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NICNET - A Hierarchic Distributed Computer Communication Network For Decision Support In The Indian Government

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A decision support information system for the Indian Govern-
ment is being evolved, based on the design of a predom-
inantly query-based computer network with hierarchic distri-
buted databases and random access communication. The four
level hierarchy spans 439 districts at the lowest level, the
Central Government headquarters in New Delhi, the set of 32
State Capitals and Union Territories, and the set of four
Regional Centres.

With interference tolerance and random access as two guiding
principles behind the choice, Spread Spectrum transmission
and Code Division Multiple Access system of satellite com-
munication was adopted. Each node of the network is a 32-
bit computer which is capable of local bulk storage of up to
three units of 300 megabytes each for purposes of query-
accessible distributed databases. The design and implemen-
tation of such a distributed database has endowed the net-
work with the capability to distribute the data related to
such databases over various nodes in the network so as to be
able to accept a query from any of the nodes.

1. INTRODUCTION

From the genesis of the concept of
the National Informatics Centre
(NIC) in 1973 to its nucleation in
1975 followed by the commissioning
of NICNET in 1977, it was a phase
of innovation penetrating through
barriers of conservatism in
Governmental organisations.

The NIC, now an organisation
structured around nearly 2000 per-
sonnel, including nearly 1500 com-
puter specialists, is giving
full-fledged Management Informa-
tion System (MIS) and computerisa-
tion services to several
Ministries/Departments and associ-
ated organisations in the Central
and State Governments by catalys-
ing the growth of computerisation
where none existed earlier. The
most important function of NIC is
to put to use the new technology
of computer networking to enable
efficient exchange of information
between the Centre and the States,
between the States and their Dis-
tricts and among the

Ministries/Departments as well as between them and the public. With emphasis on appropriate computerisation, NIC has emerged as an agent of beneficial transition in the Government of India introducing computerisation in areas conducive to efficient functioning of the Ministries/Departments and their associated organisations.

Yet, it should be regarded that the entire NIC experiment is still in its formative stage of development considering the inertial factors that are invariably present in several user organisations. Too slow a rate of transition may discourage the innovative scientists, engineerings and systems analysts of NIC whereas too fast a transition may create reactionary pressures from conservative and inertial forces within the user organisations. It is for this reason that every computerisation exercise by NIC is preceded by an analysis of the appropriateness of the problem area and the ability to assimilate new ideas and new methods by the concerned personnel in the user organisations. Recognising the need to give maximal involvement and participation to the officers and staff of the user organisations, NIC has put in massive efforts for training the user personnel at every level so that they become progressively self-reliant in the use of the NIC network facility, releasing the energy of the personnel of ÑIC for catalysing newer areas of beneficial applications.

NIC provides total informatics services to various government departments and associated organisations in the country. These services include conducting feasibility studies, development of computer based Management Information Systems, design and Implementation of Databases, Analysis, modelling and optimization, training of government officials apart from design, development, installation and operation of computer systems and local area networks.

In the past ten years, NIC has developed and commissioned a large number of information systems in various socio-economic sectors. The initial efforts of NIC during this period have been devoted towards developing these systems for the use of Central Government Ministries and Departments. From this point of view, NIC has been able to make significant headway in creating awareness in central government departments on the use of computer based MIC for planning purposes. However, the macro level data, which is used for this purpose is based on micro level data collected throughout the country. This micro-level data follows a hierarchical path to the planning agencies at various levels. At each level of this hierarchy, the micro level data is transformed into macro level and statistical data to be used at the respective higher levels for monitoring and planning purposes.

In general, the network would facilitate;

– Monitoring of vital socio-economic projects;

– Online retrieval from databases and updating;

– Optimum utilization of expensive computer resources;

– Emergency communication system;

– Sharing latest software tools;

– Dissemination of information;

– Exchange of messages and information between central government, state governments and district administrative units.

NICNET was conceived to provide the data communication capability to achieve the objectives mentioned above. It consists of a satellite based communication system, which is the inter-nodal backbone and a terrestrial network to provide communication capabil-

ity around each node. The Satellite Option was chosen to provide data communication between the districts, states, regional centres and the national headquarters.

