EARN

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Dear Colleagues,

Thank you for coming to Perugia to assist in the development of the detailed plan for the implementation of the migration of EARN to the use of ISO/OSI protocols. This is a very important meeting for EARN, and your input will be most valuable.

Before you begin your meeting, it may be appropriate to remind you that 1987 has been a very important year for EARN:- Two major decisions have been made by the Board which will determine the development of EARN in 1988 and beyond. The first 1987 milestone decision was the agreement on the funding of the EARN network for 1988. The second milestone was the decision in principle to migrate EARN to the use of ISO/OSI protocols and the acceptance of the outline strategy for this migration. The migration strategy will be formally adopted by the EARN Board at the next Board meeting, and this will set the direction for the network for the coming years.

The strategy document has been a major achievement in itself - thanks largely to the dedication of the EARN Technical Groups and the inspiration and leadership provided by Dr Paul Bryant as the EARN Technical Director. The challenge now is to turn the strategy into a fully fledged plan for the implementation of the EARN migration to OSI. This is the task of this Perugia meeting.

Developing this detailed plan is a complicated task. The plan must be consistent with the adopted strategy; it must provide for a truly open architecture which will allow the connection and interoperation of all ISO/OSI systems; it must flesh out the details of the lower level X.25 infrastructure, and at the same time provide for progress towards the adoption of the OSI Applications, especially X.400; and it must provide sufficient detail so that both the national backbone nodes and all EARN nodes (VAX/VMS, IBM VM/CMS and IBM MVS/TSO systems in particular),running the current variety of hardware and software systems can find a cost-effective path towards the adoption of the EARN migration plan and standards. Lastly, the plan must provide for the management and operation of the international X.25 infrastructure.

This is a challenging - not to say a daunting - task, but one that I am confident can be tackled and brought towards completion at this Perugia meeting. It is my hope that the actual implemenation of the EARN ISO/OSI migration plan can begin in early 1988, and it is clear to me that this Perugia meeting can provide the key.

May I take this opportunity to thank your hosts in Perugia - the Centro Studi La Colombella and the EARN members in Italy - and to thank you all for the generous contribution of your time to this extremely important work. May I especially thank our guests from RARE at this meeting who have come to assist EARN in this task.

On behalf of the many tens of thousands of European researchers who rely on EARN for the day to day support of their research activities, may I wish you well in your deliberations.

I look forward to your report.

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DENNIS JENNINGS
PRESIDENT

# EUROPEAN ACADEMIC RESEARCH NETWORK

## ISO TRANSITION WORKING PARTY 14/15 SEPTEMBER 1987

## PERUGIA - ITALY

At the Berlin EARN Board of Directors meeting in November 1986 a study was commissioned to determine how EARN should migrate to use ISO protocols. A strategy document was produced (paper 2) as a result of the EARN technical meeting in Crete on March 26/27, 1987. This document was presented at the RARE Valencia workshop on May 4/5/6, 1987 and to the EARN Board of Directors in Nice on May 21/22.

The Board of Directors commissioned a detailed plan based on the strategy. The EARN Executive at their meeting in Geneva on 14/15 July 1987 considered an early draft of the plan and decided to dedicate the September 14/15, 1987 EARN technical meeting in Perugia to a workshop on transition at which the plan would be refined.

The transition plan (paper 3) falls into a number of sections. Some sections are very detailed and concern the early stages of transition. Some later sections, for example to do with JTP and VTP, contain little more than statements of intent.

A considerable number of statements are made which are open to question, such as the use of X.121 DTE addressing. However, there are many other areas where decisions are needed, for example with X.400 OR names. In some of these cases the decisions being made by the CEN/CENELEC functional standards activity or the RARE working parties will change or extend the plans.

The workshop will start with a presentation of the outline strategy. It is then proposed to split into a number of working parties to consider in detail various aspects of it.

The object of the workshop is to produce a better transition plan for EARN.

I look forward to an exciting and fruitful meeting as EARN starts to progress towards its transition.

Paul Bryant

ISO TRANSITION WORKING PARTY 14/15 SEPTEMBER 1987

AGENDA

Monday 14 September

09.00 Presentation of the overall strategy (paper 2)

09.30 Briefing on objectives for meeting

10.00 Set up initial working groups

10.30 Working groups (including coffee)

1 X.25 infrastructure to include:
- topology and location of switches;
- selection of switch manufacturer;
- DTE address scheme;
- management.

2. NJE over X.25 to include:
- the hardware and software requirements;
- migration problems;
- management.

3. Use of X.400 mail to include:
- OR names;
- use of 1984 or 1988 recommendations;
- possible products;
- time scales.

13.00 Lunch

14.00 Working groups continue

16.00 Reports from working groups

17.00 Close

Tuesday 15 September

09.00 Summary of progress so far

09.30 Set up working groups. The groups to be set may well depend on the previous day's progress.
Suggested topics include:

4 Use of other high level protocols to include:
- use of DECNET;
- use of coloured books;
- other protocols;
- advisability of allowing these protocols;
- gateways required.

5 High level ISO protocols FTAM, VTP and JTP
- gateways required;
- possible products;
- time scales.

6 Mail gateways between X.400 and RFC822 to include:
- the possible introduction of domain addresses into EARN;
- the possible products.

7 Extension of EARN to include:
- connections to existing networks;
- NSAP addresses;
- extension of the EARN x.25 infrastructure;
- management considerations.

Some groups may continue from the previous day.

12.00 Progress reports

13.00 Lunch

14.00 Final session
- final reports;
- production of meeting report;
- future activities;
- timescales for implementation.

16.00 Close

Paper 3

IBM.PB380

Version 5 1 August 1987

# The EARN transition to ISO protocols.

Draft for comment

## Section 1 - Introduction and summary

### 1 Summary

The EARN (European Academic Research Network) Executive, in pursuance of the requirement for EARN to move to use the ISO (International Standards Organisation) protocols, initiated a study to recommend a transition strategy.

A group, set up to study transition strategies, recommends that:

- A network aligning with the CCITT Recommendation X.25 (1984) should be provided. This should initially include the international EARN nodes. (See section 2).

- For an interim period, the IBM NJE protocol should operate over the X.25 network. (See section 3).

- For an interim period, DECNET, Coloured Book, and possible other non ISO protocols should be permitted to use the X.25 infrastructure. (See section 4).

- ISO protocols should operate over the X.25 network as soon as suitable implementations become available. (See section 5).

- The transition of national components of EARN should be encouraged and this should take place under national direction and in conjunction with any national academic network activities. (See section 6).

- Non ISO protocols should be phased out as and when suitable ISO products are available and providing a suitable service. (See section 7).

Tactical details of the migration are outlined in subsequent sections together with areas requiring further study.

### 2 The transition to use ISO protocols

EARN has agreed to migrate its network to use ISO protocols as a result of a request form CEPT (the advisory committee for the European PTTs).

It had been hoped to conclude this transition by the end of 1987 to meet the request from CEPT. As a result of the slow development of some of the essential standards and subsequent products this date can not be met. There is now sufficient information to produce a firm proposal for the initial stages of transition including the costs and time scales.

A working group set up by the EARN Executive to study the transition of EARN. Various strategies were developed and a final one was determined and agreed at EARNTECH FIVE held in Crete, 25/26 March. Subsequent refinement has taken place as a result of further discussions and investigations. The EARN Board of Directors has endorsed this strategy.

The EARN Executive requested a further report to further define the strategy and tactics in full detail. This document is a resultant report. This document was considered at a joint meeting between EARN and RARE experts held in Perugia 14/15 September 1987 after which this final document was produced.

The strategy recommends the setting up a private leased line X.25 network. Although this is contrary to the CEPT request the group concluded that the public networks could not be used as they do not currently provide X.25 (1984), which is required to support the ISO network service. In addition, the early services require the use of X.25 permanent virtual circuits (PVCs) and these are not available on international connections. The use of a private leased lines network does not exclude the possibility of migrating part or all of the service to the public X.25 services at a later date.

Although other bodies are involved with the elaboration of functional standards, all references in this document refer to those of CEN/CENELEC and CEPT.

## 3 Public versus private networks

Leaving aside political considerations the main concerns are tariffs and performance.

### 3.1 Tariffs

Current calculation show that the current EARN traffic would be between 5 and 10 times as expensive if carried on the public X.25 networks. The exact value has not been calculated but the cost will certainly effectively prevent much of the EARN traffic ever being generated and so disadvantaging the community.

The public X.25 networks will continue to attract a volume tariff in the foreseeable future. The tariffs are likely to remain relatively high since X.25 networks are not very profitable. A private X.25 network is cheaper since it does not have the same level of availability (24 hour staffing). In a private network many of the costs are hidden since the operation, maintenance, and management of the network can be undertaken by computing centres at marginal cost. The benefit of a leased line network is that its cost is known and fixed. Thus the exact amount of money needed can be requested from the funding bodies or the users.

The principle draw back of a volume tariff is the inescapable conclusion that the costs have to be returned to the end user to avoid a given user bankrupting the organisation. The management of such accounting and control mechanisms is difficult and expensive.

3.2 Performance

The public packet switched data networks have, for the most part, been used for interactive or transaction purposes when connection times are high and data volumes low. These calls are cheap and do not demand high data rates. In fact the user should not expect more than 2000 bits per second on an international link. This is compensated by the ability to sustain a number of connections but this is of less value for a network passing bulk traffic.

EARN is characterised by bulk traffic which is therefore expensive on a public X.25 network.

Most of the international lines in the Public X.25 networks are 9.6 K bits per second. It is understood that these links will be upgraded to 64K digital ones as these become available. The effect of this is difficult to estimate. The expectation is that public networks should be able to provide the performance required at some future date. A private network with about the same number of international leased lines as EARN should be able to provide a performance similar to the current EARN network. This is supported by observation of some existing private networks.

There are some indications that private networks, such as EARN, may have more freedom to exist in the future with the further liberalisation of the European PTTs.

3 The benefits of the use of ISO protocols

Ideally the world should be served by a single set of communication protocols. In this way services could be provided to all regardless of the various systems used and constrained only by management and not technical considerations. This is particularly important in the academic community with the wide variety of equipment and wide range of serviced required.

Currently the academic community use a wide variety of communications protocols and this is proving an impediment to the increasing demand for academic collaborations.

The community is now faced with many gateways between the various sub networks which cause loss of quality of service, such as loss of some service or loss of some aspects of a service. The many gateway systems require considerable resources to develop them and maintain them.

Within Europe there is now widespread acceptance of the ISO protocol standards and confidence that manufacturers will provide these as fully supported products both on existing and future systems.

When EARN was set up the ISO protocols were not well defined and furthermore implementations were not expected for some years. Moreover, a large variety of protocols were in use within Europe which gave no indication of the possible directions of development.

The recently set up RARE organisation has brought together the major academic networking interests in Europe and from the discussions and statements made it is clear that there is confidence that services in the near future can and will use ISO protocols and such services will continue for many years.

## 4 Constraints

The working group was constrained by the terms of reference determined by the EARN Executive. These are:

- The eventual transition must be to protocols harmonised with the emerging recommendations of RARE (the European academic and research networking organisation).

- The EARN user base must see no loss of quality of service. In particular communications with other networks such as BITNET, DFN, and JANET must be preserved.

- During the transition the user base must not be disrupted.

- The transition must be principally concerned with the international connections. A secondary concern is the effect within countries. This is particularly important with EARN nodes which are not able to migrate due to technical or financial reasons. Connections to sub-networks within an organisation must be considered.

- The migration of all the major machine types must be considered even though some types may not have direct international connections.

- The exploitation of new services, such as ISDN, is not considered. These services not yet sufficiently available to allow consideration of their exploitation by EARN in the near future.

### 4.1 Harmonisation with RARE recommendations.

The academic wide area networking in Europe is expected to be based at the lower levels on ISO transport service over an X.25 packet service.

The upper levels are likely to be MOTIS (or its CCITT equivalent X.400 series Recommendations) for mail and FTAM (file transfer and management) for file transfer both using the appropriate ISO session and presentation layers. JTP (job transfer protocol) and VTP (virtual terminal protocol) are not yet stable enough to be considered.

Interactive services will be provided by the CCITT X.3, X.28, and X.29 over X.25 Recommendations although these protocols are not, and are unlikely to become, ISO standards. None the less, these protocols are in widespread use and this is likely to continue for some years.

RARE is expecting to follow the functional standards being elaborated by the CEN/CENELEC CEPT project. Functional standards define the exact stacks of protocols to be used to provide given services. They define the options to be provided and any parameter values required. The use of functional standards ensures that implementations will interwork.

It is not the task of EARN, and it is beyond the resources of EARN, to develop the products required for a transition. Thus, the task of EARN is to select products already available which conform to the relevant standards and functional standards. The speed of the migration of EARN is, to a large extent, dependent on the emergence of such products.

The connection mode protocols RARE is advocating are well suited to the relatively slow and error prone lines currently in use. There are attractions in following the ARPA TCP/IP protocols in that BITNET, Israel (and possible other countries), and many local area networks are following them. EARN would have difficulty following TCP/IP as part of its transition strategy since they are not part of the ISO set of protocols and one would be faced with a further migration to ISO transport protocol class 4 (TP4) over appropriate lower layers at a future date. Consideration of the use of TP4 based services should be considered when higher speed lines with low error rates are available as well as stable ISO protocols and products in this area.

This document does not consider the RARE and CEN/CENELEC work in detail but further study will be required in the future particularly with the adoption of higher level ISO protocols.

## 4.2 ISO products

At the lower layer X.25 (1980) is available for all major systems as fully supported products from the manufacturers. In many cases there are alternative products for machines from third parties. Products conforming to X.25 (1984) are available for a small but growing number of systems. The availability of X.25 (1984) is expected to improve as the PTTs start to offer services based on it. In many cases no firm dates have been announced. In principle it is not possible to operate ISO network service without X.25 (1984) since this Recommendation contains essential facilities for the support of the ISO network service. These facilities allow network level gateways. The lack of these facilities may be overcome in a single network but in concatenated networks higher (than network layer) gateways or relays would be needed at some inconvenience. The relevant functional standard is T/31 which is now available. The conformance of products with T/31 has yet to be determined.

Products to support CCITT Recommendations of the X.400 series are becoming available from several major systems. In the case of IBM there is currently an experimental version for use under VM. A supported IBM product under MVS has been announced. DEC now offer a fully supported product. There are a number of third party products available or under development. A major incentive to provide these products is the expected introduction of services by the PTTs and value added suppliers. The performance of X.400 products is not yet well known and will depend not only on the protocols themselves but on the quality of their implementations. The relevant functional standards are A/3211 and A/323 which are available. The conformance of products with the functional standards is not known. X.400 is currently undergoing revision for the CCITT 1988 Recommendations. Opinion suggests that services should be targeted on this version and in the mean time only experimental or pilot services should be offered.

A small number of FTAM products exist mainly as experimental implementations or following the MAP (Manufacturing Applications Protocol) recommendations. The performance of FTAM has yet to be established. FTAM is not expected to be widely available for some time. The relevant functional standards are being elaborated.

At a future date JTP (job transfer protocol) and VTP (virtual terminal protocol) will be available but the standards for these are currently unstable. The relevant functional standards are not yet being elaborated.

The CCITT Recommendations X.3, X.28, and X.29 are not ISO protocols but they are expected to provide an interactive service for the foreseeable future. Products to support these Recommendations are available for all major systems. These mainly provide services for line mode terminals. Some products are available for providing screen mode services over X.29 but currently there are no standards in this area. The relevant functional standards are Y/11 and Y/12 which are available.

As yet, products do not necessarily conform to the CEN/CENELEC CEPT functional standards as these have only been in place for a short time or are still to be finalised. However there is expectation that products will conform.

Conformance test centres are to be set up which will guarantee that products will interwork. EARN should acquire certified products where possible.

## 4.3 Maintenance of quality of service

EARN currently provides file transfer, job transfer, mail, and messaging services. Network management is provided on a pragmatic basis in that the management tools have been produced by EARN and BITNET themselves.

EARN provides added value services which currently include the NETSERV information services, directory services, the LISTSERV mail distribution system, and RELAY the interactive real time conferencing system.

The RARE recommended protocols will probably provide file transfer, mail, and interactive services. Job transfer and better interactive service will be provided at a later date. Note that job transfer services may be provided using FTAM but with limited functionality.

Some study is being undertaken in RARE into services similar to NETSERV.

There is, therefore, a mismatch between the services provided in the two cases.

The NETSERV information service could be provided easily. It could be via gateways or directly using X.400 or FTAM. There are development projects within DFN to provide such facilities. The content of NETSERV will need some enhancement to reflect the new styles of networking in EARN.

X.400 currently has no distribution list services but the 1988 revision will. It would not be difficult to modify LISTSERV to provide these services to X.400 and RFC822 services.

Directory services are not all that successful although the current service could be used via X.400. CCITT is defining directory services but these are not likely to be available for a some time.

The EARN message service will be lost. This service is popular and its loss is serious. To some extent its loss can be ameliorated by the use of interactive services or mail. It would be possible to develop a protocol to carry the EARN messaging service across X.25 but such a move would require resources and be counter to the objectives of a transition. Further study is required to assess the impact of this loss. Further study is needed to determine if and how an alternative service could be provided. RELAY is based on this service.

It is inevitable that the user interfaces may be different. This is not serious as long as the services are more or less as easy to use.

Ideally the user interfaces should not change or should only be extended to avoid confusing the users.

Temporary note - I am not so sure. Some of the user interfaces are not very good and would benefit from a decent burial. Also I would like to see some conformance with user interfaces which do exist e.g. X.28- but I am biased.

User interfaces depend on the particular implementations. There is no intention in this exercise to recommend any move to common user interfaces. If this is to happen it should be as a result of further standardisation activities of standards bodies or at least of RARE. In many cases ISO applications will be provided via existing user interfaces possibly with some extensions.

EARN may have to use software and maybe hardware provided from a variety of sources on a particular machine. This strategy is preferable to waiting for systems from particular sources which could delay a transition.

It is vital that at no time should the network be divided into two or more unconnected parts either logically or physically. Thus gateways or relays are needed between different network systems to preserve interworking.

## 4.4 Disruption during transition.

During transition there will inevitable be a measure of disruption as network methods and user interfaces change. This must not adversely effect the users even though there may be some inconvenience. Careful testing of new equipment and software is essential before it is brought into use.

## 4.5 The systems to migrate.

The initial migration will concern the international nodes or a subset of them.

All the international nodes are machines operating under the IBM VM/CMS or MVS systems. These use RSCS(revision 1), RSCS(revision 2), or JES2. The services NETSERV, RELAY and LISTSERV operate under VM/CMS.

The initial stages of migration will therefore only concern IBM VM and IBM MVS machines.

The migration of EARN within a country is expected to be the responsibility of the management in that country in order to take account of any national plans. In some cases countries will expect to receive some assistance from EARN to aid their migration.

It is important to consider how systems other than VM/CMS and MVS ones can migrate either instep with the international part of the network or at some other time. The DEC VMS systems are of greatest interest as these constitute over 40% of the EARN nodes.

## Section 2 - X.25 infrastructure

### 1 Transition strategy and tactics

A network aligning with the CCITT recommendations 1984 is required as only this type of network can support the ISO network service. This is because the network service access point (NSAP) address is carried in the 40 digit extended address of the X.25 call request packet. During the early stages of transition the network service would not be required but using a network based on the 1980 recommendations would then require a further transition to the 1984 recommendations at some inconvenience.

### 1.1 CCITT X.25 (1984) Recommendation

An X.25 infrastructure will be developed. Initially this will connect a few international nodes with good network experience. The remaining international nodes will be connected at a later date. Countries may wish to connect their own X.25 network to the EARN infrastructure. These connections require further study on a case by case basis as requests are received.

Systems connected to the X.25 infrastructure should conform with the functional standard T/31 where ISO applications are supported.

The lines for the infrastructure will be provided in three ways:

- The provision of new lines. This will be used when new lines are installed specifically for transition or when lines are being re-routed for financial reasons or when lines are being re-routed for traffic reasons.

- Conversion of existing lines. This will be the usual transition route.

- Split the bandwidth of an existing line and use one channel to preserve the existing service and the other for an X.25 service. Dual channel modems will be required and the split of bandwidth between the channels will depend of traffic levels. This scheme will be useful where the international node is unable to run the relevant X.25 and NJE protocols but requires X.25 services to other nodes operating other types of service. This would be regarded as an interim provision.

1.2 Location of switches

EARN will requires a number of switches to provide the X.25 backbone.

The factors affecting the number and location of switches are:

- The number of switches should be a minimum as they are expensive and require maintenance and manning.

- Switches should be located so as to reduce line costs. Lines crossing several countries are usually more expensive.

- Switches should be located so as to maximise performance.

- Switches should be located where there is already good X.25 expertise.

An analysis of the EARN traffic and line tariffs was undertaken by IBM (annex 5). As a result of this study a minimal line cost topology was developed and is in the 'Financing of EARN during Year 1988' 30 April 1987 as 'Fig 3' (annex 4). This suggests that a network based on 4 interconnected 'stars' at Rutherford Laboratory, Montpellier, CERN, and Stockholm would provide near minimal line costs. Such a configuration would also be suitable for an X.25 network with switches of about eight line capacity at these sites. A small number of changes would be needed to the topology in 'Fig 3'. A fairly substantial reconfiguration involving about 9 lines is needed to move from the current leased line network to the proposed one.

Initially the four sites would be connected in a square which will provide a certain amount of resilience in the event of line failure. If and when traffic levels rise wider band connection could be made and/or cross connections between the corners of the square as traffic dictated.

Some of the reconfiguration will be undertaken as a result of currently developing plans for the EARN RSCS network and hence the reconfiguration as a result of transition is small and results in reduced costs.

It will be convenient if new lines were to operate with X.25 from installation thus providing a good fall back position during the changes.

As some national parts of EARN migrate and possible become part of the EARN address space a different switch topology may develop due to the provision of local switches which could be used for local and international EARN. This is any area for further study.

It is recommended that:

* four 8 line switches be purchased and installed at Rutherford Laboratory, Montpellier, CERN, and Stockholm.
* new lines between Stockholm - Rutherford and Rutherford - Montpellier

be installed and an X.25 service commenced.
* the Stockholm - Geneva and Geneva - Montpellier lines be converted to X.25 as confidence builds.
* existing RSCS lines will be converted to X.25 as convenient.
* when possible new lines will use X.25.

Areas for further study:
* the development of X.25 services within countries.

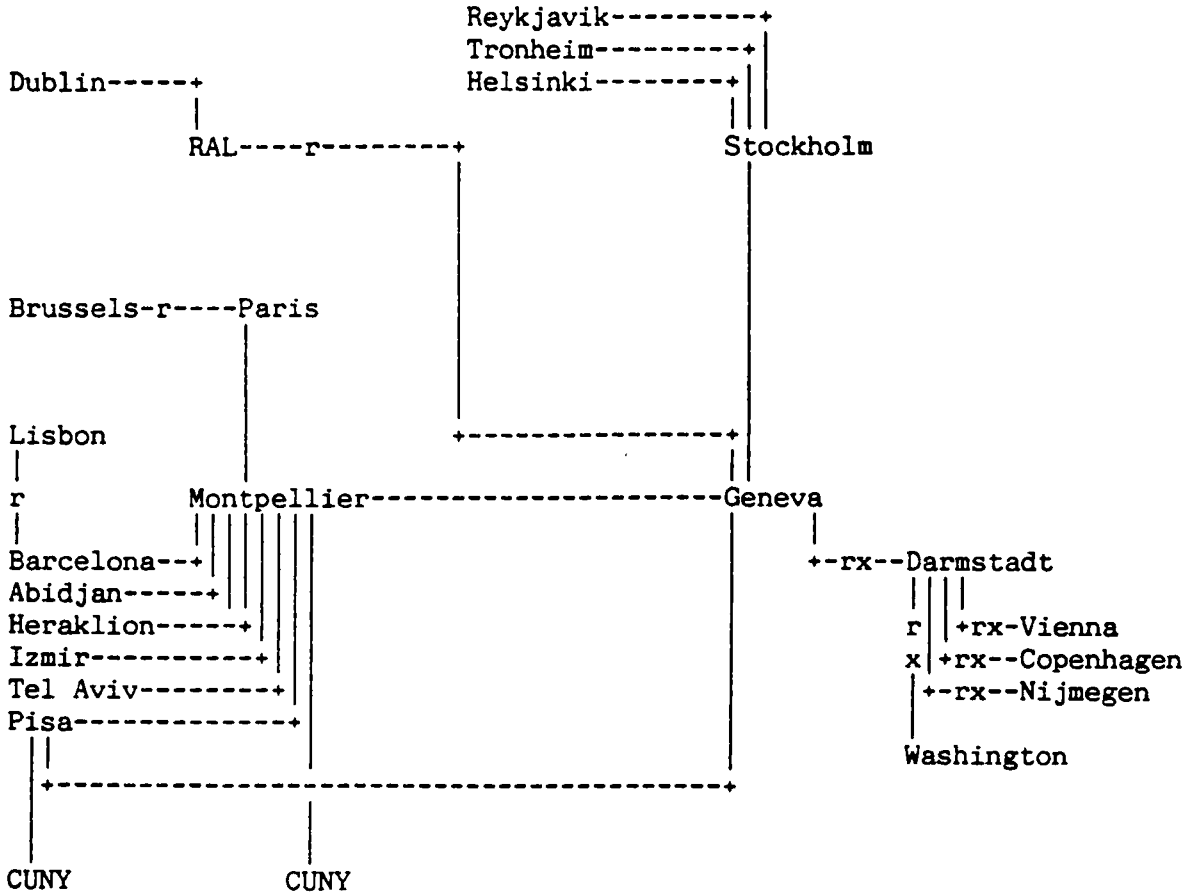


Fig. 1 Current Configuration of EARN
rx=lines scheduled for relocation, r=lines to be relocated for X.25

```
                              Copenhagen---n-----+
Nijmegen--n--+                Reykjavik---------+|
Brussels--n-+|                Tronheim---------+||
Dublin-----+||                Helsinki--------+|||
           |||                                ||||
           RAL-----------n-----------------Stockholm
           |                                |
           |                                |
           n                                |
           |                                |
           |                                |
           |                                |
           Montpellier---------------------Geneva
           |||||||                           ||
Barcelona--+||||||                           |+-n----Bonn
Abidjan-----+|||||                           +--n----Vienna
Lisbon----n--+||||
Heraklion-----+|||                              ?
Izmir----------+||                              |
Tel Aviv--------+|                              Washington
Pisa-------------+
                  |
                  Cuny
```

Fig.2 Proposed X.25 infrastructure
n=relocated lines

## 1.3 Switch specification

The requirements for an X.25 switch are:

- Must provide X.25 (1984).

