

Network Scenario for Countrywide Natural Resources Information Management and Dissemination

Pushpalata B Shah, I C Matieda
Geomatics Systems Division (GEG/SIIPA)
Space Applications Centre
Ahmedabad 380 053 INDIA

Extended Abstract

The remote sensing technology has been operationalised under the umbrella of National Natural Resources Management System (NNRMS) by the IRS and INSAT satellites for the management of land and water resources, disaster management and environmental monitoring. Under the Integrated Mission for Sustainable Development (IMSD), the gigantic task of involving all the major concerned departments was taken up to arrive at locale specific prescriptions for micro level development, by integrating thematic information derived from remotely sensed data with other collateral information. This heralded a unique movement in the country as regard to sustainable development of land and water resources. Towards providing information for decision makers at planning level, the Natural Resources Information System (NRIS) has been initiated in a major way as the repository of all natural resources data. This data has been standardized and is in digital form.

Also, integration of this information with socio-economic data such as demography, financial allocations, development targets etc, will aid in the decision making process. To accomplish this a framework of nodes with GIS data has been identified at district, state and center levels. These nodes will have GIS systems handling spatial and non spatial data at scales of 1:50,000 at district level and 1:250,000 at state level. The center level node will be used for decision making and planning. All data is stored in standard format as defined by the NRIS project. The accessibility to these databases from remote clients using a customized application specific model based shell is a key issue in this project. This involves the selection of networking technology along with suitable topology.

Networking plays a very vital role in fulfilling the NRIS objectives. The Network and all that it takes to build and manage it, is the most important factor in the total information equation. The challenge lies in selecting a heterogeneous combination of networking technologies such as LAN, WAN and MAN, to suit, the hierarchies and volumes of data criss-crossing between nodes. The backbone selection will be a cost effective, state wise need based requirement from a combination of ISDN, PSTN, DSDB and VSAT. The network of nodes is setup, so as to systemize and maintain the sectoral and hierarchical information systems. Of all the network modalities available the WEB based approach over a countrywide intranet has been zeroed upon. The WEB approach provides the necessary security protocols as well as graphics support for a live GIS connection and access, using public domain software viz. Netscape or Internet Explorer. The nodal data servers will be configured heavily with backup systems in contingencies, so as to handle multiple hits, for the access of spatial and aspatial layers. Procedures are being studied for optimal information transfer and exchange mechanisms with minimal data loss. This includes information filtering as well as GIS data aggregation methods.

Web based solutions for query and analysis of the GIS data layers are being worked out. Using the Common Gateway Interfacing (CGI) protocols we simulated an internet map server environment using languages Viz. ARC/INFO macro Language (AML) and CGI-c. With this a sample shell for Decision Support System (DSS) was developed. The front end of these shells is user friendly and menu-driven. The servlets technique was also adopted for implementing the shell to assess the efficiency in throughput.

Now, each state node has the flexibility to adopt to any GIS package of its choice, with a mandatory discretion of using object oriented GIS only. This is a necessary and sufficient criterion for achieving interoperability, and providing a seamless interface for query and analysis across state nodes through heterogeneous GIS packages. The CORBA architecture has been studied and implemented for concept proving. A judicious combination of servlets, CGI and map objects encapsulated with tailor made functions will be used to achieve interoperability at operating system, GIS packages and database level. The problem of interoperability at the data level has been addressed by complying with the standards developed for the project, the NRIS standards. No solution in a GIS scenario is complete until the end user is provided with a means to plot/print a map of his desired scale at his end. For this, a GUI based interface is provided where the user specifies the map composition and scale of his choice. The task is carried out at the server end and the map is downloaded at the thin client where it can be printed offline. The current paper elaborates upon these issues and modalities in providing a seamless solution in such a heterogeneous environment for efficient management of the information in NRIS project.