The analysis of informatics requirements of the government agencies in the country requires decentralised collection and processing of information to meet the requirements at various levels of administration in the country. A typical nation-wide Management Information System requires information to be collected and processed at different places in the country. The NICNET computer and communication facilities provided nation-wide make the computing resources available at the places from where the information emanates. However, in order to effectively use the network facilities it is essential that the data captured at different places be integrated in the form of a single nation-wide database. The design and implementation of such a database requires the capability to distribute the data over various nodes in the network and to be able to submit a query from any of the nodes. The Distributed DBMS which provides such facilities should be capable of partitioning and posting of queries onto different network nodes and collect the results from these nodes and provide a unified answer to the query submitted from the originating node. It is primarily to meet this requirement of NIC that a distributed DBMS called UDMS is being implemented on NICNET.

2. HIERARCHY OF GOVERNMENT INFORMATICS

The hierarchy of government informatics is four fold:

a) National level informatics through the Central Government;

b) State level informatics through the State Governments and Union Territories (32)

c) District level information through the District Administrations (439)

d) Grass-root level information through Block Development Agencies (5000)

2.1. National Level Informatics

During the last decade, NIC has been able to make headway in creating awareness in the Government sector of computer-based information systems as an effective tool for decision support. NIC has played a promotional role in creating appropriate computer-based information systems in various sectors such as;

    Agriculture
    Commerce
    Communication
    Finance
    Financial Resources
    Industry
    Water resources
    Human resources
    Natural resources
    Energy
    Urban development
    Personnel and public grievances
    Steel and Mines
    Law
    Social welfare, etc.

These systems provide macro level information in the respective sectors, for the purpose of project monitoring and national planning.

2.2. State Level Informatics

State Government Departments get about 700 reports in the prescribed proforma with different periodicity (monthly, quarterly /half-yearly, annual) regarding the financial achievement/physical achievement in respect of both plan and non-plan schemes being executed by the State. The NIC state centres provide facilities

to organise and process the infor-
mation contained in these reports.

The information with respect to
the sectors such as state revenue,
law and order, education, agricul-
ture, industry etc., which are
under the direct purview of the
states, is processed to meet the
requirements of the state. How-
ever, macro information with
respect to schemes for which cen-
tral assistance is sought is sent
to the centre on a periodic basis.
Similarly, macro level information
is sent by the states on the cen-
tral schemes.

2.3. District Level Informatics

There are more than 20 major
developmental agencies and depart-
ments on an average at the dis-
trict level at present. Under the
Seventh Five Year Plan, there are
about 2000 schemes under implemen-
tation in a state of which about
1500 are mainly at district lev-
els. In order to ensure that the
resources and machinery are
optimally utilized, effective mon-
itoring is essential on a regular
basis. The district administra-
tion, line and functional depart-
ments send about 700 reports
(monthly, quarterly or half-
yearly) to various state and cen-
tral government departments.
These reports provide micro level
information with regard to
developmental activities. As
there is no standardization of
data format in these reports, no
consolidation of information or
comparison is possible, which is
necessary for macro level planning
purposes. In order to assess the
comparative development of various
districts in general, the central
government has evolved guidelines
in the form of "Indicators of
Development" which include demo-
graphic indicators, agro-economic
indicators and infrastructure
indicators.

NIC is establishing district level
information system called DISNIC

to facilitate the development of
information systems in the follow-
ing disciplines:

1. Industry
2. Agriculture
3. District Planning
4. Health
5. Road and Bridges
6. Rural development
7. Social Forestry
8. Animal Husbandry
9. Social Welfare
10. Building and Works
11. Power
12. Irrigation
13. Public Instruction
14. Collegiate Education
15. Town Planning
16. Transport
17. Employment and Labour
18. Fisheries
19. Water Authority
20. SC/ST development
21. Civil Supplies
22. District Collectorate
    functions
23. District Treasury
24. Census

The major advantages of DISNIC
will be:

a) access to detailed data in
   respect of:

   – socio economic indicators
   – demographic indicators
   – agro economic indicators
   – infrastructural facilities
   – plan schemes/non-plan schemes

b) improvement in quality of data,
   and

c) enhanced capability of analysis
   and its presentation through
   graphics

2.4. Grass-root Level Informatics

As the Block is the smallest
developmental unit, especially for
implementing development pro-
grammes, and the blocks generate
basic information, the development

of block level information system will go a long way in increasing the availability of such information for decision making purposes at the block level.