- Must provide both switched and permanent virtual circuits.

- Must provide for up to 20 DCE interfaces.

- Must provide for up to 500 virtual circuits.

- DCE interfaces must operate up to 64K bits per second.

- Must provide management facilities.

- Must be capable of supporting the EARN address scheme (X.121).

- Must be capable of 800 packets per second.

- Must be supported in the EARN countries where they will be installed.

## 1.4 Switch suppliers

There are a large number of X.25 switch suppliers most of which expect to develop X.25 (1984) products. A survey in the UK suggested that that there are a number of possible products meeting the EARN requirement (see annex 1). IBM can provide a switching service based on 3725 equipment together with an MVS system for management.

It is essential that the network is provided with a management service and this implies (with the current state of standards) that the switches are provided by a single supplier.

The IBM product, X.25 SNA interconnect (XI), can provide an X.25 network. It has the attraction that some of the equipment required already exists. Currently, of the projected switch sites, only Rutherford and Montpellier have IBM 3725 equipment and thus equipment would be needed at Stockholm and CERN. The purchase of equipment for these sites would incur a high cost, in fact higher than the cost of four switches from an alternative manufacturer. Alternatively a different topology could be considered which would probably incur higher line costs and may have performance implications. Due to the relatively small number of IBM 3725s at the international sites it would not be possible to set up such a network without substantial reconfiguration. The provision of an MVS system to manage the network would not be a problem since this function only requires a fraction of a machine. If existing equipment were to be used then this equipment would in most cases be providing other services and would be more liable to failure or interruption for reasons connected with the local service. It is unclear how prepared sites would be for their equipment to be managed from elsewhere. If new equipment were to be purchased for all the switch sites this would be expensive compared with switches from other sources.

A further advantage of using IBM switching equipment is where countries have substantial amounts of IBM equipment and wish to be part of the

EARN managed X.25 infrastructure then this could be easy and cheap to do. On the other hand countries with little IBM equipment and wishing to be part of the EARN managed X.25 infrastructure would find it expensive compared with the purchase of alternative switches.

The UK switch survey suggests that the TelePAC switch provides the cheapest suitable equipment. The company claim to provide X.25 (1984). Six UK universities and Rutherford now have such switches. The TelePAC switch is based on M68000 processors. It can be expanded up to 32 lines, can switch 1162 packets per second, support 1500 channels, and support lines up to 153K bits per second. It can be mounted in conventional 19inch racks and has no moving parts.

Details of the TelePAC switch are in annex 2. This is not an endorsement of this particular switch but is evidence that at least one suitable switch exists.

If equipment were purchased specifically for the network based on the requirement for up to 8 lines at 4 sites then such switches would cost about 10,000UKL each excluding management equipment.

It is recommended that:
* the EARN X.25 infrastructure be based on dedicated equipment unrelated to equipment used for other purposes.
* EARN should evaluate suitable switches.

## 1.5 X.25 address scheme

EARN must define an X.25 DTE address structure. A number of considerations are relevant:

- The scheme must allow the DTE numbers to be allocated as automatically as possible.

- The leading digit of the DTE must be non zero. The UK has had considerable problems as they have a number of leading zeros in their DTE numbers which has led to ambiguities.

- It is impossible to define an address scheme which harmonises with all the existing networks. To do so would prevent EARN freely allocating numbers or prevent the other networks freely allocating numbers and this is unacceptable.

The CCITT X.121 Recommendation defines a DTE numbering scheme and is the only standard in this area.

X.121 states that an address is of the form:

| | | |
|---|---|---|
| P<br>up to 1<br>digit | DNIC<br>4<br>digits | NTN<br>up to 10<br>digits |

P is the international prefix. As yet its use requires further study by CCITT but it is expected to differentiate between various address formats. From X.121 it is far from clear how the digit is used and the points of question are:

- It is unclear whether the digit is used by the originating DTE in order to control the construction of the DTE number or prefixed to the DTE number and used by the DCE equipment. (Temporary note - I subscribe to the former view).

- As far as is known no PTT uses the prefix as part of the called DTE which is passed to the DCE.

- To avoid ambiguity with a DNIC the prefix may only be 0, 8, or 9.

DNIC is the Data Network identification code. This consists of a 3 digit country code (see below for the European codes or see X.121 for a complete list) plus a further digit to identify the network within the country.

NTN is the National Terminal Number. This is allocated by the network operator. Common use indicated that the NTN should be 8 digits followed by a optional 2 digit subaddress which is not policed by the network. Several administrations split the 8 digit number into an area code (identical or similar to the telephone area codes) plus digits to differentiate between equipment in the area.

Temporary note - HEP have proposed an address scheme for their community which:
- Addresses should be the same address that they have (or would have?) from the PTT.
- If an address is preceded by 9 (that is, the P digit is 9) then the call would go via private networks, otherwise it would go by the public networks.
- It is unclear what happens when a single public DTE number is used to a gateway to a number of machines which may be directly on a private network.
- From X.121 is is unclear whether this is a legitimate use of the P digit. X.121 suggests that the P digit may only be processed by the DTE and may not form part of the DTE number as put in the call set up packet.
- If possible there would be advantage in aligning the EARN address scheme with the HEP one.

Without prejudice to further discussions with HEP and other communities EARN should adopt X.121.

It is considered that the P digit only has local significance.

An attempt could be made to select the fourth digit of the DNIC so as to make the EARN address orthogonal to those of the PTTs. There is no guarantee that this can be achieved or maintained. There could be merit in selecting the digit so that EARN is orthogonal to other private networks with which EARN may wish to connect. For the time being the recommendation is to make the digit 0.

The X.121 DNICs for Europe are:

| | |
|---|---|
| Austria | 232 |

| | |
|---|---|
| Belgium | 206 |
| Denmark | 238 |
| Eire | 272 |
| Finland | 244 |
| France | 208 |
| Germany | 262 |
| Greece | 202 |
| Israel | 425 |
| Italy | 222 |
| Ivory Coast | 612 |
| Luxemburg | 270 |
| Netherlands | 204 |
| Norway | 242 |
| Portugal | 268 |
| Spain | 214 |
| Sweden | 240 |
| Switzerland | 228 |

The 8 digit part of the Network Terminal Number defines the data terminal equipment within the country. Countries are responsible for selecting the national number scheme but it is suggested that the first 4 digits should define the site and be based on the public telephone area codes. The subsequent 4 digits should define the DTE within a site. Many public X.25 follow a similar scheme.

The final and optional 2 digits which are termed the subaddress will not be policed by the network. No specific use has been specified for these digits.

It is essential that the DTE numbers are registered centrally in order to maintain the consistency of the network and to provide directory facilities. This should be undertaken by a network management centre.

The recommended scheme will provide a firm base for almost unlimited growth both in the countries connected and within the countries and sites.

It is recommended:
* EARN uses a number scheme based on CCITT Recommendation X.121.

* DTE number should be-

| DNIC 4 digits | NTN | | |
|---|---|---|---|
| | 4 digit site code | 4 digit machine | 2 digit subaddress |

* The fourth digit of the DNIC should be selected by the country but 0 is recommended.
* It is recommended that the '4 digit site code' should be selected by the country and that it is based on telephone area codes.
* It is recommended that the '4 digit machine' should be selected by the site but a country may wish to impose further recommendations.
* The optional '2 digit subaddress' will not be policed by the network and the use to which these digits are put is not defined.
* The DTE numbers shall be registered with a network management centre.

1.6 Management centre

The X.25 infrastructure will require management to:

- equipment selection, purchase and installation

- to configure the switches and other equipment

- allocate DTE numbers

- to monitor performance

- to respond to faults

- forward planning.

Initially this will require a modest amount of effort at one central site and a small amount of effort at each switch site. The effort required will increase with the extension of the X.25 network into some national parts of EARN. None the less each country will have the responsibility of managing its part of the network in conjunction with the international management. Further study is needed to provide a more accurate estimate but the total should not be dissimilar to that absorbed by a comparable RSCS network.

It is advisable to locate the centre at a site which already has expertise with network management. This should reduce the costs involved and ensure a high standard of management.

It is recommended that:
* a network management centre is established to undertake the management of the X.25 infrastructure.

1.7 X.25 within a country

It is essential that EARN maintains its connections with the existing user base. It is desirable that EARN has connections to other existing and emerging academic networks.

The decision as to whether EARN within a country will operate over the public X.25 network, use leased lines for X.25, or use some other technology will be a local decision depending on national academic plans.

Countries may wish to share the EARN DTE address scheme. In this case the country may join the EARN X.25 management structure which would (with current standards) almost certainly require them to use the same switches as the international part of EARN. If a country uses alternative switches then they will have to totally manage their network and a suitable management interface will be required to ensure that service is maintained between the networks and that the number scheme remains consistent.

Where countries have entirely separate networks gateways and relays will be required at network or higher levels which are considered in section 8. In this case there may be restrictions on the traffic which can pass between the networks.

It is recommended that:
* Countries migrate their national parts of EARN to use ISO protocols in conjunction with their national academic plans.
* Each country should study and decide how they will connect to the EARN X.25 infrastructure.

## Section 3 - Use of the IBM Network Job Entry protocol

### 1 Network job entry (NJE)

The network products of IBM will normally be based on the SNA (system network architecture) products. Products within this architecture allow the IBM NJE protocol to operate over X.25. This scheme demands the use of X.25 permanent virtual circuits. Currently the PTT X.25 networks do not provide such circuits on international links. In addition several national PTT networks do not provide them.

Temporary note - Recent announcements by IBM indicate that NJE can operate over switched virtual circuits. This announcement has yet to be studied.

The use of the IBM NJE over X.25 products will allow the current EARN traffic generated in the existing nodes to cross the X.25 network with out change to node software or user interfaces. That is, apart from the changes in the nodes directly connected to the X.25 network.

It is possible to operate a number of proprietary IBM protocols over the X.25 infrastructure such as LU 6.2 or IBM 3270. If these protocols are introduced, which patently have no current ISO equivalent, the removal of IBM proprietary protocols will be made more difficult.

It is recommended:
* NJE is provided over the X.25 network as an interim protocol.
* NJE is phased out as suitable ISO protocol products are developed, introduced, and proved to provide a satisfactory service.
* IBM products implementing proprietary protocols apart from NJE should not be allowed to use the X.25 infrastructure.

### 2 Management

It would be possible to consider the NJE over SNA service as a single SNA network and take advantage of the management. This is not recommended as:

- A single SNA management point would have to define and control the addressing and this would be unacceptable to sites as it would limit there ability to control their machines.

- The machines may have to operate the same releases of network software.

- The management of the SNA names and addresses would take considerable effort.

It is recommended:
* Either SNA extended addressing (ENA) or multiple SNA networks interconnected with SNA network interconnect (SNI) are used.

## 3 Software and hardware required

All the international EARN nodes operate under the IBM VM or MVS operating systems and these are the only systems capable of operating NJE over X.25.

For both VM and MVS the software stack is:

```
+--------------------------+
| RSCS V2     or    JES    |---- to national EARN nodes
+--------------------------+
|   VTAM                   |
+--------------------------+
             |
+--------------------------+
|            NCP           |
|           NPSI           |
+--------------------------+
             |
           X.25
```

The software products required are:

ACF/NCP V4 5668-754
ACF/SSP V3
X.25/NPSI 5668-981
ACF/VTAM 5664-280

The hardware required is an IBM 370 computer or similar with an IBM 3720/3725 communications adapter or IBM 4361 or 9370 with integrated communications adapter.

The availability of the hardware and software on international sites is:

| Site | Sys | VTAM | NCP | NPSI | RSCS2 | JES2 | 3720 | 3725 | 3705 | 4705 |
|---|---|---|---|---|---|---|---|---|---|---|
| FINHUTC | VM | | | | | | | | Y(1) | |
| FRMOP11 | VM | Y | | | | Y | | Y | Y | |
| DBNGMD21 | MVS | Y | Y | Y | | Y | | Y | | |
| DEARN | VM | Y | | | Y(2) | | | | Y | |
| EBOUB011 | VM | Y | Y | Y | | | | Y | | |
| CEARN | VM | | | | | | | | Y | |
| EARNET | VM | Y | | | | | | Y | | |
| IRLEARN | VM | | | | | | Y | | | |
| CIEARN | VM | Y(2) | | | | | | Y | | |
| HEARN | VM | Y(2) | | | | | | Y | | |
| UKACRL | VM | Y(2) | Y(2) | Y(2) | Y(2) | | | Y | Y | Y |
| SEARN | VM | Not known | | | | | | | | |
| BEARN | VM | Not known | | | | | | | | |

| | | |
|---|---|---|
| PTEARN | VM | Not Known |
| AEARN | VM | Not Known |
| TREARN | VM | Not known |
| GREARN | VM | Not known |
| TAUNIVM | VM | Not known |
| NORUNIT | VM | Not known |
| DKEARN | VM | Not known |

(1) Equipment on loan from IBM.
(2) Software expected before the end of 1987.

Section 4 - Use of other non ISO.

There are large user communities within Europe who use DECNET, Coloured Book, and other protocols. These communities are unable to move to ISO protocols in the near future. They use a mixture of leased line and public networks.

In the interests of reducing the overall costs to the academic community and the provision of greater connectivity there is merit in allowing such protocols be be used over the EARN X.25 infrastructure.

Such services would have to be provided by connections from the EARN switches to relevant machines or to national X.25 services to which the machines connect. The exact mechanisms will have to be studied within each country. Note that such provisions may require further connections into the proposed switches or for switches to be provided within the relevant countries. The financing of this equipment requires study.

It is likely that there will be a demand for gateways or relays between the various gateways. The provision of these requires further study.

The use of these protocols should be phased out as soon as suitable ISO alternatives become available.

The protocols of most interest are:

- The UK and Ireland both use Coloured Book protocols and until they migrate to use ISO protocols they wish to maintain a Coloured Book service between the countries. There are a number of other European sites using these protocols.

- SPAN (the space physics and astronomy network) and some high energy physicists use DECNET. If EARN were to carry this traffic then it would prevent the development of new separate networks and would allow the current international DECNET networks to amalgamate with EARN should this be thought desirable. Such a development could reduce aggregate costs significantly.

There may be other interim protocols of international interest which could be considered. The increase in the number of protocols should be discouraged to avoid problems in phasing them out.

It is recommended:
* EARN should allow the use of popular high level protocols over the X.25 infrastructure for an interim period.

* The provision of gateways between the various protocols should be studied.
* Discussions should be held with interested parties such as SPAN, HEP SG5, Coloured Book community.
* The use of such facilities should be studied within each country wishing to make use of them.
* The use of such protocols should be phased out as suitable ISO protocols protocol products become available.

## Section 5 - Use of ISO high level protocols

### 1 ISO services

In general the high level protocols require an underlying X.25 network as far medium speed wide area networks, such as EARN, are concerned. At the start of transition the EARN X.25 network will only connect to a small number of machines. Thus the provision of ISO protocols on these machines will attract little use initially. However, such services should be mounted as soon as convenient to gain experience and to encourage the use of ISO protocols.

In addition to the ISO services, converting gateways and relays will be needed to maintain connectivity between users. These are considered in section 8

### 2 CCITT X.400 series Recommendations

The first ISO high level protocol to be introduced is likely to be X.400 the message handling or mail protocol. This protocols is now well developed and there are several implementations now in existence.

Current products are based on the 1984 version. The 1988 version is expected to have various changes which suggest that it would be unwise to provide a service based on the earlier version as this would entail a transition to the later one at some inconvenience.

EARN is now concluding a study of the IBM Heidelberg X.400 system developed by the IBM European Network Centre. The conclusion of the study is that the system is capable of providing a service of the type required by the academic community. It is close to the CEN/CENELEC functional standard and indications are that it will interwork with other implementations. The group understands that the system is being modifies to operate over the IBM X.25 supported products and will therefore be able to coexist with the NJE product. It currently uses an IBM Series/1 computer to provide the X.25 packet service. The system has the useful facility of allowing part of the user agent to be remote and across an NJE or other suitable network. This will allow X.400 to be available rather more widely than the EARN X.25 infrastructure. There are a number of other X.400 products such as EAN, for use with VAX computers, and DEC's own X.25 product. As these products do not operate on the international nodes their use becomes of interest as the EARN X.25 network expands into countries or connects to other X.25 networks.

The product stack for an IBM VM system is:

```
+-------------+
|Heidelberg   |
|X.400        |
+-------------+
|   OTSS      |
+-------------+-----------+
|   OSNS      |  RSCS V2  |---- to national EARN nodes
+-------------+-----------+
|   VTAM                  |
+-------------------------+
            |
+-------------------------+
|           NCP           |
|          NPSI           |
+-------------------------+
            |
           X.25
```

It is recommended:
* The Heidelberg X.400 system based on the OTSS and OSNS products is provided on the EARN international VM nodes.
* X.400 services should be provided to other EARN VM nodes over RSCS as required.

## 3 CCITT X.3, X.28, and X.29 Recommendations

X.3, X.28, and X.29 provide interactive services. They are not and are unlikely to become ISO standards. They are popular and implementations are widely available. If offered this will provide a new type of service for EARN.

Although the basic protocol is matched to simple terminals it has been found possible to provide more complex services such as IBM 3270 albeit at a slow speed using protocols over X.29. For example, the Rutherford 'async 3270' and the UK 'simple screen mode protocol'.

No extra equipment or expense is involved in the provision of this service by EARN although countries or sites may wish to provide PADs (packet assembly disassembly facility) to aid access.

Systems providing the protocols should conform to functional standards Y/11 and Y/12.

It is recommended:
* CCITT X.3, X.28, and X.29 should be allowed to use the X.25 infrastructure.

## 4 FTAM, VTP, and JTP

The ISO protocols FTAM (file transfer and manipulation), VTP (Virtual terminal protocol), and JTP (job transfer protocol) are not as well developed as other protocols.

FTAM implementations should be available in a year or so and pilot implementations are now in existence. If these implementations are used then services may be disrupted as the products developed and possible change to align with the functional standards being elaborated.

VTP and JTP standards are unstable and implementations are unlikely in the foreseeable future. EARN is particularly interested in VTP developments since many services now require full screen services as provided on local terminals by IBM 3270 and DEC VT200 equipment.

It is recommended:
* FTAM is not promoted until suitable stable products are available.
* EARN should monitors the development of the VTP and JTP standards and subsequent products and promotes them at a suitable future date.

## Section 6 - National components of EARN.

### 1 Types on national components.

There are three cases to be considered:

- Where a non ISO network already exists.

- Where a country has an ISO network.

- Where a country has an ISO network which is part of EARN.

### 2 Existing non ISO networks.

Currently all networks fall into this category. Initially EARN will only provide ISO protocols at and below network layer.

A variety of converting relays and gateways will be required. Many of these exist or are under development. The products required will change as EARN and the national networks develop. The availability of such products is examined in section 8.

In the initial stages of transition, that is with IBM NJE protocols over X.25, all the current relays (there are no gateways in the strict meaning of the term) will continue to operate unchanged. Thus user will perceive no change in the perception of the service.

The application relays depend on the use of high level addresses such as those found in X.400 and RFC822. In both of these areas agreements are required. There is some progress in this area within RARE.

### 3 ISO networks.

On the assumption that EARN and the national network will be running compatible products, that is conforming to relevant functional standards, then there will be network level relays between the networks. In the mean time it is difficult to make any further statements as plans for such networks are only now emerging and certainly there are no definitive statements.

The use of network level gateways requires the use of NSAP (Network Service Access Point) addresses and these are an area of study. EARN will need to study how it will connect to such networks as their details emerge.

4 EARN within a country.

In a number of cases countries may wish to share the EARN X.25 DTE number plan in which case they will be part of EARN as regards the services offered at the X.25 level. If they use the same switch manufacturer then the network management will be able to be common. If different switch manufacturers are selected then it is unlikely that the management will be common and suitable pragmatic management arrangements will have to be developed to maintain the service between the networks in each case. There will clearly be advantages with respect to reliability and availability if the management is common but the political and financial consequences require study.

Although in this case the X.25 network would be common the higher level protocols may be different although this would be undesirable. None the less if it is the case converting relays or gateways may be needed.

It is recommended that:
* further study is required within each country to determine what developments should take place.

## Section 7 - The phasing out of non ISO protocols.

The fist target is to provide an international X.25 infrastructure and to encourage the development of an X.25 network within each country. For financial and political reasons whether this takes place and by when cannot be stated. Therefore, in practical terms the discussion is centred on the phasing out of non ISO protocols on the international X.25 infrastructure.

With an X.25 network it is not possible to police the higher level protocols used and therefore the phasing out of non ISO protocols can only be by removing their use within a country and/or by providing suitable converting relays and gateways between the national networks and the international part of EARN.

The principle protocol to be phased out is NJE which would include the use of RFC822 over NJE. The prerequisites for this are an X.400 to RFC822 relay and an FTAM to NJE relay or gateway. Since EARN currently uses these protocols exclusively and some countries are likely to take some time to be in a position to phase them out it is likely that there early removal will be difficult. Relays exist between NJE and Blue Book file transfer and DFN file transfer. These protocols are expected to have gateways or relays to FTAM which will remove the need for relays to NJE.

It is understood that DEC intend to migrate DECNET to ISO protocols. The details of this move are not entirely clear as there are some services within DECNET which currently have no ISO counterpart.

The UK is planning to phase out the use of Coloured Book protocols in favour of ISO ones. Any use of these protocols within EARN is therefore expected to cease with their removal from JANET.

## Section 8 - Gateways and relays.

### 1 The need for relays and gateways.

A number of converting relays and gateways will be required in order to preserve the current connectivity and to enable EARN to reach a larger population.

### 2 Converting relay between NJE and NJE over X.25.

A converting relay is required between IBM NJE over bi-synch and IBM NJE over X.25. This relay is essential for connecting the current EARN network to the proposed X.25 infrastructure and is provided as a supported product from IBM.

### 3 Converting relay between RFC822 and X.400.

X.400 is expected to be the first ISO high level protocol be be used over the EARN X.25 infrastructure.

DFN is promoting the production of an RFC822 to X.400 relay which is being undertaken by Softlab GmbH. It is hoped that EARN will be able to use this product which will be an important and essential for providing a gateway between the RFC822 and X.400 communities. The product will operate operate under the IBM VM operating system and therefore further hardware should not be required. The product is scheduled for completion by the end of 1987.

The relay between RFC822 and X.400 is expected to be in accordance with RFC987. This raises difficulties as the address scheme of EARN is unsuitable as it is not based on domain concepts. It is possible to modify the EARN RFC822 address scheme to be changed to provide a domain address scheme which would be easy to relay. Details of this scheme is in section 14.

A relay exists between Grey Book mail and X.400 which operates on a VAX. Such a product will be required if EARN moves to X.400 before the Coloured Book community. This product has been developed by the Computer Science Department of University College London.

It is recommended that:
* a gateway be provided between X.400 and RFC822.
* the availability and functional specification of the DFN promoted product should be studied.
* the availability and functional specification of the Grey Book to RFC822 product should be studied.
* the EARN RFC822 address scheme is modified to a domain scheme. It is recommended that pressure is brought to bear on all EARN sites to

extensions to X.28 expected in the 1988 Recommendations to allow the extended address to be specified.

It is recommended that:
* no action be taken.

## 8 Converting relay between IBM NJE and Blue Book FTP

A suitable relay exists at Rutherford Laboratory and no further action is required.

It is recommended that:
* no action be taken.

## 9 Relay or gateway between DECNET and other protocols.

The extent to which the EARN X.25 infrastructure will carry DECNET traffic is not known. It must be remembered that DECNET provides process to process communication and that any file transfer facilities are provided by operating system facilities, such as a copy command. JNET may operate over DECNET by one JNET process making a connection to a remote one. The two most satisfactory solutions would either be DECNET on an IBM machine or NJE over X.25 on DEC machines together with suitable relay software, these do not exist and could be substantial projects.

There are two further options for a file transfer gateway both of which have awkward address mechanisms:

- The GIFT project could be extended to include an NJE facility and this could probably be based on JNET. This would allow a user on a DEC machine attached to DECNET to use the COPY command to transmit a file to the GIFT machine which would then use JNET to pass it using the existing EARN protocol.

- JNET can operate over DECNET. This would allow NJE to be carried across X.25. This could be relayed to NJE over bi-synch and so over the current EARN network or eventually to a relay providing NJE over X.25. This requires no software development. The scheme will be suitable for mail. Each DEC site will have to install the JNET software.

For DEC mail the only possibilitiy is the CERN MINT system.

It is recommended that:
* the need for a relay or gateway between DECNET and other protocols should be studied when further information on the use of the EARN X.25 infrastructure by DECNET is known.

## 10 UNIX and UUCP

UNIX systems on EARN have an implimentation of NJE and it would seem unlikely that this could be enhanced to emulate the IBM NJE over X.25. This is a similar position to DEC machines with JNET with the exception that there is no possibility of operating NJE over other low level protocols.

UUCP is the principle file transfer and mail system for UNIX systems and in the main it operates over dial up connections. There appear to be a number of ways of getting between EARN and UUCP which require further study.

It is recommended that:
* the position of UNIX systems within the transition of EARN is further studied.

11 Network level gateways.

Network level gateways will be required between the EARN X.25 infrastructure and some national or public networks. These will be required as these networks adopt X.25 (1984). As yet there is no indication of where such products will come from.

It is recommended that:
* sources of network level gateways should be studied.

12 Other gateways and relays.

This document is not an exhaustive survey of the gateways and relays which may be required.

It is recommended that:
* the need for gateways and relays not mentioned above be studied by each country.

Section 9 - Required products for nodes.

1 Required products for nodes.

This section surveys some of the ISO products which are available. It is not definitive and further details can found from the various suppliers.

2 Nodes operating with IBM VM.

There are a number of products which are of interest from various sources.

The IBM SNA(ISO) products provide services up to and including session level. X.400 has now been announced. As yet FTAM has not been announced. IBM supports X.25 (1980) and has not yet announced support for X.25 (1984). X.3, X.28, and X.29 (1980) PAD and packet mode DTE support is provided but no support for the (1984) version has been announced. It is believed that the 1980 products will interwork with DCE equipment supporting 1984. The provision of 1984 will only become important as the higher level ISO services are introduced and as the need to traverse network gateways develop.

The Heidelberg X.400 system provides support for X.25 (1980) via a Series/1 front end for VM systems. There is no information on the support of X.25 (1984). There is confidence that the Heidelberg system will be developed to operate over the SNA(ISO) products.

There are several other product sets which are mainly aimed at the support of national network services although operating over X.25. Examples of these are the Rutherford Laboratory and Salford University products which support Coloured Book protocols. Indications are that these systems could connect to the EARN X.25 network if required. These systems are likely to be phased out as networks move to use ISO protocols and manufacturer supported products.