1.0 Introduction

At the Department Of Space, India, a program has been visualized and defined for the management of Natural Resources related to land, water, forest, minerals, soils, oceans and so on, under NRIS program. . This will entail the maximum utilization of existing natural resources and promote sustained development. The NRIS is a network of spatial information systems inter linked with each other around an intranet and is oriented towards providing information for decision makers. It encompasses information on natural resources related to land, water, forest, minerals, soils, communication facilities, et al and socio-economic information such as demographic data, educational facilities, medical facilities etc. The integration of these sets of information would provide a synoptic view and aid the decision-making process for systematic resources utilisation and development. In the initial phase, the information is being generated at around 30 district nodes and 4 state nodes. Each of these nodes is equipped with ARC/INFO GIS package on SGI platform using IRIX operating system, with customized application packages for information extraction, analysis and presentation. The information, both spatial as well as non-spatial is stored in databases in a pre-defined NRIS standard format. Also, integration of this information with socio-economic information such as demographic data, financial allocations, development targets etc, will aid in the decision making process. To accomplish this a framework of nodes with GIS data has been identified at district, state and center levels. (Fig. 1) These nodes will have full fledged GIS systems handling spatial and non spatial data at scales of 1:50,000 at district level and 1:250,000 at state level. The center level node will be used for decision making and planning. All data is stored in standard format as defined by the NRIS project [Node Design and Standards - SAC/SIIPA/NRIS-SIP/SD-02/98].

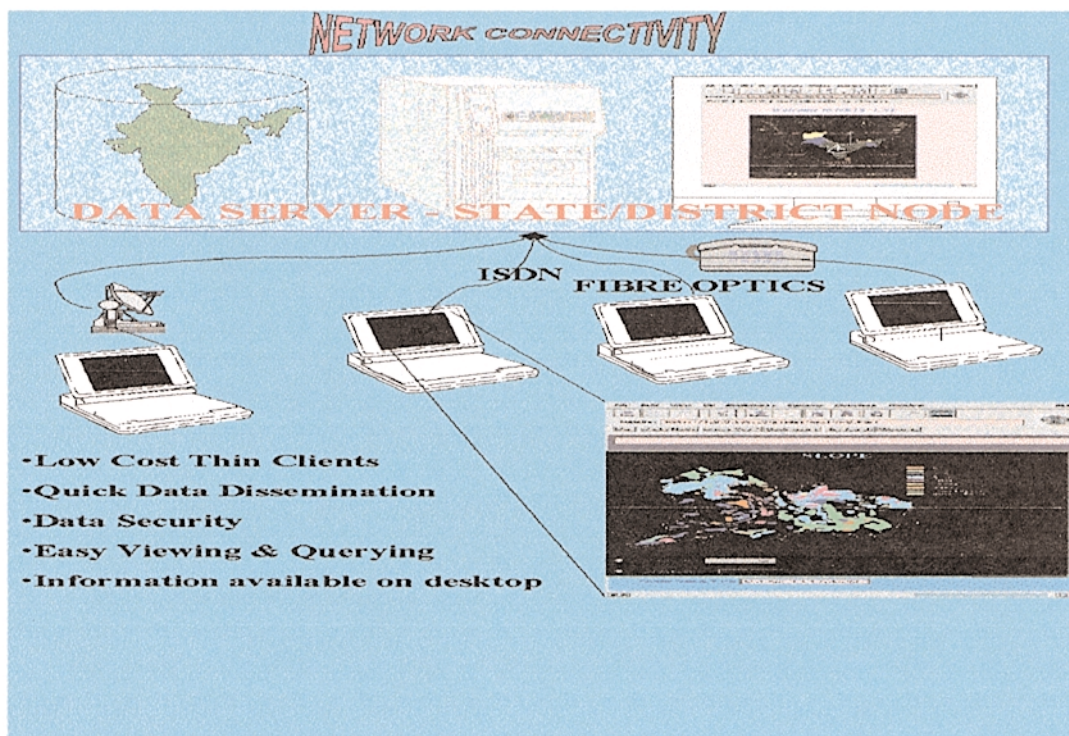
The network of nodes is setup, so as to systemize and maintain the sectoral and hierarchical information systems. Next, procedures are being studied for optimal information transfer and exchange mechanisms with minimal data loss. Operational user friendly packages have been realized and demonstrated for database access of thematic as well as socio-economic information stored as per NRIS standards. These packages allow users to query over the information stored in the databases. They also provide models for planning and decision making. These models are flexible for adding as well as updating the logic for decision making. The user friendliness and acceptability of these customized packages has been proven without doubt. However another dimension of providing accessibility to this information through similar customization programs over wide area networks has also to be addressed. This includes information filtering as well as GIS data aggregation methods. This calls for the evaluation of the current network backbone technology in India and to arrive at the optimal network configuration to accomplish the information exchange & management in NRIS perspective. Further the issue of network infrastructure and management is discussed in detail in the paper.

