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The United Nations University

SMR/774 - 26

THIRD COLLEGE ON MICROPROCESSOR-BASED REAL-TIME CONTROL - PRINCIPLES AND APPLICATIONS IN PHYSICS
26 September - 21 October 1994

WIDE AREA NETWORKING (WANs) FOR DEVELOPING COUNTRIES

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Under these conditions the available options can be discussed in the following manner:

Using dial up lines

Using dial up lines from the telecommunication network for national connectivity as well as international connectivity is the quickest and the cheapest in terms of start up costs, but certainly not the easiest.

The start up costs can include:

- the cost of obtaining a telephone line (if not already available)
- with IDD facility for international dialling
- the cost of obtaining a suitable modem and few accessories.

It is assumed that you will have access to a PC or a workstation. In this connection it is interesting to note **how easy it is to buy a PC or a WS which costs much more than a modem** !!

UUCP (Unix-Unix CoPy) software which was originally developed to use over dedicated lines is now available for both the PCs (UUPC) and WSs and is adequate to operate a reasonable electronic mail service using dial up connections. For this purpose ***version g*** of the UUCP protocol is used which fragments data into packets, uses a checksum to detect errors and retransmits when necessary. The ***versions f*** and ***t*** are available to use with X.25 packet switching networks and TCP/IP networks respectively.

The telephone line and the PC will be used only for the duration of the call to transfer the email messages and hence can be used for other purposes during other times.

Since it is operated on a dial up basis it will have the following features.

1. the usage cost is proportional to the time.
2. it is an off-line network
3. interactive computing is possible with suitable software (such as kermit) but will be both slow and expensive.

The problems with this type of network operation can be two fold.

Firstly in developing countries the **telephone lines are both unreliable and of poor quality**. There is very little you can do about the unreliability. Although the poor quality can be ignored in a voice conversation this seriously affects the data transfer rate when the line is used for data communications.

Secondly if the line can be driven at the highest possible data rate then it increases the throughput. This means either you **transfer a given amount of data within a shorter time** and hence at a lesser cost or for a **given amount of money you can transfer more data**.

Nowadays there are modems with built in error correction which will take care of line noise and other irregularities.

The second important feature of a modem is the ability to compress your data so that more data can be sent/received within a given time. Again there are modems which will automatically compress your data when transmitting and uncompress when receiving compressed data.
To derive benefits from error correction and data compression it is **necessary that both ends of the link use compatible modems**. In order to make this possible there are international standards for:

- the modulation techniques in modems
- the error correction techniques used in modems
- the data compression algorithms used in modems.

There are also very good proprietary modems sometimes better than the ones conforming to the international standards. However it must be noted that their use is restricted specially if they do not support alternative features conforming to the international recommendations.

Selecting a modem

The most popular modems conforming to the ITU-T (formerly known as the CCITT) recommendations are:

V.22 *bis* Standard

V.22 *bis* is the international standard for modems operating at 2.4 Kbps. These modems are not very costly and are freely available. For telecommunication lines which cannot support high speed data transfer this is a good choice.

High Speed Modems - V.32 and V.32 *bis*

Modems conforming to V.32 standard operate at 9.6 Kbps where as V.32 *bis* operates at 14.4 Kbps. V.32 *bis* is downward compatible with V.32 and can automatically fall back to 12 Kbps, 9.6 Kbps and 7.2 Kbps.

A little expensive but a very good choice.

V.34 Standard for very high speed modems

This standard specifies a modulation technique which allows data transfer to take place at a **raw speed in the range of 24 Kbps - 28.8 Kbps** on a standard voice grade telecommunication line. Already there are commercial products running at these speeds but not strictly conforming to the V.34 standard. They are known as **V.fast** modems and the manufacturers are promising a free upgrade to the V.34 standard.

V.42 Error Control Protocols

One of the most **essential characteristics** of a modem for a line of poor quality is the ability to **carry out error control**. The ITU-T standard recommended for error control in modems is V.42. This is available with modems conforming to V.22 *bis* as well as V.32 and V.32 *bis*.

MNP-4 (Microcom Networking Protocol - Level 4) is a proprietary error control protocol developed by Microcom and is available in some modems. Since V.42 uses LAP-M as the primary scheme and MNP-4 as the alternate scheme, a V.42 modem can establish an error controlled connection with a modem that only supports MNP-4.

V.42 *bis* Data Compression

The ITU-T standard for data compression is V.42 *bis*. A modem with V.42 *bis* capability will automatically compress the data on transmitting and decompress on receiving. The maximum compression that a V.42 *bis* modem can achieve is 4:1. This will give a V.32 modem a maximum throughput of 38.4 Kbps.