Salford university has developed a version of FTAM which operates over a Series/1 front end and indications are that this could coexist with the Heidelberg X.400 system. It may also be possible to develop it to operate over the IBM X.25 product which could give some early services with this protocols. This requires further study.

Note that only IBM computers and systems can offer NJE over X.25 which will limit the penetration of this method of working within countries.

3 Nodes operating with IBM MVS.

As with VM the IBM SNA(ISO) products offer a service up to and including session level. X.400 has been announced for use within DISSOS.

Temporary note - what do we know about X.3, X.28, and X.29 also X.25 (1984)?

A version of the Rutherford Coloured Book protocols operate under VMS.

4 DEC VAX VMS systems.

DEC provides X.25(1984) in the current release of PSI. X.400 is now on field test. FTAM will be available this year but this will be a version conforming to MAP requirements. DEC provides support for X.3, X.28, and X.29 (1984) for PAD and packet mode DTE. There is also a PAD available from St. Andrew's University for the (1980) Recommendations. A version of X.400 is available from Queens University Canada or from Sydney Corporation which has achieved some popularity in the European academic community. This is known as EAN.

The DEC product structure is:

```
+-------------+ +-------------+ +-------------+
| X.400       | | FTAM        | | PSI PAD     |
+-------------+ +-------------+ +-------------+
       |               |               |
+-----------------------------+        |
|            OSAC             |        |
+-----------------------------+        |
              |                        |
+-----------------------------+        |
|            VOTS             |        |
+-----------------------------+        |
              |                        |
+-----------------------------+-------------------------+
|                        PSI  | Packet mode DTE         |
|                             +-------------------------+
|                                                       |
+-------------------------------------------------------+
                               |
                              X.25
```

The hardware required is:

VAX (not micro VAX) with KMS11 or DMF11

or

Micro VAX with KMV11

5 Other systems.

Most, it not all, other systems now have X.25 (1980) support and have plans to provide (1984) versions as well as ISO higher level protocols. Details of these products are of less interest and are not included here.

6 Packet assembly disassembly facilities (PADs).

Many PAD manufacturers are expecting to support the 1984 Recommendations and although migration does not depend on such equipment there will be no difficulty obtaining PADs. PADs supporting the 1980 Recommendations will normally interwork with packet mode DTEs supporting the 1988 ones and vice versa (see Y/11 and Y/12).

7 Screen mode services.

A number of schemes have been developed for supporting IBM 3270 and DEC VT200 over X.29 connections. Async 3270 has been produced at Rutherford and allows special terminals, IBM PCs, or VT200 (connected to a VAX) to operate as 3270 terminals. The UK has develop Simple Screen Mode Protocol which also operates over X.29. This allows a range of terminals to connect to special boxes and emulate a wide range of screen mode terminals. The protocol has also been implemented on an IBM PC. This protocol allows the emulation of many types of screen mode terminal.

The extent of the requirement for screen mode services is not known. The effect of such services on the performance of the network is not known.

Section 10 - Time scales.

All the products required to implement the X.25 backbone are available. It is assumed that before a decision to proceed is agreed that the topology, switch locations, and switch supplier will have been decided. The principle events with respect to a start date when decisions have been agreed and finance is available are:

| | |
|---|---|
| - Decision to proceed | 0 |
| - Order switches | 0 |
| - Order line between Rutherford and Montpellier | 0 (1) |
| - Order line between Rutherford and Stockholm | 0 (1)(2) |
| - Experiment between Rutherford and Montpellier | 3 (3) |
| - Service between Rutherford, Montpellier and Stockholm | 6 |
| - Conversion of CERN/Stockholm and CERN/ Montpellier to X.25 | 8 (4) |
| - Conversion of international sites and topology changes | 6 onwards |
| - X.400 on some international sites | 6 onwards |
| - Provision of RFC822/X.400 gateway | 6 |
| - Migration of national EARNs | 6 onwards |
| - Provision of FTAM, JTP, and VTP | As available |

(1) There is a spare pair of IBM modems from the Rutherford/Dublin link. Rutherford is prepared to loan EARN modems. Eventually modems will be recovered from the redundant lines. Thus no modem purchases are envisaged unless speeds greater than 9.6K are required.

(2) The Stockholm line is dependent on the provision of VTAM, NCP, NPSI, and RSCS V2 at Stockholm.

(3) Rutherford is prepared to loan EARN switch capacity if the delivery of switches is delayed beyond the delivery of the lines.

(4) The conversion of the CERN/Stockholm and CERN/Montpellier line depends on the provision of VTAM, NCP, NPSI, and RSCS V2 and suitable hardware at CERN.

The transition of some international nodes are likely to be delayed by lack of suitable hardware and software. The transition of national parts of EARN will be dependent on local circumstances.

The X.400 system to be used initially will be from Heidelberg but this decision must be reviewed as other systems become available.

X.3, X.28, and X.29 will be provided as and when nodes wish to provide them either as PADs or packet mode DTEs.

Section 11 - Alignment with functional standards.

The aim of functional standards is to ensure that implementations will interwork. CEN/CENELEC and CEPT are producing a range of functional standards which will meet all the requirements of EARN. The functional standards of interest are:

- T/31. This concerns transport service over X.25 and will support X.400 and FTAM. This work is complete.

- Y/11 Y/12. This concerns the CCITT recommendations X.3, X.28, and X.29 for PADs and packet mode DTEs.

- A/312. This concerns the use of X.400 in a private mail domain. The work is complete. There are a number of related functional standards concerned with the use of X.400 in public networks and for various gateway functions.

- A/111 to A/123. These functional standards are for FTAM and the work is just started. RARE will be having a strong input into this activity.

Only the basic version of VTP is complete but this provides little or no further functionality that X.3, X.28, and X.29 provide. The more advanced version is far from stable. Thus no functional standards in this area expected for some time. There is some pressure for a functional standard for ISO 6429 over ISO session from the European commission but this will be unlikely to provide the screen mode services users would like.

Currently no products conform with the functional standards. This situation will change as manufacturers and customers become familiar with them. EARN should attempt to procure conformant products.

In the short term non conformant systems may have to used but EARN should take all possible steps to ensure that the systems migrate to conform.

It is recommended that:
* EARN attempts to use products which conform with the relevant functional standards and brings pressure to bear on suppliers for such products.

Section 12 - Costs.

Detailed costs depend on the exact equipment required and the discounts that suppliers will give.

The funding sources are a matter for the EARN Board of Directors.

1 Switches.

A survey of manufacturers suggests that suitable switches can be obtained for 10,000 UKL making 40,000 UKL in total. See annex 1 and 2.

2 Line costs.

The eventual line charges should be less than the current ones as the topology expected is near optimal from the studies carried out by IBM and D. Lord (annex 4 and the 'financing of EARN in 1988'). Each line relocated will incur an installation charge estimated at 2,000 UKL. There will be an overlap of lines which depends on the overlap time and is estimated at 3,000 UKL.

3 Hardware and software costs.

It is not possible to estimate the cost of IBM hardware and software as these depend on local discounts.

4 National costs.

It is expected that any costs incurred beyond the X.25 international infrastructure (the four switches), some line costs, and possible some costs associated with the international nodes will be met nationally. These costs may include national X.25 switches, further hardware and software on national node, and any line costs.

5 Management.

As with the current EARN network manpower will be required for the management of the X.25 infrastructure. It is reasonable for this to be met centrally. If the management also looks after national parts of EARN then a contribution would be expected from that country. Some effort would be needed during the setting up of the infrastructure estimated at two man months. Running effort would be about one man month a year assuming that the international infrastructure remained fairly static and that the equipment and lines were not unduly unreliable.

Section 13 - Network level addressing

The ISO network service is defined in IS 8348. The network layer is above the X.25 packet layer and below transport layer. It provides an end to end service across a concatenated set of X.25 networks. This is achieved by the use of a 'network service access point' (NSAP) address which defines the remote entity. The NSAP address can be regarded as a global address. In the case of an X.25 network the NSAP address is carried in the 'extended address' which is an 'optional user facility' in the CCITT X.25 (1984) recommendations.

EARN expects to be connected to other X.25 networks with different address schemes and must decide what NSAP address scheme to use.

The NSAP address is 40 decimal digits or binary fields. Since it is more convenient to 'name' entities a name registration mechanism will be needed to define the mapping. Users on other networks will have to have access to the mappings as well as EARN having access to theirs' if entities are to be known universally by names rather than the 40 decimal digits which may also be more liable to change.

EARN will not only have to deal with its own NSAP addresses but also those of other networks to enable such traffic to be directed to the correct gateways. The difficulty, or otherwise, of this will depend on the schemes chosen by the networks and currently only JANET has proposed a scheme.

The OSI NSAP addressing scheme defines a number of allocation schemes for a set of hierarchical nested registration bodies. An NSAP address starts with an initial domain part (ISP) followed by a domain specific part (DSP). The ISP is further divided into an authority and format identifier (AFI) and initial domain identifier (IDI). There are AFIs for various PTT network types (X.121, PSTN, Telex, ISDN, etc) and for ISO network independent schemes. The network independent schemes are the ISO-DCC scheme, which names national registration authorities, and the ISO-6523-ICD scheme, which names international organisations and authorities.

The network independent schemes are preferred as they are not tied to any particular network type and are thus potentially more stable. Note that this type of scheme has been adopted by JANET.

It is unclear whether EARN should regard itself as an international organisation and come under the ISO-6523-ICD scheme or a set of national organisations and be registered with or alongside other national networks. There appear to be three options:

- Like the UK, each national academic community will seek registration and that EARN will use such registrations in collaboration with the community. Thus EARN would seek no independent registrations. On a particular entity there may be ambiguity as to which route specific traffic should follow, for example, EARN or the public network.

- EARN should seek registrations within each country. This would have the considerable disadvantage that a machine connected to a national network and EARN would have two NSAP addresses. There would be no ambiguity with routing. EARN would have to administer these registrations.

- EARN should seek international registration. There will be ambiguity with machines connected to EARN and other networks. EARN would have to administer the registration.

Current opinion is that the EARN international X.25 infrastructure is likely to develop into an overlay network between national networks which would favour the first option.

If ISO-DCC is followed the format of the NSAP will be:

| DIP | | | DSP |
|---|---|---|---|
| AFI | IDI | | |
| ISO DCC AFI (38) | Country identifier ISO 3166 | Allocated by National Administration | For allocation by customer |

The the case of the UK the NSAP will be:

38 826 1100 DSP

where 826 is the UK ISO 3166 code and 1100 has been allocated to JANET by the British Standards Institute.

The format of the DSP has been decided within JANET but each country will have to consider its own schemes or RARE may provide recommendations.

The NSAP should contain the DTE address of the EARN entity or possible the DTE of a local area network the entity is attached to so allowing algorithmic extraction of the DTE address.

It is unclear what facilities suppliers will provide in their products.

It is recommended that:
* that EARN will use the NSAP scheme selected by the national academic communities.
* failing national schemes EARN will use the ISO-DCC scheme pending national decisions.
* EARN will study the options for the DSP where there are no national schemes.
* manufacturers plans for NSAP addressing should be determined.

## Section 14 - Mail addressing.

EARN has connections to several networks providing electronic mail using various protocols and various addressing schemes. Important representatives are ARPA, JANET, UUCP and EARN which use variants of the RFC822 protocol and EAN using a variant of X.400. Further X.400 networks can be expected soon including EARN.

Users require mail exchange between current EARN systems, future EARN X.400 systems and systems accessible via gateways. This involves four protocol/address schemes:

- The native IBM NJE addressing used in EARN

- Internet domain style addressing used in EARN

- X.400 addressing

- Other schemes used in academic networks

1 EARN.

The native IBM NJE-RSCS address scheme used in the IBM systems is the RSCS 'spool tags' or MVS 'destination/subdestination'. It consists of an 8 byte 'user identifier' and an 8 byte 'node identifier'. The RFC822 mail system used within EARN uses these 8 byte pairs as the RFC822 addresses of the form 'user identifier'@'node identifier'. Mail may be generated by the user either by the use of an editor or one of the several mail programs or systems.

Many sites operate mail user agents, for example the Crosswell mailer. These are also capable of utilising the 8 byte 'user identifier' and 'node identifier' pairs. In addition these systems can (generally) deal with 'internet domain addresses'. The internet domain address scheme is based on a hierarchical mail address. They provide an address scheme for a set of concatenated networks. The scheme is used in a number of networks with which EARN and BITNET have connections. The top level domains have tended to be large organisations in the states, such as EDU or BITNET, whereas in Europe the ISO 3166 two character country codes are favoured. The second and subsequent levels are at the discretion of the organisation 'owning' the top level domain. For example, CAMBRIDGE.AC.GB could be the address of some facility in Cambridge which is within the academic community which is within Great Britain.

There are conflicts with domain addresses in that an address may be reachable via several routes or no routes. For example, name@VAX1.CAMBRIDGE.AC.GB generated in domain EDU, say, may arrive via:

- The Wisconsin (ARPA to BITNET) and Rutherford (EARN to JANET) gateways.

- The Pisa (ARPA to EARN) and Rutherford (EARN to JANET) gateways.

- The University College London (ARPA to JANET) gateway.

The problem can be overcome by the use of 'source routing'. This requires the user to have knowledge of the route the mail is to take. The use of such routing is discouraged and not universally supported.

In some cases a country may be in several disjoint mail systems and only particular routes will be successful. For example, name@BONN.GMD.DE may be accessible via EARN but not DFN. The basis of domain names is in RFC 920. RFC997 defines the internet addressing rules.

It would be possible to register the address of all entities centrally but this is unlikely in view of their large number. It is more likely to be done on a per domain basis.

2 X.400.

X.400 addressing is based on OR (Originator/Recipient) names. A name consists of a number of 'attributes'. The registration of OR names or parts of them is unclear. In some countries it is expected that this will be organised by government agencies. The attributes are:

- CountryName. The fairly reasonable assumption is that a given mailbox will reside in a single country. CCITT recommends that this should be the X.121 code or the ISO 3166 two character country code.

- AdministrativeDomainName. A country may have a number of suppliers of public mailbox facilities, such as TELEBOX in Germany, which will each have a unique name. Thus mail can in principle flow between various systems run by the administrations.

- PrivateDomainName. An organisation, for example JANET, may wish to set up a private mail system.

- Organisation Name. Normally the name of the organisation. For example 'Siemens'.

- Further fields define a OrganizationalUnit and the actual name of a person which do not concern this discussion.

CCITT claim that Country and AdministarationDomainName are mandatory. The implication of this is that PTTs expect mail passing between private mail domains is expected to pass through a public one. Some commentators believe that such an activity is un-enforceable both practically and legally. For example, it does not seem possible to legally differentiate between mail and other data traffic.

ISO regard both PrivateDomainName and Administrativedomainname as optional. This recognises that private mail domains may interconnect directly but still recognising the possibility of public suppliers providing the interconnection between private mail systems if wanted.

An EARN X400 service may take a number of options:

- Ignore other activities and define a scheme most convenient to EARN. For example, define a PrivateDomainName of EARN and allocate an OrganizationName to each site. This strategy will require complex gateways between the EARN X.400 service and other ones. Many users may have different names depending on where mail is coming from which will create considerable confusion.

- Follow the strategy taken in each country. The principle advantage is that no application level relay would be required to the X.400 academic services provided by any national academic mail service. The disadvantage will be that EARN may have to provide its own relays between its various national components. Fortunately it is highly likely that RARE will recommend the form of names for use within Europe which will remove, hopefully, the need for EARN relays.

It is unclear what name structure will be recommended by RARE. There is some pressure for the country name to be longer than two characters (against CCITT Recommendations). However there is some agreement that the X.121 codes should not be used. It is unclear whether the AdministrativeDomainName will be used and if used which one of the several registered in a country will be used.

The PrivateDomainName may be allocated on a per site basis in some countries (Germany) while in others the academic community is expected to have a single name for the community and for an OrganizationName to be allocated to a site.

Temporary note- The author has not been reading the latest documents from the relevant RARE working party and the above comments may be out of date.

3 Converting relays between RFC822 and X.400.

EARN will require a relay between RFC822 and X.400. Recommendations are needed for the address mappings which may be different in different countries but should follow RFC 987.

If EARN were to use domain addressing then it would be possible to follow the recommendations in RFC 987 which defines how an RFC822 to X.400 should operate. It would not be possible for mail based on the EARN 8 byte 'user identifier' and 'node identifiers' to pass through a relay to X.400. It would be possible for X.400 mail to pass through a relay and to sites only accepting the 8 byte form. This would be undesirable in the interests of a consistent address strategy.

The key document for the production of an RFC822 to X.400 gateway is in RFC987. The fields of the X.400 name are mapped to the components of an RFC822 name. The RFC987 assumes that the RFC822 name follows the DARPA domain recommendations.

Domain addressing with RFC822 (see RFC920) demands that a mail box has a unique name and address. The address has a hierarchical form so that addresses can be selected at a particular level without reference to other parts of the structure while still maintaining uniqueness.

The top level is normally a country code and it is recommended that this is the two character ISO 3166 code. The structure below the country code is at the discretion of the 'owner' of the country code. In general this would take the form of an organisation such as an academic community. At the next level there would be a site name. At the bottom level the name of a machine. However there is considerable flexibility at the lower levels. The name and address are separated by '@' and the domain components by '.'. The most significant part of the address comes last. A typical name and address would be:

P.Bryant@IBM-B.Rutherford.AC.GB

It is unclear what the exact form of RFC822 and X.400 addresses will be within Europe. It is fairly certain that the country code in X.400 and in RFC822 will be the two character ISO 3166 one.

It should be added that the adoption of domain addressing will allow a much more flexible mail service in that it will no longer be necessary for each site to have a record of the universe of mail addresses within EARN.

Some minor developments within the mailer may be needed.

The ISO 3166 European two character codes are:

| | |
|---|---|
| Austria | AT |
| Belgium | BE |
| Denmark | DK |
| Eire | IE |
| Finland | FI |
| France | FR |
| Germany | DE |
| Greece | GR |
| Israel | IL |
| Italy | IT |
| Ivory Coast | CI |
| Luxemburg | LU |
| Netherlands | NL |
| Norway | NO |
| Portugal | PT |
| Spain | ES |
| Sweden | SE |
| Switzerland | CH |

The RFC822 mail systems would require rather more extensive tables since they would have to know about each RFC822 to X.400 gateway and which addresses should be sent to it. For example it is likely that all addresses ending in AC.UK would go to a single gateway. In Germany there is expected to be many PrivateDomainNames and mail would be directed to one or more gateways. This situation may become more complex if countries decide on a wide variety of interpretations of the X.400 OR name. This reinforces the urgent need for EARN recommendations for mail addressing and address mapping.

It is likely that nodes will be members of EARN as well as other networks. Ideally the address of an entity should be the same for all the networks connected to. This implies that EARN should make an attempt to use any address scheme decided on within the academic community of a country. This should present few problems as it is expected that RARE will provide recommendations. Thus each country must discuss their X.400 addressing with RARE.

The conclusion is that RFC822 mail within EARN should adopt domain addressing. This will involve a radical change in EARN mail. It will cause difficulties with sites not operating mail systems. There is therefore an urgent need to encourage all sites to operate mail systems and to use domain addressing as soon as possible.

The EARN mail systems would have to be adapted to deal with addresses in a given domain some of which are in EARN and some which may not. The Crosswell mailer is capable of this but a study of other mail systems is required.

It is recommended that:
* EARN RFC822 addressing adopts domain addressing with the top level being the ISO 3166 two character code. The rest of the domain structure is for a national decision based on the form that the X.400 OR names take in that country.
* pressure is brought on all sites within EARN to operate mail services and for the above recommendations to be followed.
* a full specification of proposed EARN RFC822 mail service should be

drawn up.

.* the various mail systems should be studied to determine if any developments are required.

## Section 15 - Definitions.

Product - any protocol implementation rather than the IBM specific meaning of an IBM strategic product. Where necessary it is qualified by terms such as 'experimental', 'pilot', or 'supported.

Relay - a mechanism whereby a file is completely received at some point between a originator and a receiver before being resent towards the receiver. For example, in an IBM NJE network every intermediate node acts a relay.

Converting relay - a relay which undertakes a protocol conversion. For example, the gateway between EARN and JANET relays file transfers and also converts between IBM NJE and Blue Book file transfer.

Gateway - a mechanism through which an end to end connection may be made and which may undertake some address manipulation, authorisation, accounting or similar functions. For example, where two X.25 networks connect a gateway would be required to solve address conflicts between the two networks.

Converting gateway - a gateway where a protocol conversion takes place. For example the GIFT machine provides a converting gateway between Blue Book file transfer, DECNET, and CERNET file transfer.

## Section 16 - References.

The CEN/CENELEC CEPT functional standards are:-

| | | |
|---|---|---|
| PrENV 41 104 | T/31 | Transport service over X.25 |
| PrENV 41 201 | A/3211 | MHS-UA+MTA: PRMD-PRMD (P2+P1) |
| | A/323 | MHS-(Intra-PRMD) (P2+P1*) |
| | A/325 | Mailbox Service Access (P7) |
| | A/111 | Simple File Transfer |
| | A/112 | Positional File Transfer |
| | A/113 | Full File Transfer |
| | A/122 | Positional File Access |
| | A/13 | File Store Management |
| PrENV 41 901 | Y/11 Y/12 | X.3, X.28, and X.29 |

Note- Items with no Prenv numbers are not available but are currently of secondary interest.

ARPA RFC references:

D H Crocker, Standard of the Format of ARPA Internet Text Messages, RFC 822, August 1982.

J Postel and J Reynolds, Domain Requirements, RFC 920,

S Kille, Mapping Between X.400 and RFC 822, RFC987, June 1986.

ISO references:


ISO 6429, Information Processing - ISO 7-bit and 8-bit coded character sets - Additional control functions for character-imaging devices. IS: 1983.

ISO 7498, Information Processing Systems - Open Systems Interconnection - Basic Reference Model IS: 1984

ISO 7776, Information Processing Systems - Data Communications - HDLC - Description of the X.25 LAPB compatible DTE single link procedure DIS May 1985.

ISO 8072, Information Processing Systems - Open Systems Interconnection - Transport Service Definition IS: 1986.

ISO 8073, Information Processing Systems - Open Systems Interconnection - Transport Protocol Definition IS: 1986.

ISO 8208, Information Processing Systems - Data Communications - X.25 packet level protocol for DTE DIS March 1985.

ISO 8326, Information Processing Systems - Open Systems Interconnection - Basic Connection Oriented Session Service Definition DIS September 1984

ISO 8327, Information Processing Systems - Open Systems Interconnection - Basic Connection Oriented Session Protocol Definition DIS September 1984.

ISO 8348, Information Processing Systems - Data Communications - Network Service Definition DIS July 1985.

ISO 8571/1, Information Processing Systems - Open Systems Interconnection - File Transfer, Access and Management - Part 1 : General Description DIS July 1986.

ISO 8571/2, Information Processing Systems - Open Systems Interconnection - File Transfer, Access and Management - Part 2 : Virtual Filestore DIS July 1986.

ISO 8571/3, Information Processing Systems - Open Systems Interconnection - File Transfer, Access and Management - Part 3 : File Service Definition DIS July 1986.

ISO 8571/4, Information Processing Systems - Open Systems Interconnection - File Transfer, Access and Management - Part 4 : File Protocol Specification General Description DIS July 1986.

ISO 8648, Information processing Systems - Data Communications - Internal Organisation of the Network Layer DIS February 1986.

ISO 8822, Information Processing Systems - Open Systems Interconnection - Connection Oriented Presentation Service Definition DIS May 1986.

ISO 8823, Information Processing Systems - Open Systems Interconnection

- Connection Oriented Presentation Protocol Definition DIS May 1986.

ISO 8824, Information Processing Systems - Open Systems Interconnection - Specification of Abstract Syntax Notation One (ASN.1) 2nd DIS May 1986.

ISO 8825, Information Processing Systems - Open Systems Interconnection - Basic Encoding Rules for Abstract Syntax Notation One (ASN.1) 2nd DIS May 1986.

ISO 8878, Information Processing Systems - Data Communications - Use of X.25 to provide the OSI Connection-oriented Network Service DIS March 1986.

ISO 8880/1, Information Processing Systems - Data Communications - Specification of Protocol to Provide and Support the OSI Network Service - Part 1, General Principles 2nd DP June 1986.

ISO 8880/2, Information Processing Systems - Data Communications - Specification of Protocol to Provide and Support the OSI Network Service - Part 2, Provision and support of the Connection-mode Network Service 2nd DP June 1986.

ISO 8883, Information Processing Systems - Text Communications - Message Oriented Text Interchange System - Message Transfer Sublayer, Message Interchange Service and Message Transfer Protocol Dis 1986.

ISO 9065, Information Processing Systems - Text Communications - Message Oriented Text Interchange System - User Agent Sublayer, Interpersonal Messaging User Agent - Message interchange formats and Protocols. DIS October 1986.
ISO 9066, Information Processing Systems - Text Communications - Message Oriented Text Interchange System - Reliable Transfer Service and use of Presentation and Session Services DP December 1985.

CCITT Recommendations:

X.3 Packet Assembly/Disassembly Facility (PAD) in a Public Data Network. CCITT Red Book, Volume VIII - Fascicle VIII.2, 1984.

X.25 Interface between Data Terminal Equipment (DTE) and DTA Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode and Connected to Public Data Networks by Dedicated Circuit. CCITT Red Book, Volume VIII - Fascicle VIII.3, 1984.

X.28 DTE/DCE Interface for a Start-stop Mode Data Terminal Equipment Accessing the Packet Assembly/Disassembly Facility (PAD) in a Public Data Network Situated in the same Country. CCITT Red Book, Volume VIII - Fascicle VIII.3, 1984.

X.29 Procedures for the Exchange of Control Information and User Data between a Packet Assembly/Disassembly (PAD) Facility and a Packet Mode DTE or another PAD. CCITT Red Book, Volume VIII - Fascicle VIII.3, 1984.

X.400 Message handling systems: System model-service elements, CCITT Red Book, Volume VIII - Fascicle VIII.7, 1984.

X.401 Message handling systems basic service elements and optional user facilities. CCITT Red Book, Volume VIII - Fascicle VIII.7, 1984.

X.408 Message handling systems: encoded information type conversion rules. CCITT Red Book, Volume VIII - Fascicle VIII.7, 1984.

X.409 Message handling systems: presentation transfer syntax and notation. CCITT Red Book, Volume VIII - Fascicle VIII.7, 1984.

X.410 Message handling systems: remote operation and reliable transfer server. CCITT Red Book, Volume VIII - Fascicle VIII.7, 1984.

X.411 Message handling systems: message transfer layer. CCITT Red Book, Volume VIII - Fascicle VIII.7, 1984.