Block level computerisation is expected to be taken up by NIC in its Third phase beginning with the first year of the Eighth Five Year Plan.

3. NICNET ARCHITECTURE - COMPUTERS

3.1. Hardware Profile

National Informatics Centre is the depository of information for various Central and State Government Departments. For this purpose, large databases are being developed by National Informatics Centre (NIC) in coordination with the user departments. In order to maintain these large databases on a national scale, NIC has already installed four very large computer systems (S-1000 from NEC, Japan) at Delhi, Pune, Bhubaneshwar and Hyderabad). These will be the four main nodes of the NICNET. The Delhi system acts as the main host.

Mini computer systems or a LAN cluster of mini computers/super-ATs are being installed at each of the State Capitals and Union Territories. These systems will be primarily used by the State Government to consolidate the information coming from various districts/blocks to meet their own requirements and to pass on the necessary consolidated macro level information to the Centre.

As the Districts are basic administrative units under the State, the consolidation of the detailed information pertaining to the districts is done by various agencies at the district level. In order to capture and consolidate this data, super-ATs are being installed at the 439 districts in

the country. As the Block is a smallest development monitoring unit, especially for the plan scheme implementation, they are supposed to be the generators of the basic data for this. In order to capture this basic data, PC based terminals are expected to be installed in the next phase of NIC at the Block level, covering more than 5000 of the blocks.

3.2. Distributed DBMS

UDMS is being developed as a coordinating database management to provide a unified DBMS environment for the network users. The types of computer systems which NICNET has are given in Table 1.

UDMS acts as a coordinating system for the DBMS packages mentioned above at different nodes in the network. It provides a single user interface to design a database distributed over different nodes in the network nad provides SQL-like query language to retrieve information from databases distributed over various nodes. For a user working under UDMS environment the underlying DBMS packages on different nodes are kept transparent for the design as well as for querying the database. The UDMS, however, makes use of the local DBMS packages to create a segment of the distributed database which is to be implemented on the local system as well as to process a partitioned query on a given node. From this point of view, it is possible for a user to use that part of the distributed database which is implemented on this node. However, as this segment of the database is a part of the over-all database, it may not be possible to perform such functions in a stand-alone mode which may affect the integrity of the global database.

Table 1

	System	Operating System	DBMS
(i)	NEC S - 1000 Operating System	ACOS - 6	ADBS & INQ
(ii)	ND-550 System Operating System	SINTRAN	SIBAS
(iii)	CDC Cyber 730 Operating System	NOS	IMF NOS

The major modules of UDMS are:

i) Automated Database Design Tool (ADBDT)

ii) Distributed Query Processor

A brief description of these modules is given below:

ADBDT is a software tool aimed to automate the complex task of designing an integrated database for a distributed environment. Some of the salient features of ADBDT are as follows:

a) all the relevant phases of database design have been automated

b) it allows for interaction at each stage during the design phase accommodating for any changes (updation, deletion, expansion), review and addition to the earlier defined concepts).

c) it is based on a conceptual-entity relationship (CER) model for designing the conceptual scheme.

d) automatic generation of logical and physical definitions of CODASYL and relational database models.

e) user friendly interface; all user interaction is through menus and forms. Users do not

have to learn DDL of any of the underlined packages.

f) the product has been designed and is being implemented to have a high degree of machine independence.

The significant characteristic of ADBDT is that in addition to the conventional syntactic design of databases, ADBDT captures semantic as well as operational characteristics of the database at design stage. It has become possible to capture semantic characteristics more effectively due to C-E-R model.

UDMS allows horizontal partitioning of relations on data dependent conditions. No vertical partitioning of relations is being implemented in the first phase of UDMS. Also, while structural redundancy exists in the database distributed over various nodes, no data redundancy is allowed at this stage.