MNP-5 is an alternate protocol for data compression. It can achieve a maximum compression ratio of 2:1. Virtually all high speed modems that support V.42 *bis* also incorporates MNP-5.

There are also the modems manufactured with special features and optimised to work with particular protocols. For example Telebit Trailblazer is known to work extremely well with UUCP. Some of them also will support the ITU-T standards along with their own protocols.

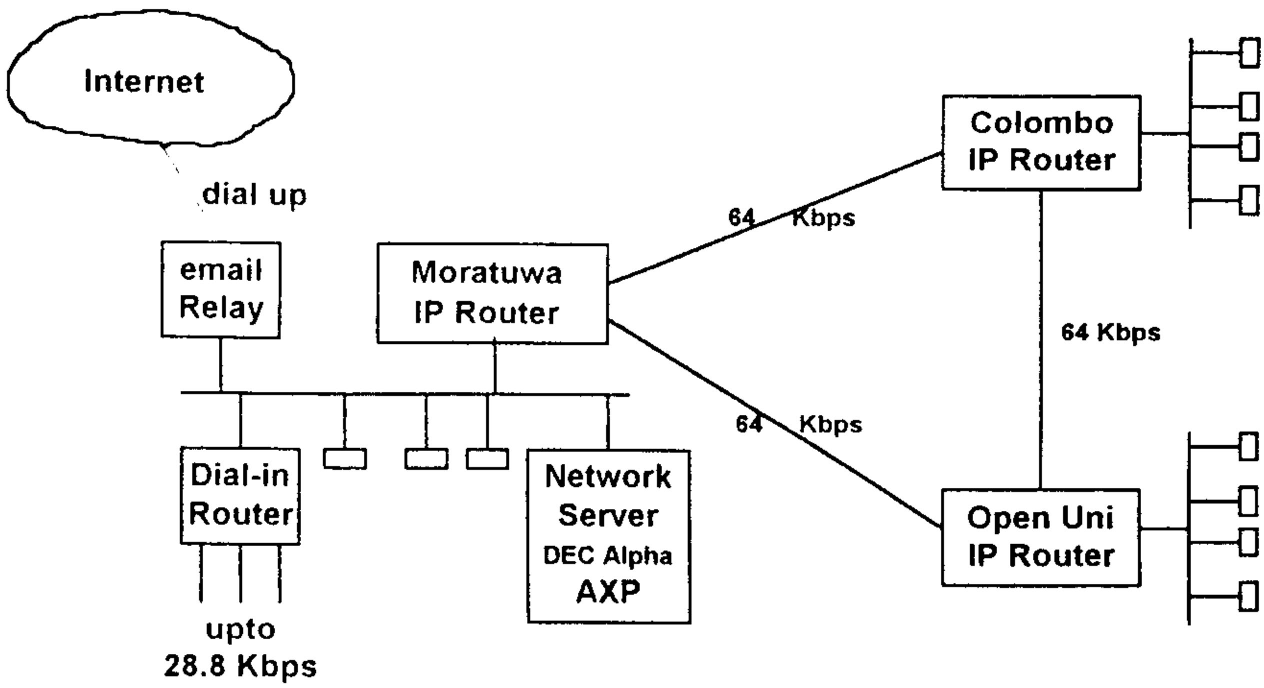
This kind of service is ideal for an institute or even for a whole country. As an example the academic email service ***LEARNmail*** is provided for **more than 50 sites in Sri Lanka using this type of technology**.

Packet Radio based on AX.25 protocol (amateur X.25; not compatible with ITU-T X.25 protocol) is another option. Usually these are slow speed in the order of 1200 bps. They use an AX.25 TNC (Terminal Node Controller) to convert data into radio signals and a radio transceiver to communicate. These devices may be useful to connect distant and isolated nodes where land lines are not simply available.

Using dedicated lines

A similar network facility can be built using data circuits leased from the telecom service providers. Although an analog leased line can be obtained to operate at low speeds such as 4.8 - 19.2 Kbps it is always better to use a digital data circuit which operates at 64 Kbps and above.

One of the most promising technologies seen in the last couple of years is in the area of **spread spectrum radio modems** for high speed data transfer. Presently there are products available to run at 256 -512 Kbps speeds over 10- 20 km distances.



LEARN Phase I - Conceptual Connectivity

The setting up of a network using dedicated circuits will then require the selection of a networking protocol to run on the network. Due to many advantages that have been discussed so far **Internet Protocol (IP)** seems to be the best choice.