X.420 Message handling systems: interpersonal messaging user agent layer. CCITT Red Book, Volume VIII - Fascicle VIII.7, 1984.

List of IBM documents to be supplied:

List Of RARE documents to be supplied:

Other references:

Transition to OSI standards, Report of the UK Academic Community OSI Transition Broup, 1987.

D. Lord, The funding of EARN for 1988.

Section 17 - Abbreviations.

| | |
|---|---|
| BOD | The EARN Board of Directors |
| CCITT | Comite Consultatif International Telegraphique Telephonique |
| CEN/CENELEC | Comite Europeen de Normalisation/ Comite Europeen de Normalisation Electrotechnique |
| CEPT | Conference Europeenne des Administrations des Postes et Telecommunications |
| DTE | Data Terminal Equipment |
| EARN | European Academic Research Network |
| FTAM | File Transfer and Management |
| IBM | International Business Machines |
| ISO | International Standards Organisation |
| JTP | Job Transfer Protocol |
| MHS | Message Handling Service |
| NSAP | Network Service Access Point |
| OSI | Open Systems Interconnection |
| PRMD | Private Mail Domain |
| PTT | Posts, Telegraphs and Telephones ? |
| RARE | Reseaux Associes pour la Recherche Europeenne |
| RFC | Request For Comment |
| RSCS | Remote Spooling and Communications System |
| SNA | Systems Network Architecture |
| VAX | |
| VM/CMS | Virtual Machine/Conversational Monitor System |
| VTP | Virtual Terminal Protocol |

ANNEX I

EDINBURGH REGIONAL COMPUTING CENTRE

COMMUNICATIONS GROUP

# X.25 Packet Switch Survey

## 1ST STAGE REPORT

### 1. General

A total of twenty four manufacturers have been approached to determine what X.25 packet switch equipment they sold and to do a brief examination into whether the equipment would be suitable for use in the Academic Community.

Of particular interest were those manufacturers who could provide equipment of greater connectivity and capacity than the existing GEC 4190 and those who sell very small switches.

### 2. Products

The following systems we found to be currently marketed:

```
Amdahl:         BBN:            BT:          Camtec:      DCA:
Dynatech:       GEC:            IPAC:        Memotec:     Motorola:
Northern Telecom:               Plessey:     SESA:        STC:
Telefile:      Telematics:      Thorn-Ericsson.
```

The following companies were approached but do not offer a distinct switch at this time:

```
CASE:          Logica:                      Timeplex (PADs only):
Jaguar:        Gandalf (PADs only):         Norsk Data.
```

In addition to the above list XTEC, currently selling PADs, aim to sell a switch shortly but no details can be obtained yet. IAL (part of STC/ICL) sell a switch but it is made by Telematics.

SESA have been approached more than once but have not sent any details.

### 3. Basis of Comparison

The basis of comparison for the alternative systems has been the JNT X.25 switch specification, expanded to include a switch with 10 ports (one at 48 kb/s) and a switch of 100 ports (8 at 48 kb/s). The prices which have been obtained are for one-off systems and the throughput figure has been adjusted where necessary to use the same meaning as in the JNT specification.

4. Results

For each of the available products a summary of the main features. In addition to these summaries two tables have been included, the first shows the approximate cost of each system and the second gives a one line comment on the product. A summary has not been prepared for either GEC or Camtec as it was felt that their products were well known within the Academic Community.

5. Confidentiality

The only confidential details in this report one the specific cost of the Telematics product which were quoted by ICL

6. Short List

Apart from GEC and Camtec who will be used as a 'benchmark' to gauge the other products it is recommended that the following are investigated in more detail:-

1. Telematics: as they produce an attractive product in all parts of the size spectrum.

2. Amdahl: as an alternative large switch.

3. Dynatech: as a main line supplier of small switches.

4. Telefile: as an alternative small to medium switch.

B. Gilmore
Oct. 1985.

# Summary

Amdahl : Cost is rather high.

BBN : Addressing problems and separate NOC required.

BT : Packet rate is very low.

DCA : Restriction on number of virtual calls per link.

Dynatech : Proposed for short listing.

IPAC : Only 9.6 kb/s lines supported.

Memotec : Configuration is too restrictive.

Motorola : Cost per line is very expensive

Northern Telecom : Basic cost of a switch is too high.

Plessey : Performance doesn't reach the JNT spec.

SESA : No information received.

SIEMENS : Addressing and throughput problems.

STC : Initial cost is too high.

Telefile : Proposed for short listing.

Telematics: Proposed for short listing.

Thorn -Ericsson: Cost is too high.

# Maximum Line Speeds

| | |
|---|---|
| Amdahl | 64 kb/s |
| BBN | 64 kb/s |
| BT | 48 kb/s |
| DCA | 64 kb/s |
| DYNATECH | 64 kb/s |
| IPAC | 9.6 kb/s |
| MEMOTEC | 64 kb/s |
| MOTOROLA | 72 kb/s |
| NT | 128 kb/s |
| PLESSEY | 64 kb/s |
| SIEMENS | 64 kb/s |
| STC | 64 kb/s |
| TELEFILE | 153 kb/s + |
| TELEMATICS | 64 kb/s |
| THORN ERICSSON | 64 kb/s |

# AMDAHL

## 1. General

Amdahl supply a wide range of X.25 equipment which can be put together to provide extremely large networks. The equipment is based on a multi-micro processor architecture and although no store sizes are quoted it is stated that the largest switch can handle 2000 simultaneous calls, expandable to 6000 calls.

## 2. Configuration Options

There is a Network Concentrator, called the 4415, which can support up to 40 links. The main switch called the 4410 Series, can spport more than 100 links and its power can be expanded by the addidition of two extra Processor Units and an optional accelerator unit.

## 3. Line Speeds/Interface Options

The 4415 supports only V24 at speeds up to 19.2 kb/s, the 4410 supports V24 and V35 at speeds up to 64 kb/s.

## 4. Throughput

The 4415 has a maximum packet rate of 60 packets/sec, the 4410 has a basic rate of 450 packets/sec upgradable to 1,350 packets/sec.

## 5. Costs

The 4415 configured with 24 links (the first configurable size above 18 links) costs £18,000. However, the 4415 requires a Network Administrator to control it (at a cost of £36 K). One would suffice for all universities although operationally this would not be practicable. A 4415 Network Administrator cannot be used to control or manage a 4410.

The 4410 costs a basic £80,000. In addition a 9.6 kb/s interface costs £1000 with a 48 kb/s interface costing £2000.

```
4410:  48 lines  -  £132,000
      100 lines  -  £188,000
```

## 6. Multinode Networks

The switch is designed to fit in a large multinode network and uses a modified X.25 to communicate between the switches.

## 7. Addressing

Although a line would normally have a single address, other mechanisms are available to achieve the desired flexibility.

## 8. Network Management

Comprehensive.

## 9. Operator Control

Comprehensive facilities are available.

## 10. Summary

The 4415 is too expensive because of the need for seperate network management.

The 4410 would be a feasible 'top end' switch but the cost is rather on the high side.

# BBN

## 1. General

BBN offer a range of X.25 networking products that form either entire networks or networks with value added services such as electronic mail. The range of products include switches, pads, Network Operation Centres, service hosts and network authorisation machines.

The switch equipment is based on a microprocessor designed and built by BBN. Connection to public data networks is normally done via a Dynatech gateway machine.

The largest switch has 1/2 Mbyte of memory and can support 1000 simultaneous calls. A MTBF of 8000 hours is stated for the C30. A maximum packet size of 1024 is supported.

## 2. Configuration Options

Two different switches are supplied, the C30 and the C300. The C30 will support a total of 44 links, of which up to 14 can be inter-network links. The C300 supports up to 64 links of which 14 can be inter-network links. The minimum size in both cases is 8 lines, expandable in groups of 8.

## 3. Line Speeds/Interface Options

Line speeds of up to 64 kb/s are supported using V24, V35 and RS449. Up to 32 links running at speeds greater than 19.2 kb/s can be supported per switch.

## 4. Throughput

For inter-site traffic (DTE-DTE) the C30 has a maximum throughput of 200 pkts/sec (400 data pkt), the C300 has a throughput of 450 pkts/sec. For DTE-trunk traffic the throughput is halved.

## 5. Costs

The C30 costs from £60 - 80K
The C300 costs from £80 - 100K

## 6. Multinode Networks

The switches are designed to operate in a multinode network and they use a private datagram protocol between the switches.

7. Addressing/Routing

There are two forms of address, a physical address and a logical address. The logical address can be used to form link groups or give a particular DTE a range of addresses over multiple switches BBN have chosen to use the 5th octet of the X.121 address but to distinguish between the two forms. This would mean conflict with our current addressing strategy.

Routing is achieved by dynamic load balancing on a per packet basis.

8. Network Management

Network Management is performed by a Network Operations Centre.

9. Operator Control

Operator control is also performed by the NOC and the facilities appear to be fairly comprehensive.

10. Conection to PSS

BBN recommend the Dynatech 'Adress Translator' to couple BBN and Public Data Networks.

11. Summary

The need for a NOC, the restriction in addressing, the low packet throughput coupled with the problems of attaching to Public Data Networks rule out the use of this equipment for campus networks.

# B.T.

## 1. General

BT sell small X.25 switches under the name **Packet NetMux**: this is a Z80 based system with a maximum 40 Kbytes of store.

## 2. Configuration Options

Packet NetMux can be configured with up to 7 X.25 links.

## 3. Line Speeds/Interface Options

Line Speeds of up to 48 kb/s can be supported (at least on a hardware level) supporting V24 or V35.

## 4. Throughput

The maximum packet rate is 16 packets/sec. When BT were asked about 48 kb/s support, the response was that it could attach at this speed but not support the potential packet rate.

## 5. Costs

Costs vary from £4,480 for 2 links to £5,605 for seven links.

## 6. Multinode Networks

Can be done using X.25.

## 7. Known Problems

Apart from the inadequate packet throughput, the following points fail to meet the JNT spec.

1. Packet and Window size are fixed at 2 and 128.
2. Addressing/Routing is extremely inflexible.
3. All configuration details, including addressing, timing and DTE/DCE are fixed and can only be changed by BT.

## 8. Summary

With the above problems Packet NetMux is not suitable for use in the Academic Community.

# DCA

## 1. General

DCA provide an X.25 interface to their DCA System 355 Master Network Processor which is primarily aimed at the terminal switching market. This equipment may be used as a switch and PAD facilities are also provided.

The X.25 interface is supported on a sepera card and with its own micro processor that fits into a card slot of a system 355. There is a major drawback in that any one card can only support 32 virtual calls. A maximum packet size of 2048 bytes is supported but there is no negotiation of packet or window size allowed.

## 2. Configuration Options

A maximum of 44 X.25 lines can be supported.

## 3. Line Speeds/Interface Options

Two options are available, first a card that drives a single 9.6 kb/s line and secondly a new pair of cards that drive 2 lines both at speeds up to 64 kb/s.

A maximum speed of 19.2 kb/s can be supported using V24 and up to 64 kb/s using V35.

## 4. Throughput

It is claimed each X.25 card can handle the maximum throughput that a 19.2 kb/s link can produce and that there is no limitation on carrying this across the lines when generated by all the ports. There is no evidence that this has ever been tried out.

## 5. Costs

A basic DCA 355 costs £6,925 (including X.25 Software). The cost of each 9.6 kb/s port is then £1,448 and pair of 64 kb/s ports cost £3,935. Thus:

10 ports - £22,444
18 ports - £37,968

## 6. Miltinode Networks

System 355s uses an internal protocol when interconnected. For large networks, DCA would recommend Telematics but their systems have not been properly integrated with the Telematics equipment.

7. Addressing

Either individual addresses or a 'wild card' system can be used.

8. Network Management

There are two packages available using an IBM PC/XT or AT which can provide alarm logging and a colour graphics package.

9. Operator Control

Only a pre-defined terminal, ie. one that is attached to a System 355, can be used for switch control.

10. Summary

The limit of only 32 virtual calls per X.25 card, the lack of packet and window size negotiation, and the rather high price per port make this equipment too constrained for use as general packet switches.

# DYNATECH

## 1. General

Dynatech sell a range of X.25 equipment including PADs, switches and a Gateway Address Translator and a Network Control Centre. The switch is called Multi Switch X.25 and has been certified for use with most of the public data networks. It is based on a Z80 with 248 Kbyts of RAM.

## 2. Configuration Options

The Multi Switch comes in two types, the Model 8 and the Model 12 High Speed supporting from 4 links to either 8 (Model 8) or 12 (Model 12) links maximum.

## 3. Line Speeds/Interface Options

The Model 8 supports a maximum speed of only 9.6 kb/s, the Model 12 supports speeds of up to 64 kb/s, which may be internally clocked up to 56 kb/s. V24, V35 and X.21 are available.

## 4. Throughput

A packet throughput of 100 data packets/sec is quoted for the Model 12.

## 5. Costs

The Model 8 costs £3,665 for 4 lines and £5,669 for 8 lines. The Model 12 costs £17,200 for 4 lines with an additional £2,297 per 2 lines.

Therefore, for a Model 12:-

10 links - £24,091

## 6. Multinode Networks

The Dynatech can operate as a concentrator type switch using X.25 to communicate with the other nodes and is capable of load sharing across multiple lines.

## 7. Addressing

Appears flexible with the ability to use single addresses and/or ranges of addresses.

## 8. Network Management

Any Dynatech switch can be interrogated by any network terminal (password protected) to determine basic data such as:- status of links, number of calls on each link, number of users on the line.

Dynatech also sell a 'Network Control Centre' based on an IBM XT connected to an asynchronous PAD port. This is all done on a 'passive' basis, ie. it is polled by the operator/NCC and it does not appear possible to obtain details of calls made or counts of various packet types.

## 9. Operator Control

The feature mentioned above can be used to control a switch remotely. Most features in the JNT spec are included with the exception of the ability to 'clear a call to a selected DTE address'.

## 10. Summary

An interesting switch which could be used as a X.25 concentrator for a larger switch. Although the cost per line is rather high, it is worth investigating this switch in more detail.

# IPAC

## 1. General

IPAC sell the COMPAC VCX which is an X.25 switch forming a part of a set of X.25 products including PADs and a Network Management Centre. The COMPAC VCX is of French design and manufacture and is based on a Z80 processor with 128 Kbytes of memory. A total of 80 simultaneous calls can be supported.

## 2. Configuration Options

Two switches are produced, the CP1 supporting 8 lines and the CP1S supporting 16 lines.

## 3. Line Speeds/Interface Options

Both switches only support a maximum line speed of 9.6 kb/s.

## 4. Throughput

Maximum packet rates of 80 and 160 packets/sec are quoted for the two types.

## 5. Costs

The cost of the 8 line switch is £8K and the 16 line switch £15,300.

## 6. Known Problems

The COMPAC VCX does not meet the JNT spec in a number of key points, they are:-

- Only 9.6 kb/s supported.
- No Fast Select.
- Can only use LCGN-4.
- Severe Addressing constraints.

## 7. Summary

The above problems must rule out this switch, IPAC say that there is a new version on the way - the 'COMPAC NPX' but there are no technical details available yet.

The cost of the NPX will be: 12 ports £24,400

# MEMOTEC

## 1. General

Memotec switches, as marketed by Drake Systems are part of a range of X.25 products including PADs and a Network Control Centre. The range is called MPAC and the switches are certified for use on a wide variety of public data networks. The equipment is manufactured in Canada.

## 2. Configuration Options

The switch comes in two types, the MPAC 2500 which supports up to 8 lines and the MPAC SP/8564 which supports 4 high speed lines.

## 3. Line Speeds/Interface Options

The 8 line MPAC 2500 has a maximum speed on all ports of only 9.6 kb/s. The SP/8564 has a maximum speed of 64 kb/s and supports V24, X21 and V35 (and RS449?).

## 4. Throughput

Unknown.

## 5. Costs

The 8 low speed 2500 costs £6,000, the 4 channel SP/8564 costs £9,197.

Cost per line (4 lines!) is £2,300 .

## 6. Summary

It has proved very difficult to obtain adequate information on this product but the fairly high line cost coupled with the constrained configurations do not justify further investigation.

Memotec are also offering a new box, the MPAC MP/8000, which is combination of switch and PAD. Up to 12 X.25 lines running at 64 kc/s can be supported at a cost of £15,093 for 12 lines. No further information could be obtained from Memotec.

# MOTOROLA

## 1. General

Motorola offer a M68000-based X.25 switch called the 'Intelligent X.25 Processor' (IXP). A maximum store size of 384 Kbytes is allowed and it is stated that up to 1000 virtual calls can be supported.

## 2. Configuration Options

Two types of switches are offered, a standard, and a high performance, both types can support from 2 to 32 physical links.

## 3. Line Speeds/Interface Options

The 'standard' switch supports only V24 interfaces up to a maximum speed of 19.2 kb/s. The high performance switch supports line speeds to 72 kb/s using V24, V21, RS422 or V35 in a flexible fashion.

## 4. Throughput

800 pkts/sec is claimed for the high performance switch.

## 5. Costs

The basic cost of a high performance switch is £15,500 configured with 2 ports. There is then an additional cost of £2,000 per port board each of which supports two links. There is an additional cost of £100-£250 for the physical interface.

This gives the following costs:-

10 ports £26,800; 18 ports £33,600

## 6. Multinode Networks

Motorola switches will work as part of a multinode network using 'simple' X.25 between the nodes.

## 7. Addressing/Routing

Addressing is handled by conversion to names - it appears flexible but obscure.

## 8. Network Management

There is no disc attached to the system, so there is no collection of statistics. However, statistics, including details of calls etc., can be directed to a network 'console', consequently a micro, or similar, could be attached to collect, time stamp and present statistics.

## 9. Operator Control

Operator control can be either from the console attached to the switch or from any network terminal (password protected). The level of control provided from this console appears to be fairly comprehensive and meets most of the requirements in the JNT spec, including the ability to list all calls, with addresses, to a particular DTE.

## 10. Known Problems

The switch supports a maximum packet size of only 128.

## 11. Other Points

It has proved extremely difficult to get a proper technical manual and consequently it has not been possible to check a number of points in detail.

## 12. Summary

This is a fairly typical small switch, even though it does go up to 32 links, with the typical disadvantages of small switches, ie. lack of network management and proper control of the switch. When this is coupled with a high cost per line (£2,250) it does not appear to be worth pursuing.

# Northern Telecom

## 1. General

Northern Telecom sell a range of network products including switches, PADs and a network control system. The system is used as the basis for DATAPAC in Canada and DATEX-P in Germany. The switches are based on multi 16 bit processors. 512 kbytes of common memory is supported, with each processor having additional private memory, no guide is given for the maximum number of calls although up to 1200 subscribers can be connected to a single switch.

## 2. Configuration Options

Northern Telecom sell a concentrator, the SL rapid, which can support up to 208 low speed lines and uses a maximum of 73 kb/s speed line to connect back to a main switch.

The main switch, called the SL10 can be configured with up to 10 line modules, or each line module can be replaced with three trunk modules supporting links to other SL10s.

Each line module can support up to 120 lines at 9.6 kb/s or 4 high speed lines (max 64 kb/s).

With 3 trunk links, and 8 links at 64 kb/s, the SL10 could support an additional 840 9.6 kb/s links.

### 2.1. Line Speeds/Interface Options

The SL10 supports V24 and V35 at speeds up to 64 kb/s. A trunk link to another SL10 can be run at 128 kb/s.

## 3. Throughput

The SL10 can support up to 1500 packets/sec (quoted at 750 user data pkts/sec).

## 4. Costs

A minimum SL10 switch system starts at £150,000.

## 5. Multinode Networks

The SL10 is designed to work in a multi node network and uses an internal datagram protocol to communicate between the switches.

## 6. Addressing

The SL10 expects to use X75 to communicate with external networks and the addressing does not appear to be flexible enough to be used in conjunction with the existing equipment.

### 6.1. Network Management & Operator Control

This is achieved in an extremely powerful manner by the separate Network Control Centre.

## 7. Summary

The need for a Network Control Centre, combined with possible addressing problems and with the extremely high basic cost rules out this option.

# PLESSEY

## 1. General

Plessey provide X.25 products that are used in large Public Data Networks, eg. PSS, and for computer networks such as the Midland Bank. The largest switch, the TP4000 is multi-microprocessor-based with a store size of 64-256 Kbyte. The smaller, concentrator, switch the Series 2500 is based on an Intel 8086 with up to 256 Kbytes of memory.

## 2. Configuration Options

The largest switch, the TP4000 supports up to 250 ports (made up out of 36 line processing cards each with 8 lines).

The concentrator switch, the Series 2500 comes in three different sizes and performances, a 16, 24 and 48 port versions.

## 3. Line Speeds/Interface Options

Both types support line speeds of up to 64 kb/s using V24 or V35.

## 4. Throughput

The TP4000 has a disappointing top packet rate of only 450 packets/sec (quoted as 225 data packets/sec). This is on DTE/DTE calls, the switch is quoted at being able to switch 2000 packet/sec on inter-switch links.

The Series 2500 had 3 different rates.

| | | |
|---|---|---|
| 16 ports | - | 60 packets/sec |
| 24 ports | - | 90 packets/sec |
| 48 ports | - | 180 packets/sec |

It can be seen from this that Plessey cannot match the JNT spec. even at 48 ports, for performance.

## 5. Costs

The TP4000 costs from £100,000 - £200,000.

48 ports - £150,000

The Series 2500 costs:-

16 ports - £13,000
24 ports - £17,000
48 ports - £30,000

6. Multinode Networks

System has been produced to handle massive networks.

7. Addressing

Apparently meets the JNT spec with the restriction that a Zone system must be used between groups of nodes, although not between members of the group.

8. Network Management

Extremely powerful but requires to run on a Prime. Plessey are, however, going to produce a micro-based Network Operation Centre for use in smaller networks.

9. Operator Control

The quality of control is considerably better than that of the GEC switch.

10. Summary

The performance of the switches is disappointingly low, the biggest switch not meeting the JNT spec and this coupled with the extremely high cost rules this equipment out.

# SIEMENS

## 1. General

Siemens produce a range of equipment for X.25 packet networking called the System EDX-P including switches, concentrators, PADs and Network Control Centre. In the U.K., the system is marketed by Databit Ltd who are owned by Siemens. Packet sizes of up to 256 bytes are supported.

## 2. Configuration Options

The concentrator, the ANP2530 - which can act as a switch in its own right with additional software - supports between 8 and 128 links. The main switch, the System EDX-P can support up to 1008 links.

## 3. Line Speeds/Interface Options

The concentrator supports line speeds of up to 19.2 kb/s and network links at up to 64 kb/s. The EDX-P supports links at up to 64 kb/s.

## 4. Throughput

The switch is rated at 700/900 pkts/sec. It handles X.75 more efficiently than X.25.

## 5. Costs

ANP 2530 costs approximately £20,000-£25,000 (a 32 line £19,200 - £25,600).

A 100 line EDX-P costs approximately £100,000.

## 6. Multinode Networks

The EDX-P has been designed to work in a multinode network and uses a variant of X.75 to communicate between the nodes.

## 7. Addressing

Databit have requested information from Siemens over the use of addressing.

## 8. Network Management & Operator Control

Siemens use a Network Control Centre to down line load the ANP2520, receive the call statistics etc., and to control the network. It is possible to integrate the NCC into a System EDX-P, which then can also control any EDX-Ps in the network.

## 9. Summary

There remains the question of addressing to be resolved and it appears to have a disappointingly low throughput.

# STC

## 1. General

STC offer the DPS 1500 Packet Switching System. The product line consists of switches, PADs and a Network Operation and Management Centre.

The switches are formed from two pieces of equipment, the Packet Data Satellite (PDS) and the Packet Switching Exchange (PSE). The PDS handles the user equipment while the PSE performs switching and routing. Both pieces of equipment are based on a high speed bus supporting multi micro-processors. The hardware MTBF for a PDS and PSE are quoted at 4.93 years and 1.88 years. A maximum packet size of 1024 bytes is supported.

## 2. Configuration Options

The minimum network consists of a Packet Data Satellite with two Line Access Modules and a Packet Switch Exchange with two Line Access Modules. Each Line Access Module (on the PDS) can support up to 16 access lines with an average aggregate throughput of 32 kb/s full duplex. Consequently, the smallest switch pair can handle 32 lines (at 32 kb/s) or 2 lines at 48 kb/s and 30 lines at 37 kb/s. One or more of these lines need to be connected to the PSE.

This small switch configuration can be expanded to 16 LAMs or a maximum of 1000 links. The maximum numbert of X.25 links for a whole network is 175,000 links.

## 3. Line Speeds/Interface Options

Line speeds of up to 64 kb/s using V24, V11 or V35 are supported.

## 4. Throughput

A Packet Processing Module (PPM) is used in either the PDS or the PSE. A PPM will support 150 pkts/sec. Up to 100 PPMs can be installed in a switch, giving a total throughput of 6,000 packets/sec.

## 5. Costs

The smallest configuration (30- 32 links) costs £140,000.

## 6. Multinode Networks

The system has been designed as a large multinode network and uses the 'netgram' - an internal datagram protocol to communicate between switches.

7. Addressing/Routing

There appears to be flexibility in the use of X.121 addressing, however, the main inter-network link is done by X.75 and the DPS1500 may not support DTE interfaces.

Hunt groups, including support for an address across multiple PDS's are available.

8. Network Management

Network Management is performed by a Network Operation and Management Centre which can be either a stand alone PDP11/24 (or 11/44) or can be integrated within the PSE.

9. Operator Control

Very full operation control from the NOMC has been provided.

10. Summary

The DPS1500 appears to be too expensive for further consideration for individual universities.

# TELEFILE

## 1. General

Telefile is a small company (owned by a US parent) producing a switch called TelePAC. This is a M68000-based switch using the standard VME bus. The basic system has 192 Kbytes of store (soon to be expanded to 750 Kbytes). It is claimed that 100 virtual calls can be supported. About 100 systems have been installed world-wide in the last 3 years. TelePAC units will be able to be joined together using a DMA interface. This interface could also be used to connect to a user-programmed processor supporting a UNIX-compatible system for use as a Gateway or other such protocol converter. TelePAC is certified for use on most public networks.

## 2. Configuration

One TelePAC can support up to 30 lines, a MegaPAC will beformed by joining up to 16 TelePACs together using DMA channels.

## 3. Line Speeds/Interface Options

Line speeds of up to 153 kb/s can be supported using V24, V10/11, V35 or X21.

## 4. Throughput

A throughput of greater than 1162 packets/sec is claimed.

## 5. Costs

10 ports £11,000; 18 ports £12,500; 48 ports £35,500

## 6. Multinode Networks

The switch will work in either the MegaPAC situation or as a multinode network. Load sharing is performed across multiple links. X.25 is used between the nodes.