A significant aspect of UDMS is its capability to provide a single query language to retrieve information from a database distributed over a large number of nodes. Some of the important segments of distributed query processor are as follows:

a) Data Directory Management

A two level directory is pro-

vided by UDMS for creating dis-
tributed database structures on
individual nodes. Each of the
local nodes contain a directory
for the local segment of the
distributed database. The
union of these directories
(global directory) is kept at
the central node. The S-1000
system at Delhi acts as a cen-
tral node for UDMS. The choice
of Delhi system as central node
is primarily because of the
structure of the communication
system which necessitates all
data to flow in the network
through the Master Earth Sta-
tion at Delhi. The updates of
the local directory are
automatically communicated to
the central system to update
the global directory.

b) Query Processing

All queries are submitted to
UDMS in a network environment.
The system first refers to
local directories and the query
is first analysed with refer-
ence to it. The query is than
sent to the Central system for
processing at other nodes based
on the availability of informa-
tion at those nodes. As the
DDB is structurally redundant
at different nodes, the query
is processed at other nodes
even if it can be fully satis-
fied at the local node. Query
is partitioned based on distri-
bution pattern of the database.
The partitioned queries are
then translated into
queries/DML programs of the
local systems. The partitioned
queries are filtered for those
functions which are not avail-
able on local systems. These
partitioned queries are posted
and executed at respective
nodes. Additional processing
with respect to global func-
tions is performed at the cen-
tral node. The results are
then combined. The final
response to the query is then
sent to the originating node.

4. NICNET ARCHITECTURE - COMMUNI-
CATION

To achieve the data network a
number of features will have to be
built into the communication sys-
tem.

- Flexible Network Structure

  Terminals can be connected to
  the system directly or via
  telephone, Telex or circuit
  switched network; remote termi-
  nals can be connected via
  packet Multiplexor or PADs
  through satellite circuits.

- Broad terminal integration

  Packet terminals, non-packet
  terminals and host computers of
  different speeds can be
  integrated.

- Compatibility

  The system should interface
  with external communications
  system according to CCITT
  recommendations.

- Network access

  The system should facilitate
  access to the communication
  network, be it via leased or
  dedicated lines, switched tele-
  phone network or satellite cir-
  cuits.

- Line Utilization

  Each packet terminal can com-
  municate with a number of other
  terminals over one physical
  line.

- Error-free transmission

  The system checks the data for
  errors step by step as it
  transmits.

  Considering the above require-
  ments and the need for a low
  duty cycle interactive network
  with a large numbers of sta-
  tions, a satellite based system

was selected to meet the requirements of NICNET. Adjacent satellite interference, as well interference to and from the terrestrial system must be minimal for enabling free siting of the small aperture earth stations. In view of these considerations, a Spread Spectrum Code Division Multiple Access system was chosen for NICNET.

4.1. Spread Spectrum

Spread Spectrum is a means of transmission in which the signal occupies a bandwidth in excess of the minimum necessary to send the information; the band based spread is accomplished by means of a code which is independent of the data and synchronized reception in which the code of the receiver is used for data despreading and subsequent data recovery. It is, in fact, based upon a principle which is a direct antithesis of reducing bandwidth, namely, deliberately employing a larger bandwidth.

A characteristic advantage of this approach is that it minimizes interference from other satellites and terrestrial sources. Further due to the fairly uniform power spread over the entire bandwidth, it offers a low interference potential to other satellite and terrestrial sources. As such, site clearance problems for interference even in congested areas are substantially lower. While spread spectrum uses a larger .spectrum, this is compensated for by the significant interference reduction capability inherent in its use. Consequently, it is possible that a number of users might share the same spectral band simultaneously.

4.2. CDMA Technology

Code division multiple access (CDMA) allows efficient multiple access in extremely large networks

of low duty cycle terminals. The fact that no satellite power is allocated except during actual transmission permits thousands of relatively infrequently transmitting earth stations to share the same 5MHz transponder channel. CDMA takes advantage of the unique way in which spread spectrum technology allows transmission of signals without interference problems.

The information spectrum is spread by a direct pseudo-random noise (PN) sequence, where each data bit is encoded with a binary (chip) sequence with 15 to 2047 binary (1 or 0 "chips") per bit. The expansion is achieved by an exclusive – OR operation on the data and the chip sequence so that a "1" bit contains the chip sequence in inverted form. A "0" bit is a non-inverted chip sequence. Although the encoding chip sequence is pseudo-random, it is perfectly replicable for decoding by the authorized receiver using the same chip sequence to recover the data. The identical PN chip sequence, which is independent of the data, is operated by exclusive – OR with the chipped data (the inverse of the operation used to encode the data) to obtain the data.