2.0 End user requirements

The users of these systems are subject experts, administrators, policy makers, managers and so on. Essentially they belong to that section of system users who have peripheral knowledge of computers. Business and industry will also require the resources information because of it's increasing role in local – level development. Non-Governmental Organisations (NGOs) are another group of users who will utilise the Network for obtaining resources information for developmental activities. Academic and Research institutions will also need the information for research and science activities. They may not have any GIS background but still are willing users to GIS based models for their decision making. In fact the spatial context has a value added convincing capability for taking a specific course of action. Operational user friendly packages have been realized and demonstrated for database access of thematic as well as socio-economic information stored as per NRIS standards. These packages allow users to query over the information stored in the databases. They also provide models for querying and decision making. These models are flexible for adding as well as updating the logic for decision making. The user friendliness and acceptability of these customized packages has been proven without doubt. The cost effectiveness of providing every end user with a core GIS and add-on packages as against a network based solution was the need of the hour.

2.1 The accessing mechanism

Information access at the desktop, is the paradigm with which we step into the Twenty-first Century. This has been facilitated by the modernization of the telecommunication industry. The telecommunication facility in India is also in a developing state and it becomes necessary to look into it while adopting an approach for implementing NRIS Program. VSAT and normal telephone lines can be used for the connectivity to NRIS systems. A simple Internet browser on personal computer can access the NRIS information from anywhere and without going into the GIS/platform specific technology jargons. The shell being implemented using WEB/Intranet technology will provide the menu driven user interaction on browser to define the area of interest with querying option on any information to get desired results.



2.2 Nature of data

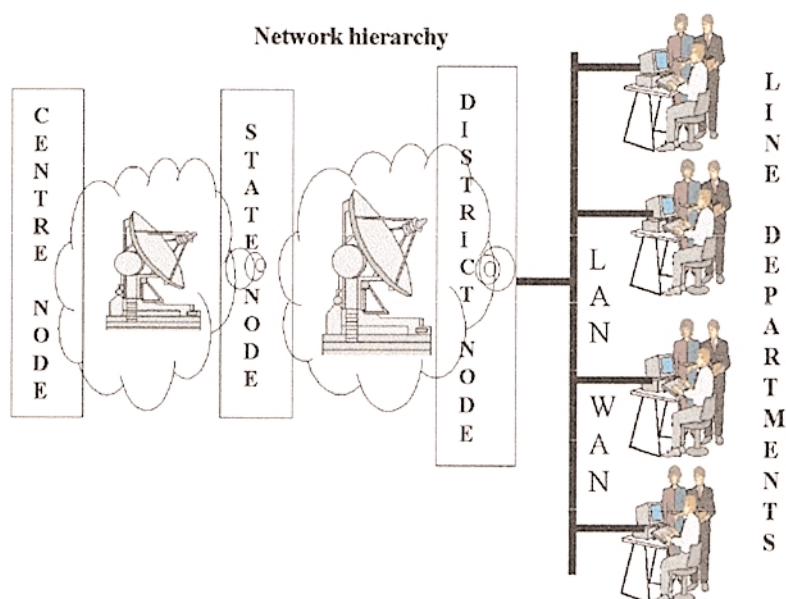
The type of data to be handled and exchanged over the vast network is manifold.

- Viz. (1) Satellite image data 150 MB
 (2) Map data 1 MB
 (3) Spatial data layers 80-100 MB
 (4) Queries as ASCII text & Reports 0.5 MB

For certain types of data such as satellite image data, the requests can be scheduled and programmed at times when the network is not being used for regular querying and analysis. Also, all non-spatial information exchange can be handled on any type of communication link and does not pose a major problem. However security of the data being exchanged has to be dealt with. This calls for authentication of clients to the data servers, as well as authentication for use of data by the client. However, spatial data has to be handled carefully without data loss and at a meaningful response time.