## 7. Addressing/Routing

The method used for routing is different from most others. All addresses are turned into 'names' and routing etc is done on the basis of these names. Single addresses or ranges can be used though as it uses 'wild cards' (eg. 50** to match a range 5000-5099). Complete flexibility on ranges is missing.

8. Network Management

The basic switch does not include a disc, although most of the required information can be routed to a network 'port'. This area in particular would need enhancing for the switch to be acceptable.

9. Operator Control

The operator control facilities appears to be flexible, with the ability to use any (password protected) terminal for the control. Lines can be reconfigured without requiring a reload of the entire switch.

10. Summary

Although TelePAC does not support all of the Network Management features required in the JNT spec, the cost, power and flexibility of the architecture warrant a closer look.

# TELEMATICS

## 1. General

Telematics offer a range of X.25 networking products called the Net 25 Product Family including concentrator switches, primary switches, backbone switches, PADs and supervisory nodes. The equipment is based on Motorola M68000s and the largest node has a store size of 4 Mbytes expandable up to 8 Mbytes. A maximum of 1500 simultaneous calls can be supported on the largest node. The equipment is sold in the UK by Telematics and also by ICL and other companies including IAL who sell it under their own label. Telematics is certified for use on most public data networks. The maximum packet size supported is 1024 bytes.

## 2. Configuration Options

The switches are sold in a wide variety of options starting at 16 lines expandable up to 1024 lines on the largest switch.

## 3. Line Speeds/Interface Options

Up to 64 kb/s is supported, even on the smallest switch, to interface standards V24, V35 and X21.

## 4. Throughput

Throughput varies from 100 packets/sec (quoted as 50 data packets/sec) at the lowest end, expandable by adding both a communications accelerator and up to two additional general purpose processors to give a maximum throughput of 1600 packet/sec (quoted as 800 data packet/sec).

6. Multi-node Networks

Designed for use in this environment, Telematics use a non-X.25 protocol for inter-switch communication

7. Addressing

Flexible control over X121 addressing is allowed. full compliance with the JNT spec still has to be established.

8. Network management

Appears to be fairly comprehensive. It is noted that the smallest switch requires to be linked up with a 'standard' switch for the purpose of network management.

There is a specific network management machine, based on the same architecture, but this function can also be integrated into a standard switch.

9. Operator Control

Appears to be very flexible, meets and exceeds most of the points in the JNT spec (the possible exception is the clearing of a particular call). Any network terminal, password protected, may also be used. Line configuration, and even the replacement of channel boards can be performed on a live system.

10. Other Points

An extremely flexible system with the ability to add user programs, eg. for YB-ISO conversion, has been constructed. There is also an optional 'protection module' for protecting switches from code added by the user.

11. Known Problems

Fast Select is not currently supported, but a release of software which includes Fast Select, is planned for November 1985.

12. X.25 (1984)

This is expected to be ready early in 1986.

13. Summary

This series is extremely cost effective, has modules right across the connection spectrum, has extremely easy upgrade paths for performance expansion and has the ability for the Community to add user designed software.

As an extremely attractive alternative to GEC it is worth considering in Stage 2.

# Thorn Ericsson

## 1. General

Thorn Ericsson offer ERIPAX which is a networking system comprising switch, PADs and network management stations. The equipment is based on a flexible mixture of Motorola 68000s and 6809s supporting a maximum store size of 8 megabytes.

## 2. Configuration Options

Up to 32 'Computer Modules' can be built into a single node. Each Computer Module can support between 2 and 8 physical links giving a maximum usable configuration of over 200 links.

## 3. Line Speeds Interface Options

The ERIPAX supports V24 to 19.2 kb/s and V35 at speeds up to 64 KB/s. X.21 and G703 are also supported.

## 4. Throughput

A single 'Computer Module' can support 200 packets/sec (quoted as 100 data pkts/sec). Based on this a maximum of 1000 packets/sec (500 data packets /sec) is claimed for an entire node, although it can be higher if a particular system is configured carefully.

## 5. Costs

| | |
|---|---|
| 10 ports | - £140,000 |
| 100 ports | - £500,000 |

A new release of hardware is due at the end of the year which will reduce the cost of the 100 port switch to £300,000 approximately.

## 6. Multinode Networks

A modified form of X.75 is used between nodes of a network and X.75 is recommended for use between different networks.

## 7. Addressing

A flexible addressing scheme is available with the ability to have ranges based on a match of less than 12 digits in an address. However, only one address or one range is allowed on a single link. Hunt groups are available but they do <u>not</u> load share.

## 8. Network Management

Network Management can be implemented on a stand-alone machine or integrated into a node.

## 9. Operator Control

Operator control must be done by a terminal attached to one of the nodes.

## 10. Summary

The limitations in the addressing structure coupled with the high cost rule out this equipment.

ANNEX 2

SEEL

COMMUNICATION AND CONTROL

SEEL LTD., 3 Young Square
Brucefield Industrial Park,
Livingston, West Lothian EH54 9BJ.
Scotland
Tel. Livingston (STD 0506) 411503
Telex 728107 SEEL G

Our Ref FRC/JCP    Your Ref    Date 2nd April 1987

Dr. P. E. Bryant,
Rutherford Appleton Laboratories,
Chilton,
Didcot,
OXON,    OX11 0QX

Dear Paul,

Further to our telephone conversation I enclose details on Telepac/Minipac as requested.

Telepac/Minipac is a high performance PSE which is based upon the MC68000 range of microprocessor products and the VME bus system architecture. High performance is achieved by providing the main processor with a private bus for program fetch and stack operations, also separate DMA processors to control each line interface.

These systems offer a range of line interfaces which cover the established data transmission standards and data rates. These include V24/V28, V35, X.27 and X.21 with data rates up to 153Kbps.

The Minipac system is available in an 8 or 10 port form, whilst Telepac is available in an expandable form from 10 - 30 ports. larger systems can be configured by linking Telepacs using the inter-Telepac channel interface.

Both products are constructed from identical hardware and incorporate, as standard, mechanisms for gateway, billing and integrated network management.

......../

Dr. P. E. Bryant,
Rutherford Appleton Laboratories

2nd April, 1987

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The Minipac 8 system is available at £9,700 and the Telepac systems from £15,600 (Telepac 10) to £24,000 (Telepac 30).

In general terms I do not perceive any difficulties with the issues you raised, in particular, X.25 (1984) and DNIC. However, we would wish to discuss these matters with you in detail to ensure implementation to your satisfaction. Seel are currently committed to tracking British Telecom PSS and also implementing the X.25 (1984) requirements as specified by the JNT.

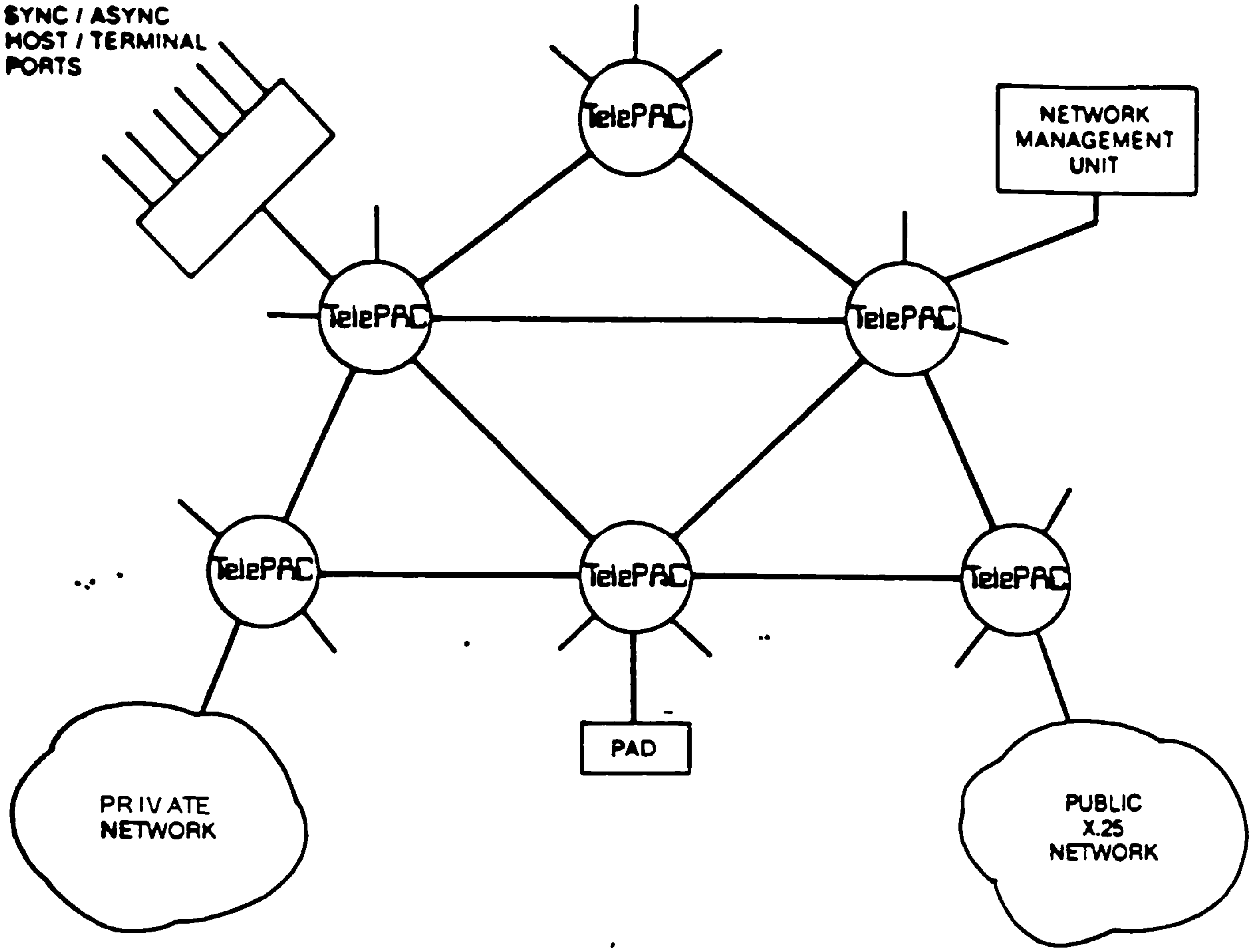
I trust that you will find our products of interest and look forward to the opportunity to discuss your requirements in detail.

Yours sincerely,
for SEEL LTD

F. R. Combe
Sales Director

Encs.

# GENERAL OVERVIEW




The diagram summarises the various major facilities provided by a TelePAC based network.

An arbitrary number of TelePACs can be interlinked to form networks of various degrees of complexity. The network links can be soft configured to be either MUXPORT (STATISTICAL MULTIPLEXORS), or X.25, and virtual circuits can pass through an arbitrary number of communications links with the protocol changing at each leg of the path. Multiple alternative routing is a standard facility, as is the ability for any terminal or host to connect to any other terminal or host connected in the network. Switching or fixed destinations (with alternative routing) are also standard configurable options.

Any asynchronous or synchronous block mode protocols are supported and most of the major synchronous protocols are supported.

Any X.25 PAD or X.25 host interface can be supported, and soft configuration options are available to cater for the minor vagarier of various equipment types.

X.25 public networks are supported, and formal approvals have been obtained for a number of these throughout the world.

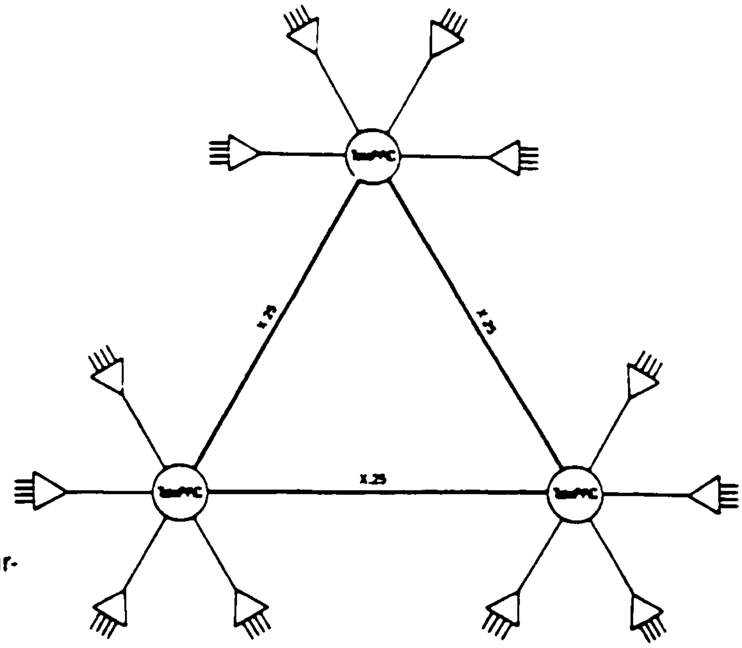
A large set of mechanisms is embodied in the software in each TelePAC to support the needs of authorised network managers; and to provide interfaces and facilities for an X.25 interfaced Network Management Presentation Service and Data Base.

The overall concept of the network is 'decentralisation', which enables the network to grow and adapt as requirements change; and this also aids diagnosis and solving of problems.

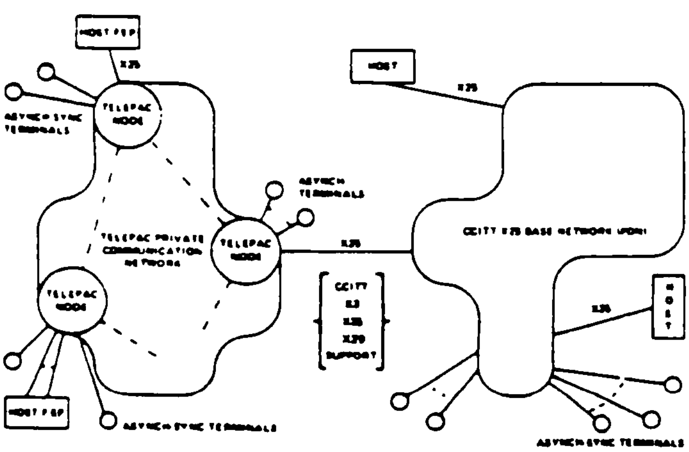
# TelePAC Features

- Advanced, high-speed, communications processor
- Oriented towards CCITT X.25
- Support of X.3 parameters and X.29
- Networking node
- Switching or fixed destinations
- Alternative routing and automatic call re-establishment
- Gateway operation
- Unique combination of X.25 and statistical multiplexing of communications links
- Complete modular expansion from small four-port nodes to large PSEs
- Multi-processor design, with option for user-programmed processors supporting UNIX compatible operating system and the 'C' language

**SAMPLE CONFIGURATIONS**




TRIANGULATION




- Synchronous and Asynchronous data
- High throughput per £ cost
- Protocol conversion
- Network management
- User friendly, simple to configure
- Open-ended design
- Approved for use with X.25 public data networks
- Menu and queueing options
- Ethernet interface

# TelePAC

## Configuration

While being user friendly, the TelePAC configuration language is generalised for open-ended expansion and as a basis for the support of OSI standards.

The main TelePAC configuration parameters are summarised below:

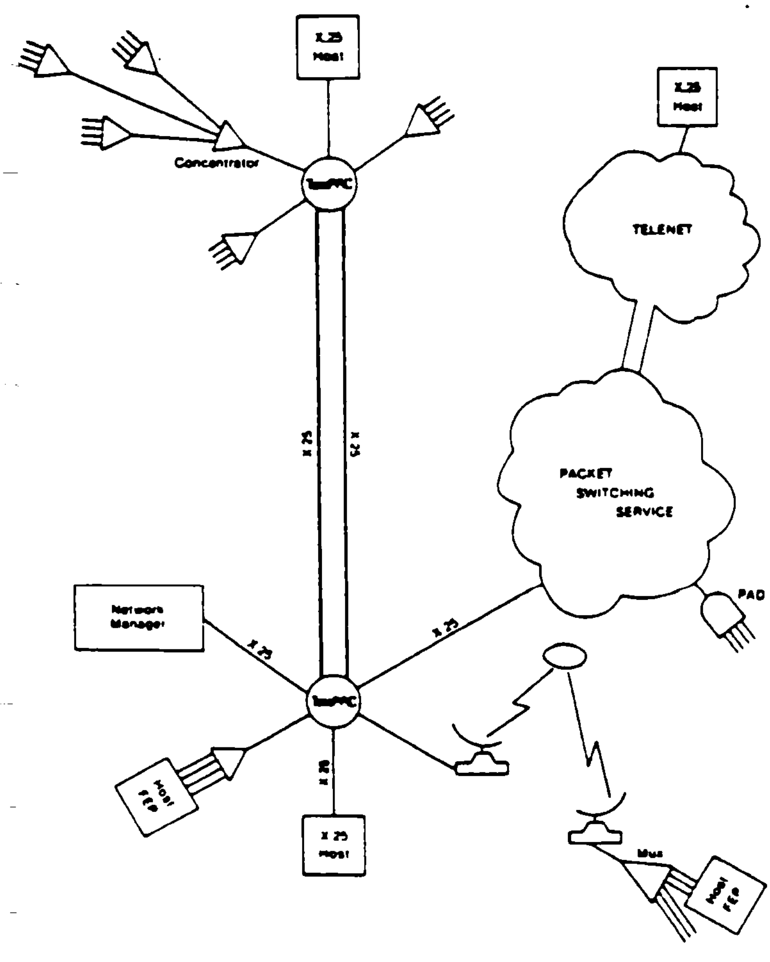
### Link Level

Link type: X.25
MUXPORT
(statistically multiplexed)
Ethernet
DMA Channel-to-channel.

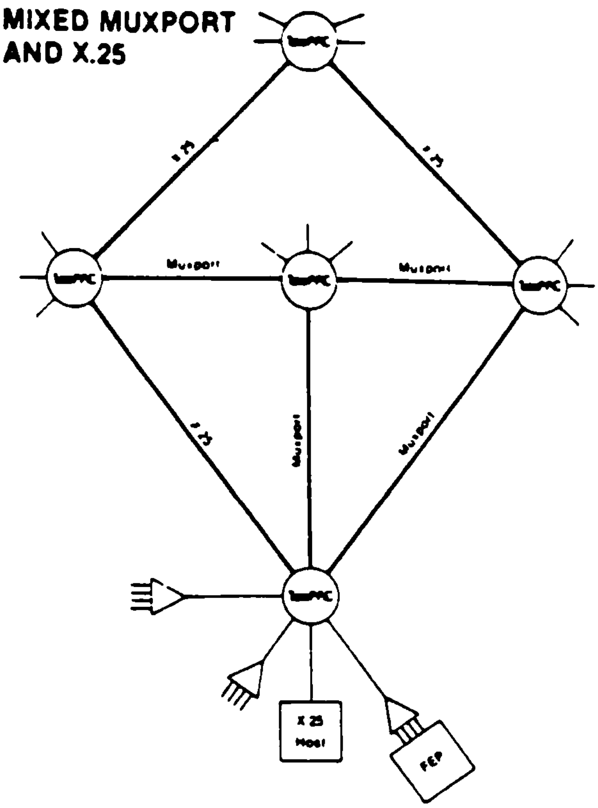
Number of logical channels per link.

DTE or DCE
LAP or LAP B; host or network interface.
Time-out and retransmission values.
Window size level 2.
Default Window size level 3.
Logical Channel Group.
Extended (0-127) or normal (0-7) frame sequence numbers.
Poll when idle (level 2 RR command with P-bit).
Remote Boot (multiplexed links).

**LINE LOAD SHARING**




**MIXED MUXPORT AND X.25**




### Logical Channel Level

Routing Method Specification.
Synchronous or Asynchronous.
PVC or SVC.
Queueing.
Automatic call re-establishment and re-routing.
Compact Network Routing Option ('DIAL').
Control of EIA signals (multiplexed channels).
Buffer threshold for flow control.
Slot size for response tuning (multiplexed channels).
Flow Control thresholds and refresh values (multiplexed channels).
Disconnection Control Character.
Menu Selection.
Short form X.25 addressing.
Alternative prioritised routing.
X.3 Parameters.
Transparent mode or Integral PAD operation (multiplexed channels).

### Network Management Features

- Control of any node from any point in the network.
- Control of any multiplexer or PAD from any point in the network.
- Virtual diagnostic port.
- Polled diagnostics/statistics.
- Session statistics, time-stamped, for network accounting.
- Network Management Unit for centralized control and storage.
- Time stamping of all network diagnostics.
- Extensive link and channel level diagnostic information on demand.

# TelePAC

## Hardware

The TelePAC is based upon the M68000 range of micro-processor products and the European standard 'VME' bus. The TelePAC processor board has an internal bus for instruction fetch and stack-oriented operations. For high throughput, link input-output operations are independent of the main M68000, via separate processors running in DMA mode. High-speed DMA channels are also used to interlink TelePAC units, in order to create very large Packet Switching Exchanges; MegaPAC statistically multiplexing nodes; or a combination of both with the option of running several user-programmed processors.

Battery backed-up RAM provides the primary level of TelePAC configuration protection. A second level can be provided as an option by floppy disc drives on which copies of the configuration can be saved, and retrieved automatically by the system.

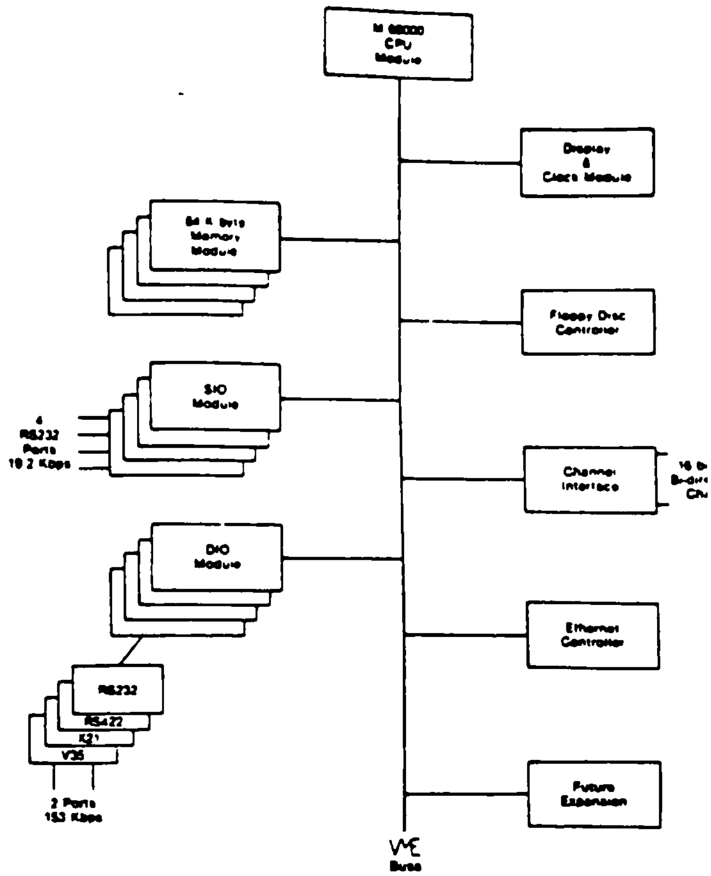
A range of link interfaces are available:

RS232 (V24), RS423/422 (V10/11), V35, X21.

Each TelePAC unit is 19 inch rack mountable.

## Environment

Temperature: 0 to 50 deg C.
Humidity: 0 to 90% (non condensing)
Power: 115 VAC 60 Hz or
230/240 VAC 50 Hz.




## Capacity

Each TelePAC unit can support up to 32 network links, soft configurable as X.25 or statistically multiplexed (multiplexed links support switching as well). Up to 1500 logical channels per TelePAC unit can be configured. The maximum number of TelePAC units per MegaPAC is 16.

The throughput parameters per TelePAC unit are as follows:—

Maximum individual link speed:
153,000 bps.

Maximum packets per second:
greater than 1162.

Maximum statistically multiplexed data rate:
greater than 32,000 bytes per second.

# NETWORK MANAGEMENT FEATURES

**Network Management and Management Tools**

The TelePAC has been designed with a view to network management recognising two very separate aspects, and involving, normally, very different management personnel. The two aspects are discussed separately below. A large number of specifically designed tools have been built into the TelePAC, in order that it can provide comprehensive solutions to both management aspects.

**Network Troubleshooter and Network Configuration Management**

The person or persons who troubleshoot networks are usually those responsible for the basic network configuration and its maintenance. These are the network controllers, who need a good understanding of the subject in order to configure the basic network functions and facilities. The same people usually are responsible for isolating occasional problems, in possibly widely scattered geographical sites within the network. Quite clearly such people, who are normally relatively expensive, cannot continually be 'on the road' in order to investigate faults. They need to be able to investigate network problems centrally or from any point that is convenient at the time. Ideally, the problem should be identified remotely by the controller, and less expensive personnel dispatched to fix a physical problem once it has been identified. This problem is overcome by the concept of the 'virtual control port' which is embodied in each TelePAC and is described below.

**Network Management and Management Tools**

The network controllers will often be employed by OEMs or distributors, and provide a support service to end-users; or, in the case of large users, one or more such persons will be employed directly.

The concept of a 'virtual control port', together with remote access capability, is a fundamental tool for the controlling network manager. A virtual control port is actually a software module which resides in every node (TelePAC, TelePAD, PAD, or Statistical multiplexor or node). It is a 'virtual' port in the sense that it is not associated with any given physical port. The software module is responsible for providing interactive configuration and diagnostic facilities.

Within the concepts embodied in the TelePAC, a virtual control port is a resource which is accessed just like any other resource. From any network access point (dial up port; X.25 public network, X.25 PAD or multiplexor) the network controller can, simply by entering a call address (e.g. via public data network or from a private PAD), or by typing a mnemonic, gain access to the virtual control port of any TelePAC in the network. In a complicated network, the access can be directly made by automatic establishment of a multi-staged virtual circuit; or the manager can step from TelePAC to TelePAC in a deliberate fashion. Once connected to a virtual control port in a given TelePAC, he has an interactive dialogue to perform configuration and diagnostic operations.

The concept of remote access to virtual control ports, via resource selection, is taken a logical step further by using the same technique to access the virtual control ports in multiplexors or PADs. For example, take a TelePAC which has, e.g. 3 high speed X.25 links to 3 VAX computers, and 27 lower speed links to 27 remotely situated statistical multiplexors. The controller, by simply typing four characters on a terminal on his desk, can immediately talk with any one of the 27 multiplexors, for example, to look at the EIA signals on a particular terminal port, or to watch the input or output characters as the user types or receives responses. (This monitor is completely passive).