The code sequence modulates the carrier using 180 deg biphase shift keying (BPSK). Data are converted to 0 and 180 deg phase modulations of the carrier, where the carrier is transmitted with one phase when the encoded sequence chip (exclusive – OR operation with the data) is a "1" and the opposite phase when the encoded sequence is a "0". The chipped data is then transmitted as if they were the original data bits, producing the phase shifted signal corresponding to each chip.

CDMA has significant advantages over Time Division Multiple Access (TDMA) for sharing a satellite channel among a large number of transactions terminals. This is

because the only constraint imposed by a CDMA system is that the total number of simultaneous transmissions are kept below a specific threshold to avoid the harmful effects of "code noise", or self-interference resulting from imperfect code orthogonality. This is a far easier constraint to satisfy than the constraints imposed by other access techniques. In most other techniques we must ensure that no more than one terminal is transmitting at any instant. As a result, very impressive throughput performance can be obtained. For example, if the threshold of code noise occurs at 100 simultaneous messages, a throughput of 84% can easily be obtained, with only about a 1% chance that a message sent in the peak busy hour will suffer any excess delay. NICNET uses a CDMA access technique of this type, combined with "throttling" to inhibit transmissions when the threshold would be exceeded by such messages. Even when such a CDMA system approaches overload, i.e., more than the allowed number of simultaneous transmissions, the consequence is not as serious with a reservation TDMA system, where a retransmission is required after a 0.5 sec. minimum delay. When a CDMA system approaches overload, 0.1 sec. delays are inserted to throttle demand, rather than requiring retransmission.

NICNET consists of a master earth station located at New Delhi. This Master Earth Station is connected to the host computer. Micro earth stations are located at all regional, state and districts centres. These Micro earth stations communicate through the Master earth station.

The components of this interactive network are described below.

- A network control centre (NCC), which incorporates host computer interfaces to connect NEC S-1000, Cyber and other host

systems.

- A number of micro earth stations and controllers which transmit to the satellite.

5. TECHNICAL DESCRIPTION OF MASTER AND MICRO EARTH STATION *

The description of the Master Earth Station and its various modules, micro earth station, protocol support and its features are given in this section.

The host computers are connected to the Master Earth Station, through a packet switching node. At present, there are six ports of 9.6 KBPS on the packet switch. The district and state systems are connected to the micro earth stations, through RS232C port. Each micro earth station can support either two asynchronous ports or one synchronous port.

The system uses X.25 protocols. The micro earth stations have X.25 built in PAD and have two ports. Through these, virtual circuits are established between the terminals like in circuit switching. Terminal (DTE) to terminal (DTE) link involves travel of signals from terminal to Master Earth Stations via satellite and again via satellite to the destination micro earth station.

5.1. Master Earth Station

The Master Earth Station of NICNET uses Equatorial MC-200 Master Earth Station, which provides two-way communication and network control between a host computer and multiple EQUATORIAL C-200 and C-250 Micro earth stations. Presently, one satellite channel is providing the link between the master earth station and the Micro

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* These details are from the technical literature provided by Equatorial Communication Co./EPIC and ITI.

Earth Stations at remote loca-
tions.

The master earth station receives
multiple data channels from the
user host computer and transmits a
binary phase-shift keyed (BPSK)
6GHz carrier. The output, con-
taining one or more 153.6 KBPS
data channels, is transmitted to
the satellite. Each 153.6 KBPS
data channel consists of demand-
basis time-division-multiplexed
(TDM) data streams and is spread
to occupy 6 MHz of transponder
bandwidth. The data streams con-
tain variable length packets with
data addressed to one ore more
users. The data streams are
received by all micro earth sta-
tions, each of which selects its
assigned traffic based upon broad-
cast, or a single address designa-
tor.

The master earth station receives
a 4GHz carrier from the satellite.
The carrier contains the simul-
taneous data stream transmissions
from multiple C-200 and C-250
micro earth stations. The modu-
lated carrier occupies 5MHz of
transponder bandwidth and consists
of multiple 1200 bps (C-200) and
9600 bps (C-250) code-division-
multiplexed (CDM) data streams
containing variable length packets
with data from multiple micro
earth stations. The input data
streams may be directed to any
output port on the Master earth
station. The output data stream
from the Master earth station is
transmitted to the user host com-
puter through a digital data link.