The use of such dedicated data circuits will make the network to operate in the on-line mode. Hence the on-line services such as *remote login, file transfer*, etc can be provided to the users.

For places where such dedicated circuits are not readily available, the services can be provided through dial up access using the techniques described above. **SLIP** (Serial Line Internet Protocol) and **PPP** (Point to Point Protocol) are available to provide full IP connectivity on a dial up basis over an RS 232 serial link. These protocols will automatically establish a connection when an IP packet arrives and needs to be gatewayed.

IP Addressing

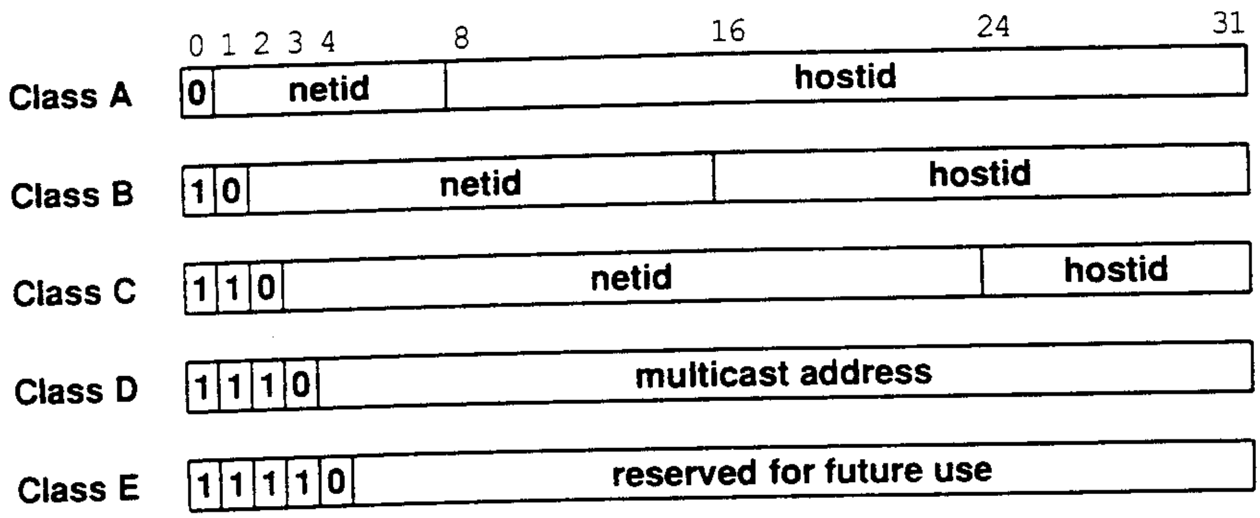
In connection with the decision to run IP on a network is the issue of allocating IP addresses to the hosts on the network. Although it is possible to arbitrarily allocate IP numbers in an isolated network which is not connected to the global Internet, it is highly advisable to start **allocating proper IP addresses from the beginning**. This will certainly be useful when the time comes to connect your network to the global Internet without having to renumber all the hosts connected on your network.

IP addresses are allocated on a domain basis by the Network Information Centre (NIC). At the moment there are three NICs namely; the **InterNIC** (for the world), **RARE** (for Europe) and the **APNIC** (for Asia Pacific). If a country is already registered with the NIC, then there is a representative in the country who is expected to manage the IP address space for that country. You should contact the registered top domain in your country for your IP addresses.

Any difficulties in obtaining IP addresses from the representative must be brought to the notice of the InterNIC or any other NIC as appropriate.

IP Address Format

An IP address is a 32 bit number which is usually expressed in the decimal dot notation (*eg.* 140.105.16.53). Each and every host connected to an IP network will have a **unique IP address**. The IP address will specify the **Host ID** as well as the **Net ID**.



The five forms of Internet (IP) addresses. The three primary forms, Classes *A*, *B* and *C*, can be distinguished by the first two bits.

What is in a name ?

The IP address space is divided into **domains** and each domain is given a name. The top domain can be a country for eg. ***.it*** (for Italy) and ***.lk*** (for Sri Lanka). In the US traditionally the top domain was divided depending on the activity for eg. ***.edu .com .gov*** etc. However the country domain for the US is ***.us,*** but is not in wide use at the moment.

After the top domain the sub domains can be divided according to the requirements of a country. These can include domains such as ***.ac*** (for academic) and ***.res*** (for research).