The diagnostic information available from the virtual control port of the TelePAC is extensive, including:

- Buffer counts
- Data in and Data out counts for communicating links
- Frame counts for links
- Transmit and Receive window positions
- CRC error counts
- X.25 level 2 state of link
- Current retransmission level
- Data in and out counts for individual channels
- Frame or packet counts for channels
- EIA signals In and Out
- X.25 level 3 state
- Transmit and Receive Window positions
- Logical state of link
- Flow control positions
- Virtual Circuit connection state
- Data restraint position
- And others

**Network Management Presentation Service and Data Base**

The other aspect of network management that needs to be covered is that with respect to the general management. Here we are talking about an almost purely administrative function, by people who are not necessarily specialists. At one level we have operational staff, who require a centralised (or multi-point) system, which 'presents' to them, information as to the state of the network, and provides an automatic method of not only generating alarms, but also of providing specific instructions as to exactly what to do. At another level we have a higher administrative function, which includes:—

1. Information on the performance of the network, for forward planning of capacity and for quality control.
2. Information on the number of problems and the time taken to fix them (i.e. performance of network support).
3. Billing information for cross-charging.
4. Achieved data for historical analysis of problems (looking back on the records).

The view taken of the Management Presentation Service is that it is linked to one or more TelePACs in a network by X.25 link(s). With this concept in mind, a number of mechanisms have been built into each TelePAC node which allows the centralised Management Presentation Service (MPS) to operate. The theory of operation and the mechanisms are outlined below.

Via its X.25 link the MPS sets up calls to each TelePAC in the network. The fact that these virtual circuits are established (or not) provide the first level of information as to the operational state of the network. If calls fail, different call addresses can be used to establish different virtual circuits to the TelePAC in question. By this method, the virtual circuits provide 'probes' by which the MPS establishes which links or which TelePAC nodes are up or down. The information is displayed graphically, and alarms are operated and recorded if required.

The destination of the probe circuit is the REPORTS channel on the TelePAC in question. The REPORTS channel is a Virtual Reports Channel, in the sense that it is a named channel which can map on to any given Virtual Circuit.

Once the MPS has attached its probe circuit to the REPORTS channel, all reports for that TelePAC are intercepted and passed through the circuit to the MPS. Only if the circuit is temporarily broken (e.g. network failure and re-routing has not yet taken place) will reports go to the reports channel itself (which is therefore a default, and could have a teleprinter or PC attached to avoid losing any reports).

Thus the MPS is receiving reports from each TelePAC in the network, on a different logical channel for each TelePAC. The reports are thus fully segregated, and, further, each report is prefixed by a level numb[illegible] to facilitate programming to process the reports.

There is a virtual statistics channel on each TelePAC, which can similarily be intercepted remotely by the MPS in order to gather billing statistics for each of the TelePACs.

Once the MPS is connected in this way to each TelePAC, further facilities are available to it, by means of commands that it can transmit to the TelePACs along the virtual circuits. Operations available are:—

(1) It can poll any component (link, channel, etc.) on the TelePAC and derive performance statistics (data counts; error counts, etc.).

(2) It can delete statistics (reset them) for each component (e.g. link or channel).

(3) It can pull off billing records in a handshake manner (so records are not lost or duplicated).

(4) It can delete billing records in a handshake manner.

As an example of (1) and (2) above in operation, the MPS keeps a profile of expected CRC errors on a link. It performs a poll every 30 seconds, followed by a statistics reset, and compares the error count against a profile. If the profile limit is exceeded, it displays an alarm and files a report. Similarily, by polling and resetting to data counts, and comparing the numbers against a profile threshold, it detects when link throughput is such that further line plant should be ordered.

# FUNCTIONAL FLEXIBILITY AND EXPANSION CAPABILITY

Certain key features of the TelePAC provide client-users with a high level of flexibility in handling their current needs. These features also provide a great deal of adaptability with respect to the modifications and evolutions that any network goes through. The unique open-endedness of the software and hardware design also ensures that future needs are protected, in terms of integrating (and this is a keyword, not just 'adding on') state-of the art technology features, as and when these arise. These points are discussed at greater length in the paragraphs that follow.

**Flexibility for Current Needs**

The TelePAC is a 'soft' machine, in that everything that may differ from system to system is interactively configureable (configurations are kept in battery backed up RAM, and, as an option, additionally on floppy disc). Even the basic link protocol is configurable. At the same time the TelePAC, whilst achieving the very high throughput per unit cost that is required of X.25 or statistically multiplexed nodes, also acts as communications processor with a wide range of configurable options not normally found in most nodes. These options, together with a unique intermixing of X.25 and statistical multiplexing (where required), and a unique transport level 'naming' system for logical channels, make it easy to set up alternative routing networks; switching or fixed destinations; contention; mixing of asynchronous and synchronous data; menu driver or automatic routing; resource queuing, etc.

At the same time the hardware is modular, can be expanded in economically prices units and a wide range of OSI level 1 communications interfaces are available, including protocols (V24, RS232, V28, X21B1S, 1S0 2110 1B12, RS423, V10, X21, etc.).

**Adaptability**

No network design is static. It evolves as requirements and traffic mixes change. The configuration of the TelePAC is unique in the sense that it is decentralised minimal topology. Information is passed between nodes (call packets or resource names), and provided that simple rules are followed the configuration of each TelePAC can be taken in isolation. This means that nodes can be removed from, or added to, a network, with no impact on other nodes. Resources and terminals can be added or removed, and become accessible throughout the network, with nothing but local, minor configuration changes required.

**Expansion of Capacity**

The number of links supported by a TelePAC can range up to 30. To incorporate extra links, it is necessary simply to purchase a modestly priced low-port or low- port line card. An interactive dialogue is used to soft-configure the links, the machine is switched off, the new card (or cards) is incorporated, and when the machine is switched on again the extra communications links are up and running.

**Resolution of Traffic Mix Problems**

Sometimes the traffic types that are to be carried by a network are in conflict, either because of protocol differences, or in terms of volume versus response. Because of the total integration capability (if required) of the X.25 and statistical multiplexing protocols, there is no problem in, for example, mixing a wide number of fixed destination synchronous protocols on the same X.25 link used by switched asynchronous data.

Some data links may be high speed, dealing with, on the whole, large blocks of data. In these cases, X.25 may be soft-configured on the protocol. On other links a highly interactive response may be required (e.g. the echo of typed characters is being performed by the remote host), and in this case the statistically multiplexed protocol may be used. In complicated networks, performance requirements may dictate a structure consisting of trunk links and host interfaces running high-speed X.25 and statistical multiplexing as the network fans out.

# NETWORK SECURITY

Network security in this context is intended to mean the security that the network offers against unauthorised access to resources, and network control functions such as the virtual control ports. It is also increasingly becoming a requirement that users should not even be permitted to use the network itself without authorisation. A related aspect is cross-charging for the use of the network, e.g. in the case where many different departments or divisions of a large company are sharing the same network. In this case a billing facility needs to be interlocked with authorisation to use the network.

All of these aspects are handled by the TelePAC, and are described below.

## PASSWORD PROTECTION

The first level of protection, which is a soft configurable option, is provided by a password mechanism. If it is configured, then users have to type a password to gain any further access to the network. Once a password has been entered successfully, the user gains access to the network, but a further set of options defined in the password record further control or define the level of access.

These options include:—

1. Billing.

   Billing records will be produced for charging against the password (which is also a user-group identifier).

2. Destination.

   The user can be automatically routed to a particular destination, or limited to a defined subset of the total destination resources in the network.

3. Menus.

   The user can have one of 32 possible menus displayed (and hence, for example, can be made aware of only certain resources in the network. Different sections of users can have different views of the network).

4. Priority/Privilege Level.

   A priority level can be set up, which can further limit the resources which the user can access. The priority level is described further below.

## RESOURCE SELECTOR

The second level of access protection is provided by the four character name used to select resources. If a user is unaware of a given resource selector name (i.e. it does not appear on his menu), then the resource name becomes, effectively, a second level of password. The Destination Resource Code mask can be further used to limit the users choice to a subset of the total destinations.

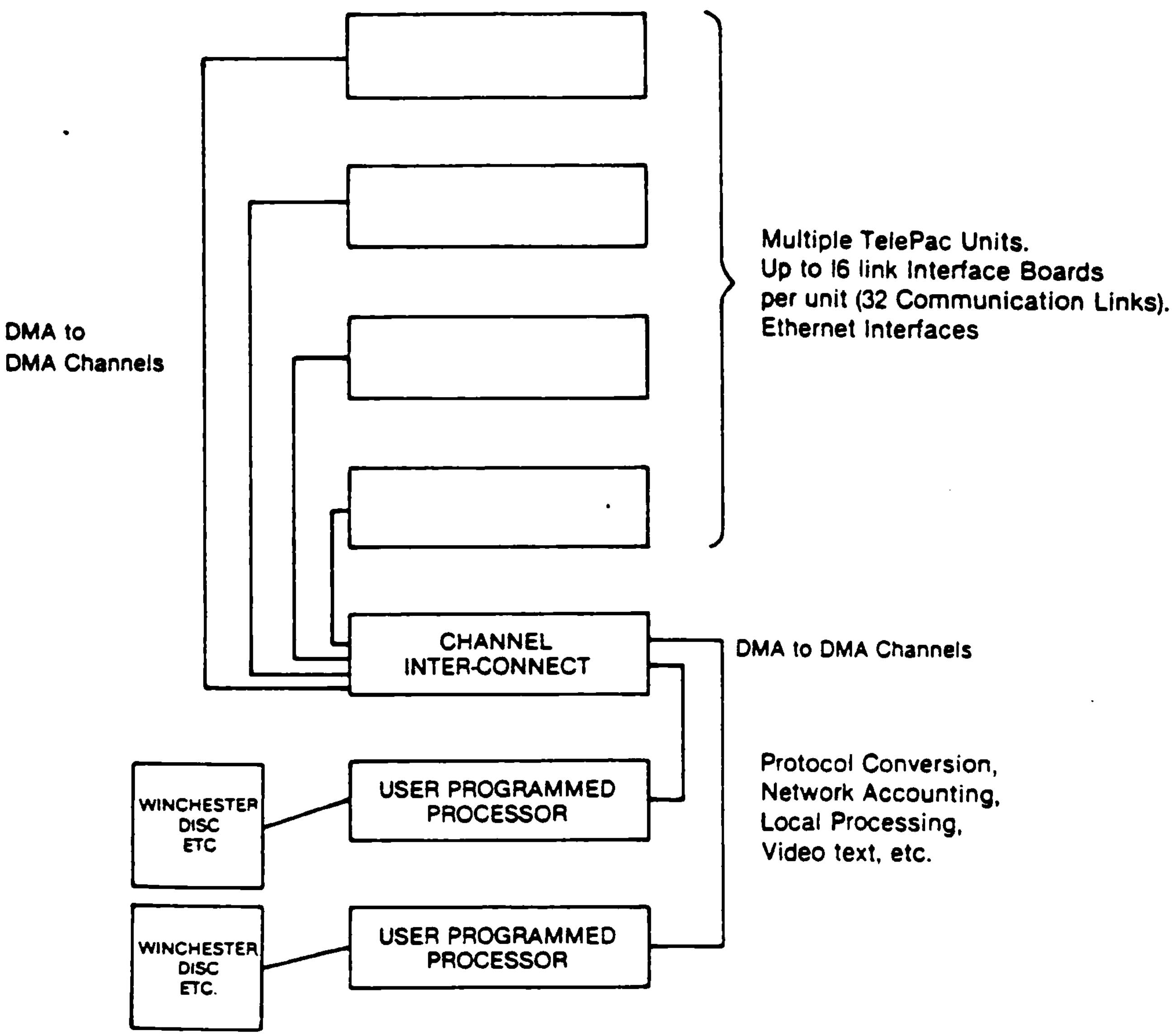
## PRIORITY LEVEL

Sixteen levels of priority (or privilege) are provided. A user cannot access any resource which is at a level of priority above his own. For example, the Virtual Circuit ports will normally be placed at the highest level of priority.

HARDWARE ORGANIZATION

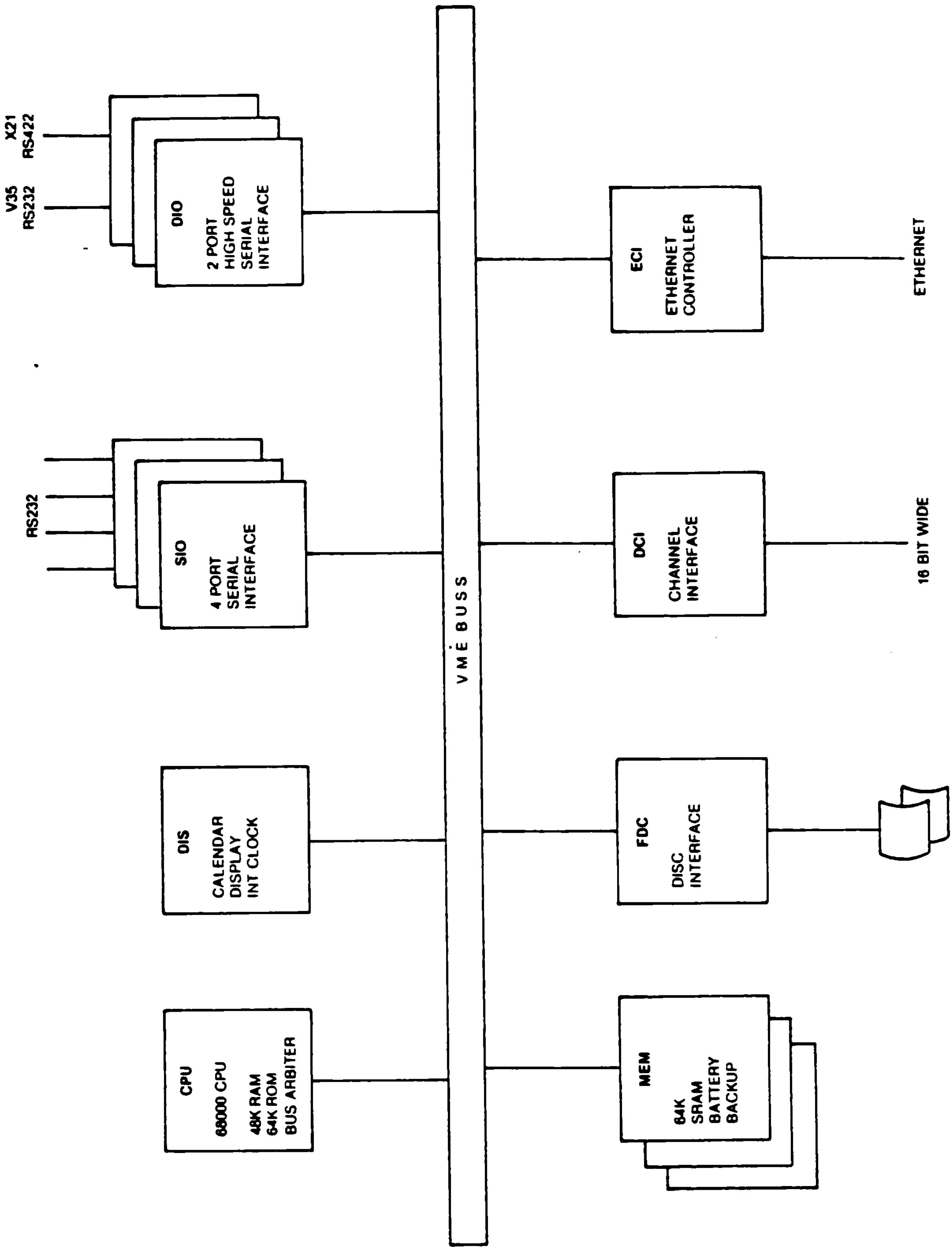
TELEPAC MODULARITY

EXAMPLE CONFIGURATION
IN MEGAPAC STRUCTURE



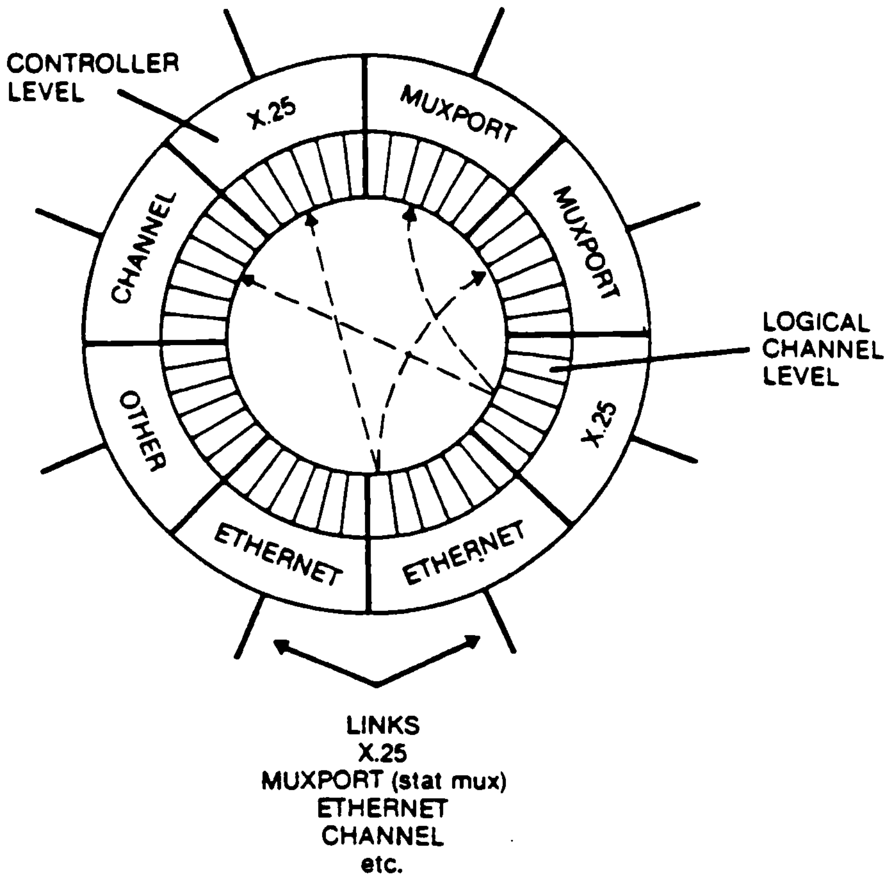
# HARDWARE ORGANIZATION

## TELEPAC UNIT

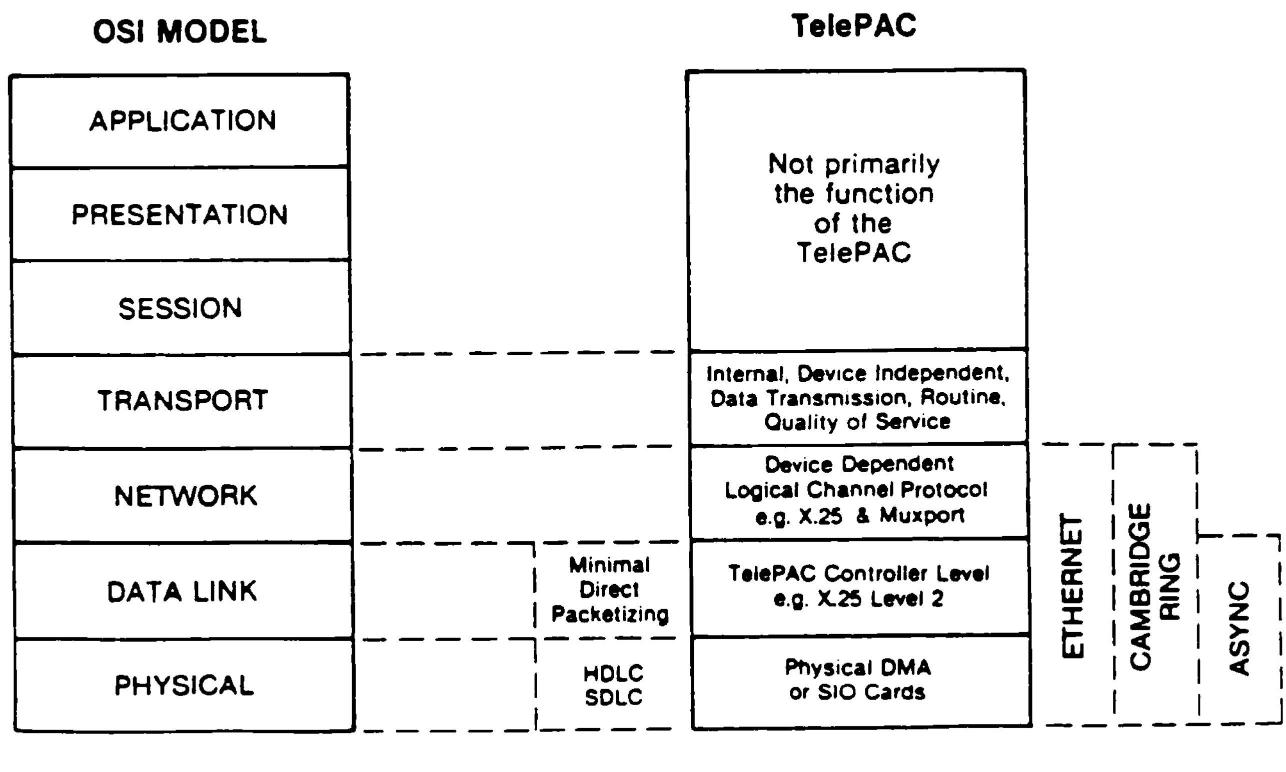


# INTERNAL AND NETWORK ORGANISATION

The following pages illustrate the internal and network organisation of the TelePAC. The onion skin shaped illustration below shows the layered concept of the design. As can be seen this corresponds to the first 4 layers of the OSI reference model.




The c ˙ am below illustrates how the onion skin structure in the TelePAC model maps on to the OSI reference model, when a cross section of the onion skin layers is taken. The diagram also shows how the proposed extensions to the TelePAC interfaces map on to the TelePAC and OSI model.



Above the physical level there are three important layers, which will exist in greater or less quantities according to device and protocol.

**Controller Level**

Provides the data link level control — responsible for controlling the state of the data link and for preserving the integrity of higher level data at the link level. For X.25 and MUXPORT the same controller is used (X.25 level 2), with minor parameter differences.

**Channel Level**

This provides the protocol dependent networking operations in terms of logical channels. For X.25 this consists of handling X.25 level 3 packets; for MUXPORT this consists of analysing and constructing multiplexed frames, (i.e. data from more than one channel is in the same level 2 frame).

**Transport Level**

This level is common to all current and future interfaces and provides for a device and protocol independent method of passing and flow controlling data and in particular, for referencing, routing and cross-connecting (forming virtual circuits) device independent logical channels. This scheme is based on the principle 'named' channels, and all transport level operations take place in terms of these names (four characters). This is discussed further below, and is illustrated extensively in the diagrams that follow.

**Transport Level Names**

All logical channels at the transport level are assigned names by default when a system is started for the first time. Thereafter the TelePAC manager may reconfigure these names to be anything that is meaningful to him and the stucture of the network. Many channels can have the same name (e.g. a contention group or a trunk link group). To form a virtual circuit through a TelePAC it is necessary simply to search for the requested name (routing) and then to link the initiating name (the caller) with the destination name (the resource). This simple operation is common to all protocol types, and happens invisibly to the higher and lower levels.

A common approach to several problems has been taken with the transport level names.

1. For configuration and diagnostic purposes, the names are used to reference channels. The concept has been extended by allowing controllers to be named for configuration and diagnostic purposes.
2. Call addresses (in X.25 call packets) are mapped to and from the transport level reference names.
3. For menu driver users, the names are the resource selectors.
4. The names are used to represent the hierarchical structure of network addressing.
5. An internal routing option, which is protocol independent and which is called the 'dial option', consists of passing names from one TelePAC to another.

To generalise the naming conventions wild characters (*) are used to 'match anything'; and multiple synonyms (" " " ") are used to simplify the expression of multiple groups on trunk links.

ANNEX 3

David Lord.

 30th April 1987.

# The Financing of EARN during the Year 1988.

# Contents.

# 1. Introduction.

At the end of 1987 the present agreements with IBM for supporting EARN terminate. The main effect of this will be that from then on all of the communication costs will have to born by the member organizations of EARN. Besides this the operation of a number of small machines that are used as National Nodes will also no longer be free of charge.

In this paper, given the trend in the attitude of many PTTs, it is assumed that we will not be faced to a serious extent with the issue of having to pay volume and time charges during 1988. Beyond 1988 is too difficult to predict at this time, hence:

**This paper is solely concerned with the financing of EARN in 1988.**

## 1.1 To-day's situation.

There are now some 275 distinct institutions that can considered to be members of the EARN Association and there are over 570 nodes on EARN. Within a number of countries, noticeably France, Germany and the UK, many if not all of the leased line costs are already born directly or indirectly by the member institutions. So the main cost problem we are facing for the leased lines, is that of the international and intercontinental lines, which at present cost a total of a little over 2.0 MSFr.[1] per year.

Currently IBM is maintaining free of charge the National Node machines in several countries such as in Germany, Switzerland and Sweden. This represents a total expenditure of approx. 90 kSFr. each per year.

The Association itself is surviving at present on the original grant made by IBM of which there remained 35k$ at the end of 1986. Expenditures have been limited to helping people attend technical meetings here and in the USA as well as to cover some of the costs of the members of the Executive Committee which are heavy because of the frequency of their meetings.

## 1.2 The Structure of the Association.

EARN and its Association are in effect organized in a federal manner. There are good reasons for this:

- The topology of the network. The part of EARN within each country is organized in a way best adapted to local conditions, varying from a complete leased line network to using part of the national network. The parts are then linked by the international lines to form the network as a whole.

- The manner in which the Director representing each country is chosen by the countries themselves. In some cases this is a person already with responsibilities for the national network or in national committees concerned with the organization of the universities and their resources. In other cases they are people elected by a national Users' Group.

1 The choice of currency was made just for my convenience.

- For the communication infrastructure we have to deal with the individual PTTs and in general this is best done by representatives from within the countries. The CEPT is an organization with which we can have general discussions, but when it comes to decisions we must deal with PTTs themselves

- Furthermore the tariffs and conditions set by the PTTs vary from one to another and again it is within the individual countries we must deal with the problems that these cause.

- Many of the day-to-day problems are dealt with within the countries and are best done in the local language without imposing the use of a foreign language.

So it appears that a federal structure based on the countries bound together by the EARN Association seems well adapted to our situation.

## 2. Possible Solutions to Financing of EARN.

### 2.1 Initial Assumptions.

1. *NATIONAL LEASED LINES.*

As already pointed out in many cases these lines are already payed by the institution at one or other end. It therefore seems reasonable to assume that this 'BITNET method' of financing can be generalized to all of these lines. It will of course be necessary to make local arrangements in some cases, for example, the sharing of the cost of a particularly expensive line linking to a group of institutions that benefit directly from it.