The Master Earth Station is
divided into four major sections.

a) Antenna module

The antenna module typically
consists of a 13 meter diameter
reflector and both outbound and
inbound subsections. The out-
bound subsection includes the
transmitter waveguide and feed
horn. The inbound subsection
includes a low-noise amplifier

and heliax cable to the RF sec-
tion.

b) Radio frequency section

The EF section provides all
master earth station radio fre-
quency transmitting and receiv-
ing functions. It interfaces
with the antenna module (4GHz
receive, 6GHz transmit), Digi-
tal section (transmitting) and
Demodulator section (receiv-
ing). Dually redundant power
amplifiers, with their associ-
ated power supplies and I/O
switches, are located in the
transmitter rack. Redundant
equipment provides a 'hot
standby' channel in case of
hardware failure. The
remainder of the RF section
consists of upconverter, down-
converter and frequency control
modules for both the active and
standby channels.

c) Digital section

The Digital Section contains
the Outbound Multiplexer (OUT
MUX), Inbound Multiplexer (IN
MUX), and the common chassis
consisting of the network pro-
cessor, Administrative Multi-
plexer (ADMIN MUX), and the
host computer interface. A 500
KBPS local area network (LAN)
provides interunit communica-
tion in the Digital and the
Demodular Sections.

d) Demodulator section

The demodulator section
includes the IF distribution
amplifier and demodulators.
One demodulator channel is
assigned to each Micro earth
station supported. Demodular
rack number one holds upto 96
channels. The rest of the
racks hold 5 Demodulator
chassis of 12 demodulator cards
each (24 C-200 or 12 C-250)
Micro Earth Station channels
for a maximum capacity of 120
Micro earth station channels
per rack. One demodulator card

in each chasis is reserved as a hot backup giving a maximum of 110 active Micro earth station channels per rack.

The following are the major functions of the Master Earth Station:

- Provides datagrams, permanent and switched virtual circuits for operation of the network.

- Provides protocol interfaces to accept and deliver data from multiple user host computer data links.

- Multiplexes data from several host sources into variable length data packets for output as a 153.6 KBPS TDM data stream.

- Receives 1200 bps (C-200) and 9600 bps (C-250) data from multiple micro earth stations and via code division multiplex (CDMA) it separates these data streams for further processing.

- Provides spread spectrum encoding of the outbound and decoding of the inbound data stream.

- Provides modulation of a radio frequency (RF) carrier with the outbound data stream, and demodulation of the inbound data stream.

5.2. Micro Earth Station

The C-200 series Micro Earth Station consists of the model C-201 which transmits at 1200 bps and the model C-250 which transmits at speeds upto 9600 bps. Both the models receive at 19,200 bps. Each C-200 series Micro Earth Station contains two basic modules - the antenna and the controller. The antenna module is easily mounted on a roof or on the ground. The controller can be placed on a desk or shelf, near the users's terminal equipment. The controller is connected to the antenna with upto 100 meters of

twin coaxial cables. The controller connects to the user's terminal equipment (DTE) by means of standard RS-232C or RS-422 cable.

The antenna module consists of 1067 mm by 1829 mm parabolic reflector with an asymmetrically positioned (offset) feed horn, transmit and received electronics, and a base with structural members. The transmit section includes an upconverter and a power amplifier. The receive section includes a low noise amplifier and a down-converter. The controller provides low voltage power to the antenna through the coaxial cable, eliminating the need for power at the antenna site.

The controller module has two user ports which connect to the user's terminal equipment. The controller contains the power supplies, transmit/receive IF circuits, control circuits, processors, and status monitoring devices. The controller consists of three microcomputer-based processors: the IF and space processor, the network processor, and the protocol processor.

5.3. Protocol Support

The CCITT Recommendation X.25 Protocol Support and Emulation System (X.25 Interface) is a firmware resident interface within the micro earth station and the master earth station controller. With the X.25 Interface, user can be provided with private satellite communication in an interactive, X.25 packet switched network environment. The X.25 Interface offers on demand connectivity between user equipment attached to network via the protocol defined by the 1980 version of CCITT Recommendation X.25. This attachment may be at Master Earth Station node, or at a micro earth station node. At the micro earth station node, a built-in Packet

Assembler/Disassembler (PAD) facility is available to permit attachment of up to two Asynchronous user terminals.

