/g on dialup line for intercontinental links with sites without a switched packet network.

[3] ASCII terminal with internal V23 modem. in France, MINITEL have been distribued free of charge by France-Telecom
[4] Public email network set up by France Telecom.



9. THE CHOICE OF PROTOCOLES

X25

1 - Transpac (French public X25 operator) provide a reliable and complete service (access by Minitel through Teletel network and terminal).

2 - In many African countries, X25 networks of very good quality have recently been set up by France Câble et Radio. The service provided is all the more important as the telephone network is often old and out-of-date.

3 - It is a real "standard", the interface with all the protocoles we use is quite satisfactory.

IP

1 - It is the only way to interconnect totally all of our local networks, and provides a large variety of services : rlogin, rsh, telnet, ftp....

2 - It is the most widely used protocole, particularly in the academic community.

3 - Its specifications are perfectly stabilized and it is available in almost all systems and platforms.

IP/X25

This hybrid between the two most widely used standards is not the most efficient one, but it does provide reliable and low cost solutions to transport IP packets and interconnect local networks on public X25 network .

UUCP

It offers numerous advantages compared with IP for long distance connections with developing countries :

1 - It allows us to make stand and forward connections, to choose exactly the right time and even to determine the operation which must be repeated in case of failure. This characteristic

allows it to benefit from off-peak hours rates, to choose the least busiest periods and to automatically repeat these connections which failed because of the rather bad quality of the lines (cut offs, noise).
2 - It works on X25 and dialup lines. The protocole F of UUCP is very efficient on X25 ; compared with SMTP/IP/X25, the cost of the carried K-byte is two to three times less expensive. However, our UUCP/f programme has bugs and requires close supervision.
3 - It allows the system called to benefit from the connection to send its outstanding messages (this is all the more important as the poor quality lines make the setting-up of the interconnection an unreliable operation).
4 - It is perfectly interfaced with SMTP and available in MS-DOS version (UULINK and UUPC).

10. CONCLUSION

The setting up of a computer network in the poorest countries is the result of slow and patient work. The technical aspects are by no means the most difficult. Pedagogic, organizational and political skills are required. The setting up of the RIO network has taken several years and it will take even longer to extend it to Central Africa. But the results are very encouraging. In developing countries, networks are not only a new tool to communicate, more reliable, less expensive, less constraining than post office mail, a means to acces to large database, but they also create links between communities which did not communicate before.

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ANNEXE : DESCRIPTION OF RIO NETWORK IN THE TROPICAL AREA

place & domain address	**UNIX plate-forms** (netw. server on first line)	**numb of PC**	**UNIX disk space**	**main applications of work-stations**	**Telecom links**	**speed in Kbs**	**protocols**
Pointe-à-Pitre (Fr. Caribbean) Pointap.orstom.fr	Sun 4/65C Apollo 4500 Appollo 3010	5 Dos	660 Mo +330 +150	BD & hydrological modeles	Transpac (X25) via dialup line	2,4	UUCP/f /V24
Cayenne (French Guyana) cayenne.orstom.fr	Sun 4/110 Sun 3/110	3 Dos 2 Mac	370 Mo +370 mo	BD , remote sensing, statistics	Transpac 2 VC	2,4	UUCP/f /X25
Nouméa (New-Caledonia) nouméa.orstom.fr	Sun 3/260 Sun 3/160C 3 Sun 3/140M 4 Sun 4/20 1 Sun 4/75 2 Sun 4/40C	20 Dos 5 Mac	3 Go	geophysic & oceanographic Data bases, GIS, remote sensing bibliographic DB	Transpac 2 VC	9,6	UUCP/F /X25 IP/X25
Papeete (French Polinesia) tahiti.orstom.fr	Sun 4/65C	5 Dos 2 Mac	600 Mo	oceanographic Data bases, statistics, bibliographic DB	Transpac via dialup line	1,2	UUCP/f /V24
Port-Vila (Vanuatu) vanuatu.orstom.fr	Sun 4/65C	6 Dos 1 Mac	600 Mo	multimédia, naturalist & oceanogic DB	dialup line to Noumea	2,4	UUCP/G /V24 bis
Ouagadougou (Burkina-Faso) ouaga.orstom.fr	Sun 4/65C	5 Dos	600 Mo	Statistics, naturalists expert systems remote sensing	Fasopac (2 VC)	2,4	UUCP/F /X25
Dakar / Hann (Sénégal) dakar.orstom.fr	Sun 3/60 Sun 4/65C	15 Dos 5 Mac	600+ 1,5 Go	statistics, remote sensing, GIS bibliographic DB	Senpac (4 VC)	4,8	UUCP/F /X25
Dakar / ISRA (Sénégal) isra.orstom.fr	Sun 4/65C Sun 4/40 Sun 3/160C Sun 4/60M	9 Dos 1 Mac	600 +140 Mo	oceanographic DB, statistics, remote sensing	dialup line to Dakar-H + Senpac (2VC)	2,4 2,4	UUCP/G /V24 bis UUCP/f /X25
Lomé (Togo) lome.orstom.fr	Sun 4/65C	14 Dos	600 Mo	Statistics, bibliographic DB	Togopac (2VC)	2,4	UUCP/F/ X25
Niamey (Niger) niamey.orstom.fr	Sun 4/65C 2 Apollo	4 Dos	600 Mo	Climatologic models & DB	Nigerpac (4 VC)	9,6	UUCP/F /X25
Bamako (Mali) bamako.orstom.fr	Sun 4/65C	12 Dos	600Mo	environment DB & IA models	dialup line	1,2	UUCP/G /V24
Victoria (Seychelles) seychel.orstom.fr	Sun 4/65C	4 Dos	600 Mo	oceanographic DB, statistics	X25 via dialup line	1,2	UUCP/F /V24

PLAN FOR 1992

place & domain address	**UNIX plate-forms**	**numb of PC**	**UNIX disk space**	**previous set-up date**	**telecom link**	**speed in Kbs**	**protocols**
Dakar / Bel Air (Sénégal) dakar2.orstom.fr	Sun ELC	10	1,2 Go	june 92	dialup line to Dakar-Hann	2,4	UUCP/G /V24 bis
Bobo-Dioulasso (Burkina-Faso) bobo.orstom.fr	Sun IPX	5	600 Mo	june 92	Fasopac	2,4	UUCP/F /X25
Brazzaville (Congo) brazza.orstom.fr	Sun IPX	10	600 Mo	September 92	dialup line	?	UUCP/G /PEP

Yaoundé (Cameroun) yaounde.orstom.fr	Portable Spark	5	400 Mo	april 92	Campac (X25)	?	UUCP/f /X25
Abidjan (Côte d'Ivoire) abidjan.orstom.fr	Sun ELC	3	600Mo	june 92	Syntranpac (X25)	2,4	UUCP/f /X25