> National lines will be financed in the countries. Typically each site will pay for one of the leased lines attached to it.

2. *NATIONAL NODES.*

That is to say the nodes that carry the international and intercontinental leased lines and in many cases provide the NETSERV and LISTSERV services for the country. At present some six of these are maintained at no cost. After 1987 the operating costs of these and possibly other national nodes that are currently paid by for by the institutions housing them, will have to covered by the EARN membership. Again it seams reasonable to assume that the countries will each organize the financing of their national node and the services it provides.

> The financing for a National Node and the services it supplies will be arranged within its country.

## 2.2 'Analysis'

Assuming that the above propositions are acceptable, we are still left with the following items to be financed:

- The International Leased Lines.
- The Intercontinental Leased Lines.
- The Operating Costs of the Association.

Let us examine these in turn.

1. *INTERNATIONAL LINES.*

   If we look at the configuration of these EARN lines as it will be after some rearrangement during the next few months, i.e. after removing some lines that provide duplicate paths, we see that we can apply the same 'BITNET' principle to these lines as well. i.e. that effectively each country should pay the **full cost** of one of the international lines attached to it. In this way all of the international lines would be financed and all of the countries except one would be paying; for the moment this is assumed to be Germany.

2. *INTERCONTINENTAL LINES.*

   There are two of these for the moment. Because of the importance of communications to North America it seems probable that we should continue to have two. If Germany **alone** was to pay for the line to Washington, **instead of** paying for an international line, then that would only leave one line to be financed by the institutions in the remaining countries. This seems a reasonable idea because the number of German institutions is large, so the cost to each would not be too high.

   This method of distributing the costs is shown as **model** A in Tables 6.2 & 6.5. For comparison **model B** shows the result of simply dividing the costs evenly between the countries.

   In the **model** E, the cost of the lines is distributed on the basis the ratios of the 'RARE Keys'.[2] The **model** F resembles model A except that the distribution of the cost of the intercontinental line from Montpellier is again done on the basis of the ratios of the 'RARE Keys'.

   **Note:** As Iceland is connected to EARN on a dial-up line and is a small user, I have limited its contribution to sharing in the cost of the high speed intercontinental line.

   **Note:** Any model for payment for these lines will involve movement of funds between EARN institutions in different countries. One reason being that many PTTs will not accept as customers organizations located outside of their country.

3. *COST OF THE ASSOCIATION.*

   Before this can be determined with precision we need to know what the Association should be doing in future. Some of the possible activites could also be financed in alternative ways, for example, further EARN8x meetings should be financed by conference fees.

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[2] These have been agreed between the RARE members to determine their annual contributions its budget.

Furthermore, besides its current activities we should consider whether the Association should or must be given the means to:

- Finance studies or development projects.
- Take over the roles of certain the IBM personnel who are at present working more or less full time on EARN matters. (At present this represents approx. three man years
- Set up a management infrastructure.

All of these can involve very significant costs and I believe that it would be much better that initiatives for this should come from the EARN membership when they see the necessity.

## 4. *TABLES.*

The first four of the attached tables provide background information on the costs of international lines between the EARN countries. The last two sets of tables concern the costing of two specific configurations of lines, which contains no redundant lines, except the 64 kb/s. line from Montpellier to New York.

**Table 1.** Basic data on the costs at each end of the international lines, in their local currencies.

**Table 2.** The costs in Table 1 converted into SFr.

**Table 3.** The ***total*** cost of the lines between countries.

**Table 4.** The ratios of the charges made at either end of the lines.

Note: In the Appendix there is a table showing the meanings of the country codes used in this paper.

## 5. *CONFIGURATIONS.*

The **Figure 1.** shows the configuration of the EARN lines as they are or will be in the immediate future. Two other configurations are then presented with their costs distributed according to the various models described above.

**Figure 2.** This shows the EARN lines (CONF2) after the introduction of higher speed lines, the elimination of some redundant lines and some changes to reduce the cost of particularly expensive lines.

**Table 5.2.** Shows the configuration (CONF2) of the lines costed in Table 6.2, the first of the countries in each pair being the one who pays in the model A. T/L indicates the high speed line from Montpellier.

**Table 6.2.** Shows the costs for each country, for the four different models.

**Figure 3.** This configuration (CONF5) shows further changes in the lines aimed at reduction of cost, without taking traffic into consideration.

**Tables 5.5 & 6.5.**
As for Tables 5.2 & 6.2 but for configuration CONF5.

**Note:** These tables **only** include line costs, other costs such as maintaining, for example, national node computers are not included.

**Note:** The results presented in these tables should be taken with **caution** as some of the data is uncertain.

## 2.3-Arrangements for Payment.

This topic needs much more detailed consideration after the model of financing is fixed. However some 'guide lines' are already clear.

- In general sites that will be making payments to say the PTT's on behalf of EARN, i.e. with funds coming in part from other EARN sites and countries, will require that these funds are guaranteed by agreements. These could be with EARN itself or bilateral agreements with other sites.
- Wherever possible for the international lines we should try to persuade the PTTs to let us make the full payment for a line at one end or other of the line.
- Where it will facilitate payments, setting up agreements and dealing with the PTTs, EARN should be legally established in other countries.
- The above should be done in a way to minimise the movement of funds between countries.

# 3. Closing Remarks.

The models A and F are perhaps the easiest to explain to the member organizations, as they present essentially the cost to connect to EARN for each country, that they must pay. The model E would probably be more convenient for handling situations in the future where for reasons of traffic or perhaps reliability it is desirable to add extra lines or not to select the cheapest connections possible between countries. The configuration in Figure 3 shows what happens when one makes choices mainly on the basis of cost, there is a concentration of connections at a small number of nodes located in countries whose PTTs have particularly favourable tariffs.

It is important that we do not choose a configuration for the international lines purely on the basis of cost, a saving in one place could very well lead to a saturation of lines elsewhere; we must keep a flexibility in our arrangements that allows us to finance extra or faster lines if saturation is occurring.

With the assumptions described above, where a great deal of the solution of the detailed problems is left up to the individual countries, the problem of financing EARN is certainly soluble during 1988 when volume and time charges are should not be a significant factor.

However, once they do become significant we will be obliged to solve the problems involved in charging institutions for the transmissions they originate and, in some cases, receive as well, even if they are in a region where volume charges are yet applied by their PTT. There are clearly solutions to these problems but they will not be very convenient as, for example, people will surely wish to confirm whether they accept to pay for an in-coming call. This sort of thing will inevitably increase the administrative overheads.

It is essential that the decision on how we are to finance the line costs for 1988, be taken during the Board meeting in May 1987. However the membership fee issue is less urgent and could well be a topic to be discussed and voted on at the Annual General Meeting during EARN87.

Local Currencies

| To-> | A | B | CH | CIV | D | DK | E | F | GB | GR | I | IRL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | 38396 | 34196 | 100196 | 34196 | 38396 | 45396 | 38396 | 45396 | 45396 | 34196 | 45396 |
| B | 76580 | | 72081 | ? | 62990 | 75473 | 83398 | 62990 | 69321 | 103783 | 76580 | 81792 |
| CH | 3055 | 3055 | | 9255 | 3055 | 4255 | 4755 | 3055 | 4255 | 4755 | 3055 | 4755 |
| CIV | ? | ? | ? | | | ? | ? | 1865500 | ? | ? | ? | ? |
| D | 3770 | 3770 | 3770 | ? | | 3770 | 4350 | 3770 | 4260 | 4690 | 3670 | 4400 |
| DK | 16165 | 11895 | 16165 | ? | 9750 | | 16165 | 16165 | 16165 | 16165 | 16165 | 16165 |
| E | 421741 | 421741 | 421741 | ? | 421741 | 421741 | | 217722 | 421741 | 421741 | 421741 | 421741 |
| F | 10500 | 9000 | 9000 | 22000 | 9000 | 10500 | 6600 | | 11300 | 10500 | 6600 | 11300 |
| GB | 770 | 603 | 770 | 2939 | 770 | 770 | 770 | 603 | | 1138 | 770 | 402 |
| GR | 445917 | 471301 | 445917 | ? | 445917 | 471301 | 471301 | 445917 | 471301 | | 381550 | 471301 |
| I | 5372132 | 5921877 | 4818795 | ? | 5372132 | 5921877 | 5921877 | 4818795 | 5921877 | 5372132 | | 6291966 |
| IRL | 1080 | 1080 | 1080 | 2997 | 1080 | 1080 | 1080 | 1080 | 480 | 1080 | 1080 | |
| ISL | 162256 | 162256 | 162256 | ? | 162256 | 162256 | 162256 | 162256 | 162256 | 162256 | 162256 | 162256 |
| ISR | ? | ? | ? | ? | ? | ? | ? | 12436 | ? | ? | 12436 | ? |
| N | 16950 | 16950 | 16950 | ? | 16950 | 6950 | 16950 | 16950 | 16950 | 16950 | 16950 | 16950 |
| NL | 3610 | 2710 | 3310 | 13750 | 2810 | 3310 | 4250 | 2810 | 2810 | 5450 | 3610 | 3610 |
| P | 520030 | 520030 | 520030 | ? | 520030 | 561830 | 393530 | 463930 | 463930 | 561830 | 520030 | 520030 |
| S | 15330 | 15330 | 15330 | ? | 15330 | 6230 | 20730 | 15330 | 15330 | 20730 | 20730 | 15330 |
| SF | 11360 | 11360 | 11360 | ? | 11360 | 6830 | 14810 | 11360 | 11360 | 14810 | 14810 | 11360 |
| TUR | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | 2974000 | ? |
| USA | 4120 | 3740 | 4120 | ? | 3710 | 4120 | 4120 | 5000 | 3710 | 3710 | 4120 | 4120 |

| To-> | ISL | ISR | N | NL | P | S | SF | TUR | USA |
|---|---|---|---|---|---|---|---|---|---|
| A | 100196 | 80596 | 45396 | 38396 | 45396 | 45396 | 45396 | 45396 | 80596 |
| B | ? | ? | 83398 | 52696 | 113993 | 82256 | 96976 | 119658 | 22351 |
| CH | 7255 | 9855 | 4755 | 3755 | 5655 | 4755 | 4755 | 4755 | 7255 |
| CIV | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| D | 17038 | ? | 3970 | 3770 | 5030 | 3870 | 4510 | 4860 | 9740 |
| DK | 38735 | ? | 6405 | 11895 | 16165 | 5249 | 6405 | 22875 | 53619 |
| E | 421741 | ? | 421741 | 421741 | 308714 | 421741 | 421741 | 421741 | 676765 |
| F | 11300 | 15000 | 10500 | 10500 | 10500 | 10500 | 10500 | 10500 | 40000 |
| GB | 1138 | 2556 | 770 | 603 | 770 | 770 | 770 | 1138 | 2364 |
| GR | 471301 | ? | 471301 | 471301 | 471301 | 471301 | 471301 | 381550 | 1034285 |
| I | 6658462 | 15491541 | 6291966 | 5921877 | 6291966 | 6291966 | 6658462 | 6658344 | 10244376 |
| IRL | 2997 | 2997 | 1080 | 1080 | 1080 | 1080 | 1413 | 1413 | 2163 |
| ISL | | 162256 | 162256 | 162256 | 162256 | 162256 | 162256 | ? | 229878 |
| ISR | ? | | ? | ? | ? | ? | ? | ? | ? |
| N | 16950 | 38950 | | 16950 | 16950 | 6950 | 6950 | 16950 | 38950 |
| NL | ? | 10300 | 3610 | | 5450 | 3610 | 4250 | 5450 | 10750 |
| P | ? | 826930 | 561830 | 520030 | | 561830 | 561830 | ? | 826930 |
| S | 20730 | ? | 6230 | 15330 | 20730 | | 6230 | 20730 | 31230 |
| SF | ? | 44930 | 6830 | 11360 | 14810 | 6830 | | 14810 | 34570 |
| TUR | ? | ? | ? | ? | ? | ? | ? | | ? |
| USA | 3775 | 4120 | 4120 | 4120 | 4120 | 4120 | 4120 | ? | |

TABEL 1.

In SFr.

| To-> | A | B | CH | CIV | D | DK | E | F | GB | GR | I | IRL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A |  | 4569 | 4069 | 11923 | 4069 | 4569 | 5402 | 4569 | 5402 | 5402 | 4069 | 5402 |
| B | 3078 |  | 2897 | ? | 2532 | 3034 | 3352 | 2532 | 2786 | 4172 | 3078 | 3288 |
| CH | 3055 | 3055 |  | 9255 | 3055 | 4255 | 4755 | 3055 | 4255 | 4755 | 3055 | 4755 |
| CIV | ? | ? | ? |  | ? | ? | ? | 9514 | ? | ? | ? | ? |
| D | 3161 | 3161 | 3161 | ? |  | 3161 | 3647 | 3161 | 3572 | 3932 | 3077 | 3689 |
| DK | 3564 | 2622 | 3564 | ? | 2149 |  | 3564 | 3564 | 3564 | 3564 | 3564 | 3564 |
| E | 4976 | 4976 | 4976 | ? | 4976 | 4976 |  | 2569 | 4976 | 4976 | 4976 | 4976 |
| F | 2625 | 2250 | 2250 | 5500 | 2250 | 2625 | 1650 |  | 2825 | 2625 | 1650 | 2825 |
| GB | 1636 | 1283 | 1636 | 6247 | 1636 | 1636 | 1636 | 1283 |  | 2418 | 1636 | 854 |
| GR | 5351 | 5655 | 5351 | ? | 5351 | 5655 | 5655 | 5351 | 5655 |  | 4578 | 5655 |
| I | 6312 | 6958 | 5662 | ? | 6312 | 6958 | 6958 | 5662 | 6958 | 6312 |  | 7393 |
| IRL | 2484 | 2484 | 2484 | 6893 | 2484 | 2484 | 2484 | 2484 | 1104 | 2484 | 2484 |  |
| ISL | 3731 | 3731 | 3731 | ? | 3731 | 3731 | 3731 | 3731 | 3731 | 3731 | 3731 | 3731 |
| ISR | ? | ? | ? | ? | ? | ? | ? | 11938 | ? | ? | 11938 | ? |
| N | 3712 | 3712 | 3712 | ? | 3712 | 1522 | 3712 | 3712 | 3712 | 3712 | 3712 | 3712 |
| NL | 2680 | 2012 | 2457 | 10209 | 2086 | 2457 | 3155 | 2086 | 2086 | 4046 | 2680 | 2680 |
| P | 5564 | 5564 | 5564 | ? | 5564 | 6011 | 4210 | 4964 | 4964 | 6011 | 5564 | 5564 |
| S | 3625 | 3625 | 3625 | ? | 3625 | 1473 | 4902 | 3625 | 3625 | 4902 | 4902 | 3625 |
| SF | 3828 | 3828 | 3828 | ? | 3828 | 2301 | 4990 | 3828 | 3828 | 4990 | 4990 | 3828 |
| TUR | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | 6096 | ? |
| USA | 6303 | 5722 | 6303 | ? | 5676 | 6303 | 6303 | 7650 | 5676 | 5676 | 6303 | 6303 |

| To-> | ISL | ISR | N | NL | P | S | SF | TUR | USA |
|---|---|---|---|---|---|---|---|---|---|
| A | 11923 | 9590 | 5402 | 4569 | 5402 | 5402 | 5402 | 5402 | 9590 |
| B | ? | ? | 3352 | 2118 | 4582 | 3306 | 3898 | 4810 | 898 |
| CH | 7255 | 9855 | 4755 | 3755 | 5655 | 4755 | 4755 | 4755 | 7255 |
| CIV | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| D | 14286 | ? | 3328 | 3161 | 4217 | 3244 | 3781 | 4075 | 8166 |
| DK | 8541 | ? | 1412 | 2622 | 3564 | 1157 | 1412 | 5043 | 11822 |
| E | 4976 | ? | 4976 | 4976 | 3642 | 4976 | 4976 | 4976 | 7985 |
| F | 2825 | 3750 | 2625 | 2625 | 2625 | 2625 | 2625 | 2625 | 10000 |
| GB | 2418 | 5432 | 1636 | 1283 | 1636 | 1636 | 1636 | 2418 | 5025 |
| GR | 5655 | ? | 5655 | 5655 | 5655 | 5655 | 5655 | 4578 | 12411 |
| 1 | 7823 | 18202 | 7393 | 6958 | 7393 | 7393 | 7823 | 7823 | 12037 |
| IRL | 6893 | 6893 | 2484 | 2484 | 2484 | 2484 | 3249 | 3249 | 4974 |
| ISL |  | 3731 | 3731 | 3731 | 3731 | 3731 | 3731 | ? | 5287 |
| ISR | ? |  | ? | ? | ? | ? | ? | ? | ? |
| N | 3712 | 8530 |  | 3712 | 3712 | 1522 | 1522 | 3712 | 8530 |
| NL | ? | 7647 | 2680 |  | 4046 | 2680 | 3155 | 4046 | 7981 |
| P | ? | 8848 | 6011 | 5564 |  | 6011 | 6011 | ? | 8848 |
| S | 4902 | ? | 1473 | 3625 | 4902 |  | 1473 | 4902 | 7385 |
| SF | ? | 15141 | 2301 | 3828 | 4990 | 2301 |  | 4990 | 11650 |
| TUR | ? | ? | ? | ? | ? | ? | ? |  | ? |
| USA | 5775 | 6303 | 6303 | 6303 | 6303 | 6303 | 6303 | ? |  |

TABEL 2.

Total Cost for Leased Lines in SFr./month.

| To-> | A | B | CH | CIV | D | DK | E | F | GB | GR | I | IRL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | 7647 | 7124 | ? | 7230 | 8133 | 10378 | 7194 | 7038 | 10753 | 10381 | 7886 |
| B | 7647 | | 5952 | ? | 5693 | 5656 | 8329 | 4782 | 4069 | 9827 | 10036 | 5772 |
| CH | 7124 | 5952 | | ? | 6216 | 7819 | 9731 | 5305 | 5891 | 10106 | 8717 | 7239 |
| CIV | ? | ? | ? | | ? | ? | ? | 15014 | ? | ? | ? | ? |
| D | 7230 | 5693 | 6216 | ? | | 5311 | 8624 | 5411 | 5208 | 9283 | 9389 | 6173 |
| DK | 8133 | 5656 | 7819 | ? | 5311 | | 8540 | 6189 | 5201 | 9220 | 10522 | 6048 |
| E | 10378 | 8329 | 9731 | ? | 8624 | 8540 | | 4219 | 6613 | 10632 | 11934 | 7460 |
| F | 7194 | 4782 | 5305 | 15014 | 5411 | 6189 | 4219 | | 4108 | 7976 | 7312 | 5309 |
| GB | 7038 | 4069 | 5891 | ? | 5208 | 5201 | 6613 | 4108 | | 8074 | 8594 | 1958 |
| GR | 10753 | 9827 | 10106 | ? | 9283 | 9220 | 10632 | 7976 | 8074 | | 10890 | 8139 |
| I | 10381 | 10036 | 8717 | ? | 9389 | 10522 | 11934 | 7312 | 8594 | 10890 | | 9877 |
| IRL | 7886 | 5772 | 7239 | ? | 6173 | 6048 | 7460 | 5309 | 1958 | 8139 | 9877 | |
| ISL | 15655 | ? | 10986 | ? | 18018 | 12272 | 8708 | 6556 | 6150 | 9387 | 11555 | 10624 |
| ISR | ? | ? | ? | ? | ? | ? | ? | 15688 | ? | ? | 30141 | ? |
| N | 9114 | 7064 | 8467 | ? | 7040 | 2934 | 8688 | 6337 | 5348 | 9367 | 11105 | 6196 |
| NL | 7249 | 4130 | 6212 | ? | 5247 | 5080 | 8132 | 4711 | 3369 | 9702 | 9638 | 5164 |
| P | 10966 | 10146 | 11219 | ? | 9781 | 9575 | 7853 | 7589 | 6600 | 11667 | 12957 | 8048 |
| S | 9027 | 6932 | 8380 | ? | 6870 | 2630 | 9879 | 6250 | 5262 | 10558 | 12295 | 6109 |
| SF | 9230 | 7726 | 8583 | ? | 7609 | 3714 | 9967 | 6453 | 5464 | 10646 | 12814 | 7078 |
| TUR | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | 13920 | ? |
| USA | 15894 | 6620 | 13558 | ? | 13843 | 18126 | 14289 | 17650 | 10701 | 18087 | 18340 | 11278 |

| To-> | ISL | ISR | N | NL | P | S | SF | TUR | USA |
|---|---|---|---|---|---|---|---|---|---|
| A | 15655 | ? | 9114 | 7249 | 10966 | 9027 | 9230 | ? | 15894 |
| B | ? | ? | 7064 | 4130 | 10146 | 6932 | 7726 | ? | 6620 |
| CH | 10986 | ? | 8467 | 6212 | 11219 | 8380 | 8583 | ? | 13558 |
| CIV | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| D | 18018 | ? | 7040 | 5247 | 9781 | 6870 | 7609 | ? | 13843 |
| DK | 12272 | ? | 2934 | 5080 | 9575 | 2630 | 3714 | ? | 18126 |
| E | 8708 | ? | 8688 | 8132 | 7853 | 9879 | 9967 | ? | 14289 |
| F | 6556 | 15688 | 6337 | 4711 | 7589 | 6250 | 6453 | ? | 17650 |
| GB | 6150 | ? | 5348 | 3369 | 6600 | 5262 | 5464 | ? | 10701 |
| GR | 9387 | ? | 9367 | 9702 | 11667 | 10558 | 10646 | ? | 18087 |
| I | 11555 | 30141 | 11105 | 9638 | 12957 | 12295 | 12814 | 13920 | 18340 |
| IRL | 10624 | ? | 6196 | 5164 | 8048 | 6109 | 7078 | ? | 11278 |
| ISL | | ? | 7443 | ? | ? | 8634 | ? | ? | 11062 |
| ISR | ? | | ? | ? | ? | ? | ? | ? | ? |
| N | 7443 | ? | | 6392 | 9723 | 2995 | 3823 | ? | 14833 |
| NL | ? | ? | 6392 | | 9610 | 6305 | 6983 | ? | 14285 |
| P | ? | ? | 9723 | 9610 | | 10914 | 11002 | ? | 15151 |
| S | 8634 | ? | 2995 | 6305 | 10914 | | 3775 | ? | 13689 |
| SF | ? | ? | 3823 | 6983 | 11002 | 3775 | | ? | 17953 |
| TUR | ? | ? | ? | ? | ? | ? | ? | | ? |
| USA | 11062 | ? | 14833 | 14285 | 15151 | 13689 | 17953 | ? | |

TABEL 3.

Ratio of Leased Line costs, Cost_at_From_end/Cost_at_To_End

| To-> | A | B | CH | CIV | D | DK | E | F | GB | GR | I | IRL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | 1.48 | 1.33 | ? | 1.28 | 1.28 | 1.08 | 1.74 | 3.30 | 1.00 | 0.64 | 2.17 |
| B | 0.67 | | 0.94 | ? | 0.80 | 1.15 | 0.67 | 1.12 | 2.17 | 0.73 | 0.44 | 1.32 |
| CH | 0.75 | 1.05 | | ? | 0.96 | 1.19 | 0.95 | 1.35 | 2.59 | 0.88 | 0.53 | 1.91 |
| CIV | ? | ? | ? | | ? | ? | ? | 1.72 | ? | ? | ? | ? |
| D | 0.77 | 1.24 | 1.03 | ? | | 1.47 | 0.73 | 1.40 | 2.18 | 0.73 | 0.48 | 1.48 |
| DK | 0.78 | 0.86 | 0.83 | ? | 0.68 | | 0.71 | 1.35 | 2.17 | 0.63 | 0.51 | 1.43 |
| E | 0.92 | 1.48 | 1.04 | ? | 1.36 | 1.39 | | 1.55 | 3.04 | 0.87 | 0.71 | 2.00 |
| F | 0.57 | 0.88 | 0.73 | 0.57 | 0.71 | 0.73 | 0.64 | | 2.20 | 0.49 | 0.29 | 1.13 |
| GB | 0.30 | 0.46 | 0.38 | ? | 0.45 | 0.45 | 0.32 | 0.45 | | 0.42 | 0.23 | 0.77 |
| GR | 0.99 | 1.35 | 1.12 | ? | 1.36 | 1.58 | 1.13 | 2.03 | 2.33 | | 0.72 | 2.27 |
| I | 1.55 | 2.26 | 1.85 | ? | 2.05 | 1.95 | 1.39 | 3.43 | 4.25 | 1.37 | | 2.97 |
| IRL | 0.45 | 0.75 | 0.52 | ? | 0.67 | 0.69 | 0.49 | 0.87 | 1.29 | 0.43 | 0.33 | |
| ISL | 0.31 | ? | 0.51 | ? | 0.26 | 0.43 | 0.74 | 1.32 | 1.54 | 0.65 | 0.47 | 0.54 |
| ISR | ? | ? | ? | ? | ? | ? | ? | 3.18 | ? | ? | 0.65 | ? |
| N | 0.68 | 1.10 | 0.78 | ? | 1.11 | 1.07 | 0.74 | 1.41 | 2.26 | 0.65 | 0.50 | 1.49 |
| NL | 0.58 | 0.94 | 0.65 | ? | 0.66 | 0.93 | 0.63 | 0.79 | 1.62 | 0.71 | 0.38 | 1.07 |
| P | 1.03 | 1.21 | 0.98 | ? | 1.31 | 1.68 | 1.15 | 1.89 | 3.03 | 1.06 | 0.75 | 2.24 |
| S | 0.67 | 1.09 | 0.76 | ? | 1.11 | 1.27 | 0.98 | 1.38 | 2.21 | 0.86 | 0.66 | 1.45 |
| SF | 0.70 | 0.98 | 0.80 | ? | 1.01 | 1.62 | 1.00 | 1.45 | 2.33 | 0.88 | 0.63 | 1.17 |
| TUR | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | 0.77 | ? |
| USA | 0.65 | 6.36 | 0.86 | ? | 0.69 | 0.53 | 0.78 | 0.76 | 1.12 | 0.45 | 0.52 | 1.26 |

| To-> | ISL | ISR | N | NL | P | S | SF | TUR | USA |
|---|---|---|---|---|---|---|---|---|---|
| A | 3.19 | ? | 1.45 | 1.70 | 0.97 | 1.49 | 1.41 | ? | 1.52 |
| B | ? | ? | 0.90 | 1.05 | 0.82 | 0.91 | 1.01 | ? | 0.15 |
| CH | 1.94 | ? | 1.28 | 1.52 | 1.01 | 1.31 | 1.24 | ? | 1.15 |
| CIV | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| D | 3.82 | ? | 0.89 | 1.51 | 0.75 | 0.89 | 0.98 | ? | 1.43 |
| DK | 2.28 | ? | 0.92 | 1.06 | 0.59 | 0.78 | 0.61 | ? | 1.87 |
| E | 1.33 | ? | 1.34 | 1.57 | 0.86 | 1.01 | 0.99 | ? | 1.26 |
| F | 0.75 | 0.31 | 0.70 | 1.25 | 0.52 | 0.72 | 0.68 | ? | 1.30 |
| GB | 0.64 | ? | 0.44 | 0.61 | 0.32 | 0.45 | 0.42 | ? | 0.88 |
| GR | 1.51 | ? | 1.52 | 1.39 | 0.94 | 1.15 | 1.13 | ? | 2.18 |
| I | 2.09 | 1.52 | 1.99 | 2.59 | 1.32 | 1.50 | 1.56 | 1.28 | 1.90 |
| IRL | 1.84 | ? | 0.66 | 0.92 | 0.44 | 0.68 | 0.84 | ? | 0.78 |
| ISL | | ? | 1.00 | ? | ? | 0.76 | ? | ? | 0.91 |
| ISR | ? | | ? | ? | ? | ? | ? | ? | ? |
| N | 0.99 | ? | | 1.38 | 0.61 | 1.03 | 0.66 | ? | 1.35 |
| NL | ? | ? | 0.72 | | 0.72 | 0.73 | 0.82 | ? | 1.26 |
| P | ? | ? | 1.61 | 1.37 | | 1.22 | 1.20 | ? | 1.40 |
| S | 1.31 | ? | 0.96 | 1.35 | 0.81 | | 0.64 | ? | 1.17 |
| SF | ? | ? | 1.51 | 1.21 | 0.83 | 1.56 | | ? | 1.84 |
| TUR | ? | ? | ? | ? | ? | ? | ? | | ? |
| USA | 1.09 | ? | 0.73 | 0.78 | 0.71 | 0.85 | 0.54 | ? | |

TABEL 4.