The domain name system will allow specifying of a host or a user on the Internet using the domains and the sub domains.

for eg. *joe@ictp.trieste.it*

in the notation ***user@subdomain1.subdomain2.domain*** will specify the user **joe** at **ictp**.

Connecting to the Internet

The use of a suitable modem and a voice grade telephone line will allow a station to get connected to the Internet. The access ports are available at the sites of commercial Internet Service Providers such as CompuServe.

The lists of Internet service providers both in the US and outside US are available from the following:

by email :

nisc@nisc.sri.com

by ftp :

ftp.nisc.sri.com
/netinfo/internet-access-providers-non-us.txt

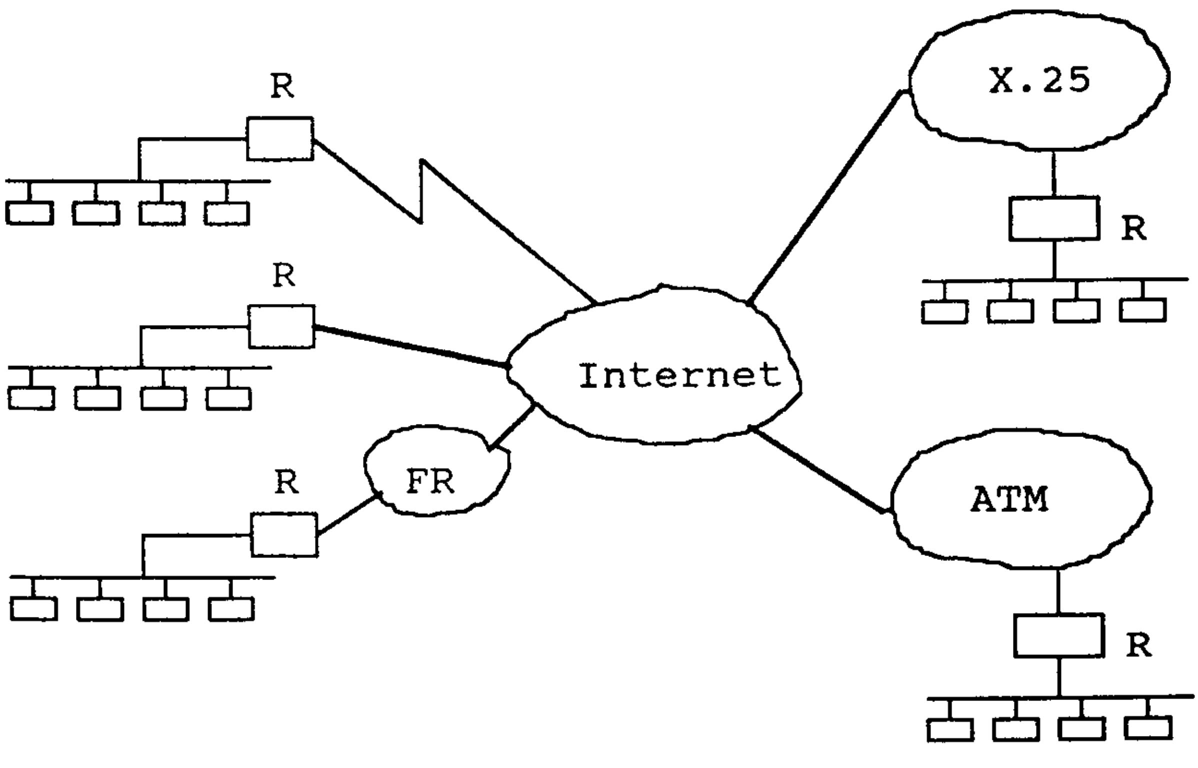
There are also Public Access Internet hosts which will allow users to access the Internet. However many of these sites will generally support modems conforming to V.22 *bis* running at 2.4 Kbps.

It is not sufficient for a network or a host to have an IP domain name to be part of the Internet; **use of IP protocol** and integration into the Internet IP address space as well as a **connection at the IP layer** are also necessary. For this purpose a link on which IP protocol is run must be established.

Alternative Access Methods

There are other ways of setting up and accessing WANs depending on the availability of alternate access methods. They are:

- using an **X.25 public packet switched** data network (PPSDN)
- using **ISDN** services
- using **Frame Relay** networks
- using **ATM** networks.



Types of access to the Internet

Clearly some of these technologies such as Frame Relay or even ISDN may not available in many developing countries for some years to come. Even if PPSDN access on X.25 networks are available they are very expensive in terms of usage cost. ATM has a great promise in the future but the commercial products are just beginning to appear and are very expensive. Hence the developing countries will have a few more years before these technologies have to be mastered.