The smart device emulation capability of the X.25 Interface is used to provide local acknowledgements, thereby enhancing response time performance while reducing space segment cost.

The X.25 Interface can be dynamically configured from the network control centre operator console by setting parameters in the Interface.

5.4. Device Support

The EQUATORIAL X.25 Interface will support most of the 1984 and earlier CCITT Recommendation on X.25 standards. Examples of devices supported are:

a) Host Computer Node

   To connect to the network at the Host Computer Interface (HCI) of the Master Earth Station, all host computers must be equipped with serial ports with X.21 bis RS-232C (CCITT V.24/V.28/ISO 2100) or RS-422A (CCITT V.11/X.27) interfaces operating with X.25 protocol, or their representatives, such as port devices, frontends, or packet-switching devices. When connected to the network at the micro earth station user ports the same properties apply.

b) Remote Terminal Node

   All remote devices equipped with serial ports with X.21 bis RS-232C (CCITT V.24/V.28/ISO 2110), or RS-422A (CCITT V.11/X.27) interfaces operating with X.25 protocol can be attached to the network at the micro earth station. ASCII terminal devices with the above serial interfaces operating

with an asynchronous start stop protocol are also supported with the available internal PAD facility of the micro earth station.

5.5. Network Features

Virtual circuits are established between end nodes providing connection oriented service similar to circuit switching, but with the advantage of statistical multiplexing of packets. End to end communication is provided through the allocation of logical paths on a permanent basis Permanent Virtual Circuit (PVC) or on a request or switched basis Switched Virtual Circuit (SVC). Subscriber access to the network is by means of one or more logical channels allocated over a physical access circuit. A virtual circuit, permanent or switched, can be established over each logical channel. Once the logical path is established, data packets are automatically routed to the appropriate destination.

Figure 2 shows how the terrestrial packet switched network can be replaced by the network equipped with the X.25 Interface. the X.21 bis physical ports of the X.25 host computer, or its representatives, connect to MES at the ports of the Host Computer Interface (HCI), the component of the MC-200 Master Earth Station.

The peer to peer connections between remote DTEs connected to a micro earth station at each location involves two satellite "hops". Data travels from the source micro earth station via satellite to the Equastar Hub, and then again via satellite to the destination micro earth station.

All standard data speeds upto 9.6 KBPS are supported at the host computer interface. However the effective data rate from a DTE to the micro earth station/DCE is restricted to 1.2 KBPS for a C-201 and 9.6 KBPS for a C-250, even

though the link is physically operating at 9.6 KBPS. The effective data rate from the micro earth station/DCE to the DTE may approach 9.6 KBPS. All these capacities will be doubled when convolution FEC add-on feature is incorporated.

6. TERRESTRIAL COMMUNICATION NETWORK

While NICNET makes use of the Satellite communication for long distance links, terrestrial communication is used for short distance intra-city network. The obvious advantages of using terrestrial links for local distribution are low cost and high speed.

Intracity network in Delhi is a star network around NEC S-1000 system, located at CGO Complex, New Delhi. About 200 terminals, spread over 60 ministries and departments are connected to the host. Similar networks are being developed at Regional Centres and State Capitals. High speed, error free, synchronous communication at 4800 bps is established from PC-Ats and XTs using PC link software, developed by NIC. NIC has also developed terminal controller software to implement hierarchical networks around PC-XTs/ATs. Slow speed asynchronous links upto 1200 bps are established using the standard communication software. The communication hardware consists of asynchronous modems upto 1200 bps speed manufactured indigenously, synchronous modems upto 4800 bps speed, statistical multiplexers, cluster controller etc.

The intracity network in Delhi makes use of about 200 pairs of leased lines between CGO Complex and user locations. A dedicated cable has been laid from NIC Headquarters to the nearest exchange to improve the reliability and performance of these lines. All leased circuits work at 4800 bps speed with an error performance of 10-5. Use of switched lines is

also made in the network to provide infrequent access to the host machine. NIC has also used point to point VHF links at 4800 bps speed using voice grade equipment. Possibility of using multi-access schemes on VHF is also being experimented.

Realising the growing importance of Office Automation and the need for sharing local information, NIC is setting up Local Area Networks (LAN) in important Government office complexes. These LANs will have a gateway to NICNET.