Main EARN Links at present. 1-5-87.

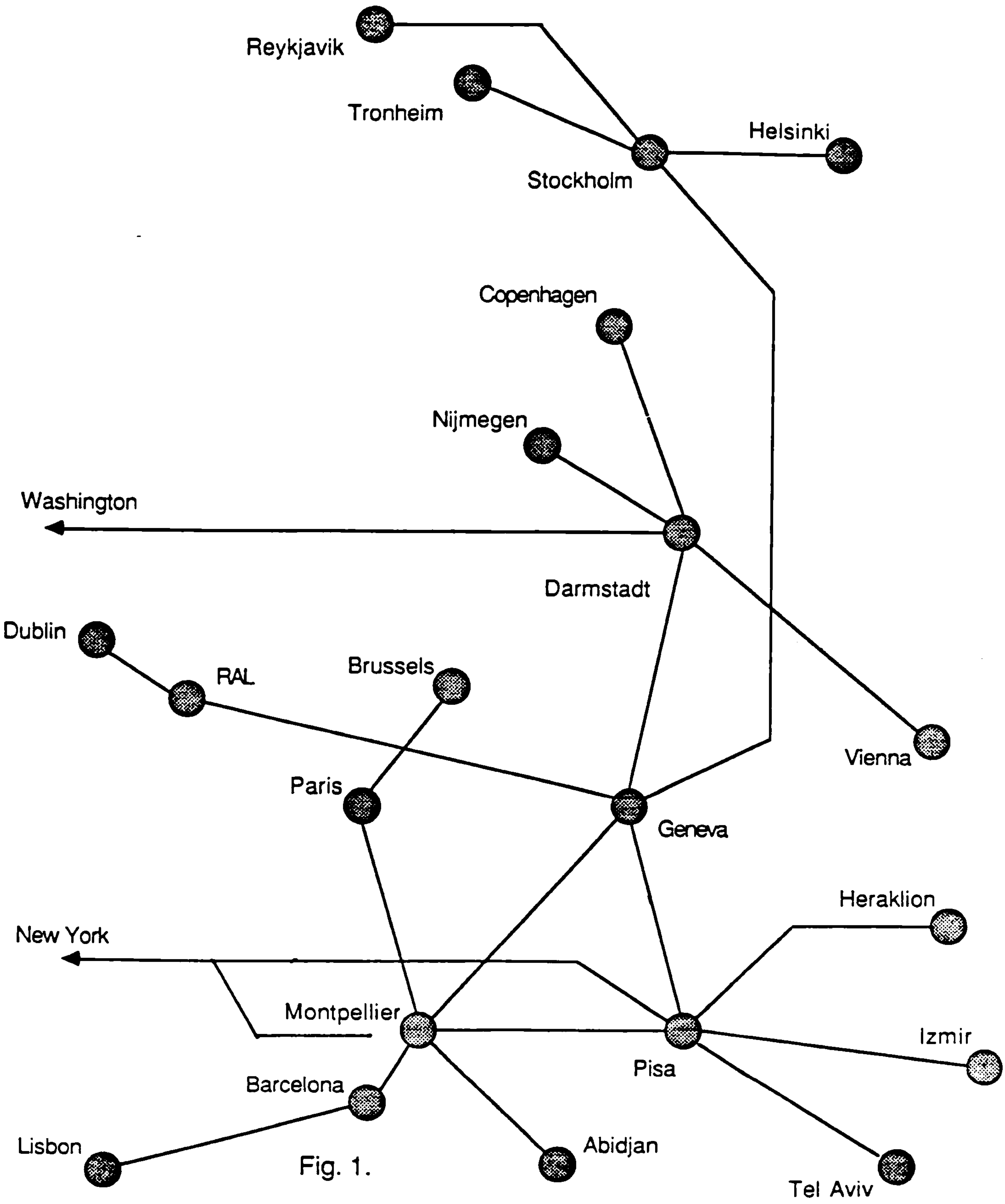


Fig. 1.

REFERENCE MODEL

## Possible New Cofiguration of EARN Main Links,

ECONF2

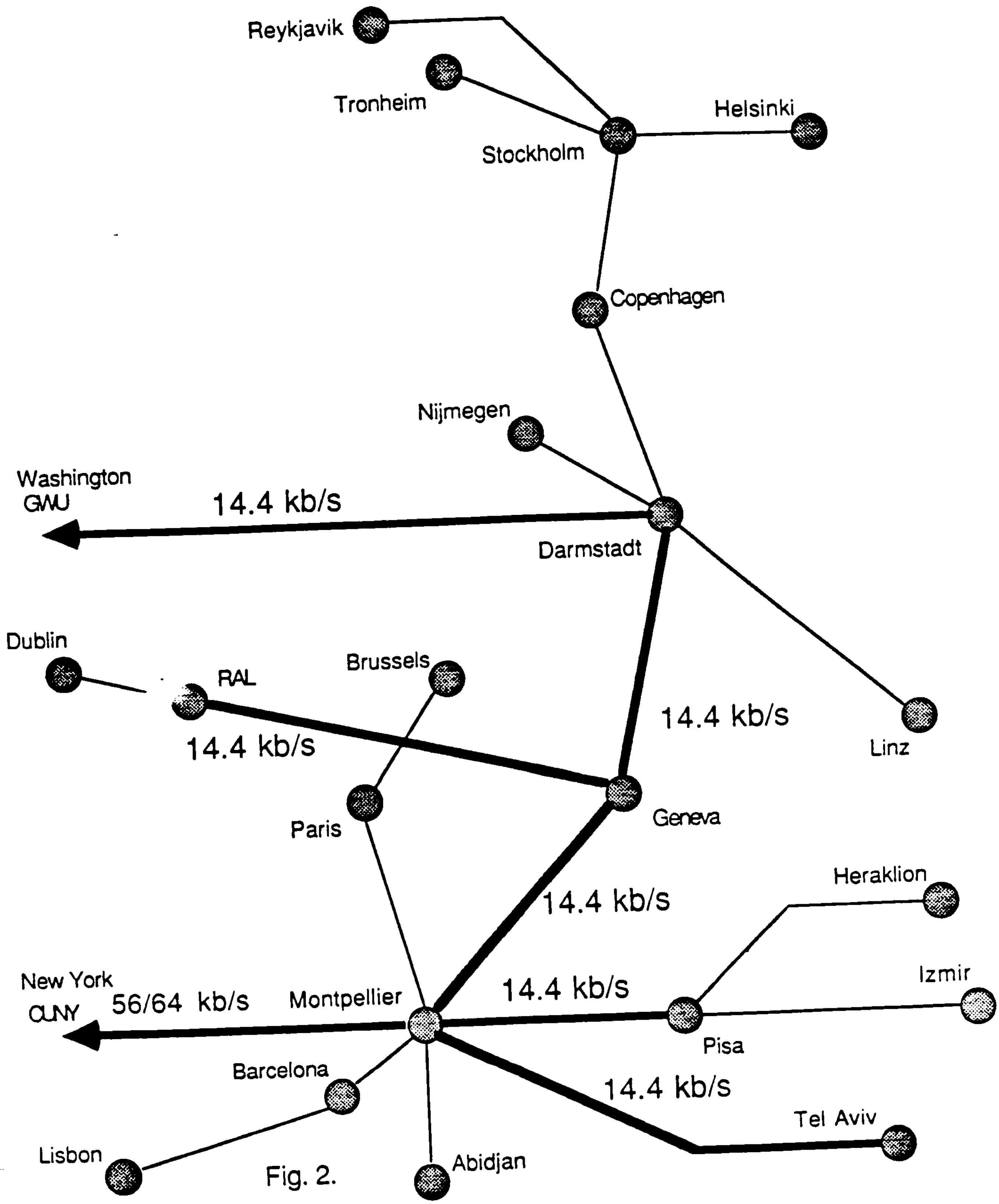


Fig. 2.

ECONF2

Links in this configuration and their costs in SFr./year.

| | | |
|---|---|---|
| A | D | 86765 |
| B | F | 57386 |
| CH | D | 74593 |
| CIV | F | 180168 |
| D | USA | 166119 |
| DK | D | 63732 |
| E | F | 50629 |
| F | CH | 63660 |
| GB | CH | 70699 |
| GR | I | 130690 |
| I | F | 87745 |
| IRL | GB | 23503 |
| ISL | S | 0 |
| ISR | F | 188262 |
| N | S | 35945 |
| NL | D | 62970 |
| P | E | 94243 |
| S | DK | 31571 |
| SF | S | 45301 |
| TUR | I | 167043 |
| T/L | F | 211800 |

TABEL 5.2

Total Annual Costs for the From_countries in SFr.

| Models: | A | B | %Key | E | %Key | F |
|---|---|---|---|---|---|---|
| A | 97912 | 99065 | 4.7 | 90494 | 5.1 | 97768 |
| B | 68533 | 99065 | 4.7 | 90494 | 5.1 | 68389 |
| CH | 85741 | 99065 | 6.3 | 120658 | 6.9 | 89263 |
| CIV | 191315 | 99065 | 0.3 | 7541 | 0.4 | 181085 |
| D | 166119 | 99065 | 7.9 | 150823 | 0.0 | 166119 |
| DK | 74880 | 99065 | 4.7 | 90494 | 5.1 | 74735 |
| E | 61776 | 99065 | 6.3 | 120658 | 6.9 | 65299 |
| F | 74807 | 99065 | 7.9 | 150823 | 8.6 | 81997 |
| GB | 81847 | 99065 | 7.9 | 150823 | 8.6 | 89037 |
| GR | 141837 | 99065 | 2.7 | 52788 | 3.0 | 137108 |
| I | 98892 | 99065 | 7.9 | 150823 | 8.6 | 106082 |
| IRL | 34651 | 99065 | 2.7 | 52788 | 3.0 | 29922 |
| ISL | 11147 | 10590 | 0.3 | 7541 | 0.4 | 916 |
| ISR | 199410 | 99065 | 4.7 | 90494 | 5.1 | 199265 |
| N | 47092 | 99065 | 4.7 | 90494 | 5.1 | 46947 |
| NL | 74118 | 99065 | 6.3 | 120658 | 6.9 | 77640 |
| P | 105390 | 99065 | 2.7 | 52788 | 3.0 | 100661 |
| S | 42718 | 99065 | 6.3 | 120658 | 6.9 | 46241 |
| SF | 56448 | 99065 | 4.7 | 90494 | 5.1 | 56303 |
| TUR | 178190 | 99065 | 4.7 | 90494 | 5.1 | 178045 |

Total International Leased Line Costs: SFr. 1892833

TABEL 6.2

# Possible New Cofiguration of EARN Main Links,

EOONF5

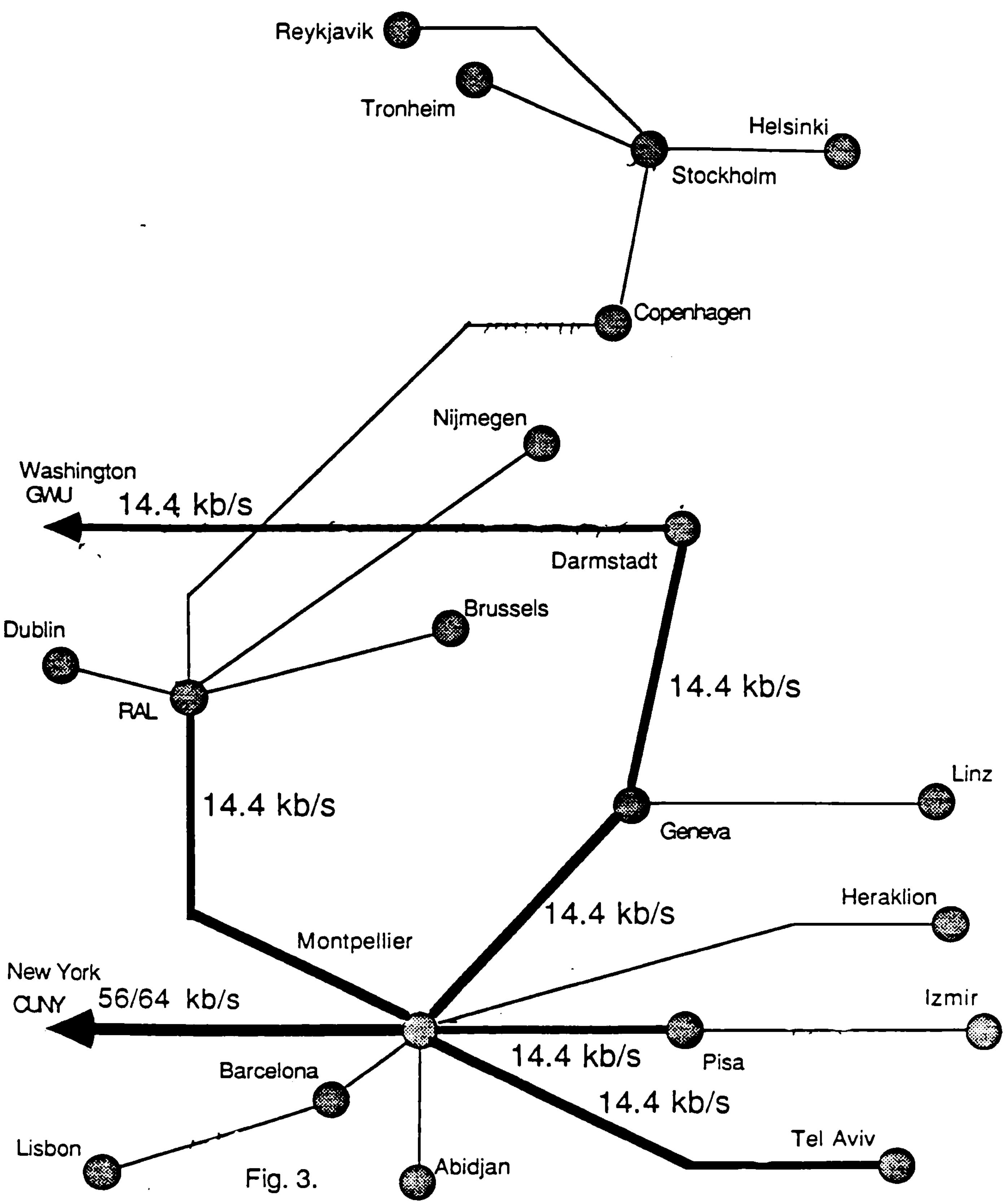


Fig. 3.

Links in this configuration and their costs in SFr./year.

| | | |
|---|---|---|
| A | CH | 85491 |
| B | GB | 48838 |
| CH | D | 74593 |
| CIV | F | 180168 |
| D | USA | 166119 |
| DK | GB | 62412 |
| E | F | 50629 |
| F | CH | 63660 |
| GB | F | 49297 |
| GR | F | 95712 |
| I | F | 87745 |
| IRL | GB | 23503 |
| ISL | S | 0 |
| ISR | F | 188262 |
| N | S | 35945 |
| NL | GB | 40434 |
| P | E | 94243 |
| S | DK | 31571 |
| SF | S | 45301 |
| TUR | I | 167043 |
| T/L | F | 211800 |

TABEL 5.5

Total Annual Costs for the From_countries in SFr.

| Models: | A | B | %Key | E | %Key | F |
|---|---|---|---|---|---|---|
| A | 96639 | 94325 | 4.7 | 86188 | 5.1 | 96494 |
| B | 59985 | 94325 | 4.7 | 86188 | 5.1 | 59840 |
| CH | 85741 | 94325 | 6.3 | 114917 | 6.9 | 89263 |
| CIV | 191315 | 94325 | 0.3 | 7182 | 0.4 | 181085 |
| D | 166119 | 94325 | 7.9 | 143647 | 0.0 | 166119 |
| DK | 73559 | 94325 | 4.7 | 86188 | 5.1 | 73415 |
| E | 61776 | 94325 | 6.3 | 114917 | 6.9 | 65299 |
| F | 74807 | 94325 | 7.9 | 143647 | 8.6 | 81997 |
| GB | 60445 | 94325 | 7.9 | 143647 | 8.6 | 67635 |
| GR | 106859 | 94325 | 2.7 | 50276 | 3.0 | 102130 |
| I | 98892 | 94325 | 7.9 | 143647 | 8.6 | 106082 |
| IRL | 34651 | 94325 | 2.7 | 50276 | 3.0 | 29922 |
| ISL | 11147 | 10590 | 0.3 | 7182 | 0.4 | 916 |
| ISR | 199410 | 94325 | 4.7 | 86188 | 5.1 | 199265 |
| N | 47092 | 94325 | 4.7 | 86188 | 5.1 | 46947 |
| NL | 51582 | 94325 | 6.3 | 114917 | 6.9 | 55104 |
| P | 105390 | 94325 | 2.7 | 50276 | 3.0 | 100661 |
| S | 42718 | 94325 | 6.3 | 114917 | 6.9 | 46241 |
| SF | 56448 | 94325 | 4.7 | 86188 | 5.1 | 56303 |
| TUR | 178190 | 94325 | 4.7 | 86188 | 5.1 | 178045 |

Total International Leased Line Costs: SFr. 1802774

TABEL 6.5

# Appendix A

## Codes.

*Table 1*: Country Codes.

```
A   - Austria.
B   - Belgium
CH  - Switzerland
CIV- Ivory Coast
D   - Germany
DK  - Denmark
E   - Spain
F   - France
GB- Great Britain
GR  - Greece
I   - Italy
IRL- Ireland
ISL- Iceland
IRL- Israel
N   - Norway
NL  - Holland
P   - Portugal
S   - Sweden
SF  - Finland
TUR- Turkey
T/L- Transatlantic between France and the USA.
```

TELECOMMUNICATIONS SUPPORT GROUP (TCC for E/ME/A)

Report Number 205

# EUROPEAN ACADEMIC AND RESEARCH NETWORK

NETWORK STUDY:

Technical: -Traffic growth accommodation
Economical: -International lines charges optimization

Claude LAURENS

La Gaude Tel 93 58 42 59

March,31st 1987

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EARN NETWORK STUDY

## 1. MANAGEMENT SUMMARY


The purpose of this document is to analyse present EARN network from both economical and technical viewpoints.
From the technical standpoint the goal is to cope with the anticipated traffic growth of the next years by adjusting the network meshing to the traffic flows and by using the services best suited to traffic volumes.
From the economical standpoint the approach is to optimize the use of international lines provided by the PTTs.
The proposed solution is to implement a hierarchical network using private leased lines with three levels:

1. A high traffic transit network
2. Regional nodes handling the traffic of neighbouring countries and acting as gateways to the high traffic network
3. Individual country nodes acting as gateways to the regional nodes for the national traffic

The high traffic transit network could use, when traffic will require so, the 64 kbps full duplex service which is going to be made available by the European PTTs (Arteres Numeriques terrestres by French DTRE)
As the network is exclusively used for batch traffic the various nodes are using "store and forward" protocols. The eligible regional nodes for the high traffic transit network are:

- Montpellier
- Geneva
- Darmstadt
- London

The other nodes can be either directly linked to this high traffic network or, for reducing the line charges, connected to another node acting like a regional node.

Implementation of this solution can be staged and each stage is described as an independent scenario. Cost benefits of each scenario are evaluated and should help the decision making. It is not mandatory that implementation follows the sequence order of the scenarios although this would be preferable.

Network management should be an almost real time process for adjusting the network resources (lines and associated transmission equipment like modems and front-end processors) to the traffic requirements. Thus great attention should be paid in the future to the collection and analysis of the data related to traffic, including whenever possible the indication of the originating and terminating points in order to closely tune the network according to the offered traffic. Failing to do so will either increase the amount paid for the lines (additional lines subscribed when existing ones are ineffectively used) or generate periods of time during which the network is congested.

The first rough total savings suggested in this document amount to 13 percent of the total amount paid in March 1987 for PTT lines. At the same time the network structure based on this solution becomes better adapted to the traffic flows as recorded in the period 1986 up to early 1987.

2. EARN NETWORK TRAFFIC AND LINE CHARGES (1987)

| FROM | TO | TRAFFIC LOAD (1) | ANNUAL BILL (2) | TAXES (3) (4) | |
|---|---|---|---|---|---|
| PARIS | BRUSSELS | 4 % | 31195 | NO 19% | |
| MONTPEL | BARCELONA | 3 % | 42613 | NO 12% | |
| NIJMEGEN | DARMSTADT | 1.2 % | 37433 | NO NO | |
| LISBON | BARCELONA | 1 % | 55163 | NO 12% | |
| LONDON | GENEVA | 22 % | 42462 | 15% NO | |
| MONTPEL | GENEVA | 14 % | 37616 | NO NO | |
| LONDON | DUBLIN | Not av. | 9707 | 15% NO | |
| GENEVA | PISA | 52 % | 55367 | NO 18% | |
| GENEVA | STOCKHOLM | 15 % | 61657 | NO NO | |
| GENEVA | DARMSTADT | 43 % | 44309 | NO NO | |
| LINZ | DARMSTADT | 3.5 % | 52580 | NO NO | |
| COPENHAG | DARMSTADT | 1.6 % | 38264 | 22% NO | TAX INCLUDED |
| STOCKHOLM | TRONDHEIM | 3 % | 20536 | NO 20% | TAX INCLUDED |
| STOCKHOLM | HELSINKI | 11.3 % | 24360 | NO 16% | |
| PISA | HERAKLION | 0.3 % | 67109 | 18% 11.2% | |
| PISA | TEL-AVIV | 17 % | 182071 | 18% 15% | |
| PISA | IZMIR | 3 % | 93401 | 18% ? | |
| PISA | USA (NYC) | 63 % | 111620 | 18% ? | TO BE REMOVED |
| MONTPEL | USA (NYC) | | 137616 | NO ? | TO BE ADDED |
| MONTPEL | ABIDJAN | | 123732 | NO ? | To be added |
| DARMSTADT | USA (WASH.) | 23 % | 124748 | NO ? | |
| REYKJAVIK | STOCKHOLM | | | | Switched |

Notes:

1. The traffic load is expressed as a percentage of a the maximum theoretical traffic that a 9.6 kbps line can handle. The maximum figure in this case is 3110 Mbytes per month.
2. The annual bill is expressed in US dollar (See Chapter 3. Currencies exchange rates)
3. Tax applicable in the country of origin (First column from the left labelled FROM). See Chapter 9. Impact of taxes.
4. Tax applicable in the country of destination (Second column from the left labelled TO). See Chapter 9. Impact of taxes.

## 3. CURRENCIES EXCHANGE RATES

From Financial Times dated 12th/Mar/87

1 US Dollar equals:

| | | |
|---|---|---|
| Austria | 13.05 | Schilling |
| Belgium | 38.61 | Franc |
| Denmark | 6.98 | Krone |
| Finland | 4.54 | Markka |
| France | 6.18 | Franc |
| Germany | 1.86 | Deutsche Mark |
| Greece | 135.91 | Drachma |
| Ireland | 0.694 | Punt |
| Israel | 1.62 | New Shekel |
| Ivory Cost | 312.5 | C.F.A. Franc |
| Italy | 1302 | Lira |
| Netherlands | 2.10 | Guilder |
| Norway | 6.97 | Krone |
| Portugal | 142.3 | Escudo |
| Spain | 130.20 | Peseta |
| Sweden | 6.47 | Krona |
| Switzerland | 1.56 | Franc |
| Turkey | 775.79 | Lira |
| United Kingdom | 0.627 | Pound Sterling |

## 4. TRAFFIC STATISTICS

### AUSTRIA

Total monthly traffic (sent + receive) per origin/destination averaged over the period July 86 / Dec 86

| | |
|---|---|
| Germany | 109 Mbytes |

### BELGIUM

Total monthly traffic (sent + receive) per origin/destination averaged over the period Jan 87 / Feb 87

| | |
|---|---|
| Belgium | 140 Mbytes |

### DENMARK

Total monthly traffic (sent + receive) per origin/destination averaged over the period July 86 / Dec 86

| | |
|---|---|
| Germany | 50 Mbytes |

### FINLAND

Total monthly traffic (sent + receive) per origin/destination averaged over the period Jan 87 / Feb 87

| | |
|---|---|
| Sweden | 350 Mbytes |

### FRANCE

Total monthly traffic (sent + receive) per origin/destination averaged over the period Jan 87 / Feb 87

| | |
|---|---|
| Belgium | 140 Mbytes |
| Spain | 95 - |
| Switzerland | 390 - |

### GERMANY

Total monthly traffic (sent + receive) per origin/destination averaged over the period July 86 / Dec 86

| | |
|---|---|
| Austria | 109 Mbytes |
| Denmark | 50 - |
| Netherlands | 40 - |
| Switzerland | 1337 - |
| USA | 715 - |

### GREECE

Total monthly traffic (sent + receive) per origin/destination averaged over the period Jan 86 / Sep 86

| | |
|---|---|
| Italy | 10 Mbytes |