2.3 The End user Network Structure

The effective exchange of information amongst decision makers and access to varied information sets by resource managers/planners is an essential pre-requisite of NRIS. The networking of NRIS nodes – both horizontally, i.e. across different nodes in a level and vertically, i.e. from one level to another level becomes mandatory for the resources management activity and decision making. Key users of the NRIS Networking facility will be the Government sector – policy-makers, resource managers and planners, administrators etc at District, State and Centre. Presently, information for resource management is available in textual form and is not timely. Also, it is not easily accessible at the right time by the right person, thereby reducing its usefulness. An NRIS node will consist of several computers on a network. For example, the NRIS district node could be located at the District Collectorate and the Node –LAN/WAN can have terminals at each department in the district – Soils./Agriculture department; Ground Water department; Forest department etc so that the departments can connect as clients to the server system and obtain information. This Node-LAN/WAN framework will reduce database porting and system problems to a large extent. While LAN/WAN ensures the remote access of NRIS-Nodes at a level, the across level networking will cater to the specific needs of information transfer from one level to the next level. This will require a high speed communications network as the transactions would be heavy and would be voluminous considering the involvement of spatial data in the transaction.



3.0 Data Security

The primary access to any application specific shell on the web can be restricted through **login-password mechanism** at all the nodes. Major HTTP servers support this feature. This may not give total security against users with malicious intentions but can provide security against unrestricted use of shells and data. **Data Encryption** is another technique to prevent tapping of data on a network. State of the art firewalls at all the data nodes will have to be used. All major HTTP server programs support **SSL (Secure Sockets Layer)** protocols, which use both data encryption and digital authenticity. Before session between client and server starts, authentication takes place. If it is from client side, it is called client authentication otherwise it is called server authentication. Session will start only after one of the sides authenticates itself. Data encryption will be used for data flow in both the directions. Objective protection of data is required when user tries to view or query on disputed area or territory. This requires user to reveal his/her identity.

Each state and district has been given unique code number in NRIS standards. This can be verified in order to get user's identity.

4.0 Present Network Backbone Scenario in India

Presently in India, DOT and private service providers provide basically dial-up telephone line network working at 33 KBPS at district node level. Integrated Services Digital Network (ISDN) telephone facility is being made available providing 64Kbps to 2 Mbps Leased Data Circuits in major cities. ISDN provides more bandwidth, less connection setup time and facility for connecting multiple devices on single line. In addition, satellite based VSAT facility is available through private service providers and can be installed anywhere. This is slightly costlier than other two and hence having a large number of installations will need large investment. Few states are planning to have fiber optics cable laid across state capital and district head quarters. This will provide 100-150 MBPS speed and will become available by end 1999. Some R & D efforts are on in ISRO to have satellite link and dial-up line combination providing 256 KBPS to 2 MBPS bandwidth, which can be, used through Data Sound Digital Broadcast (DSDB) receivers at client end & (DLTB) transmitter at server end. Under the pilot experiment planned, the performance analysis was attempted, to find out the suitability of the backbone for NRIS connectivity. Benchmarking of available Network Links under NRIS-Linkages and Network Program (LNP) Pilot project is carried out for selecting the proper Networking Technologies for NRIS. The results obtained are discussed in subsequent section.

4.1 Performance Benchmark for LAN/WAN

Benchmarking was limited to LAN (10Mbps) & WAN (VSAT link of 64Kbps).

Various tests were conducted to see the throughput of LAN & WAN. These tests include Data Transfer throughput, Packet round trip time & Performance of X-Server (Broadway X11R6.3).

4.1.1 Data Transfer Throughput

Data transfer throughput was calculated by transferring 1 MB of data in various packet sizes on LAN/WAN. Data volume of 1 MB was found sufficient to test over the link of 64-Kbps (WAN) and speed was calculated for LAN with respect to WAN.

LAN: 10 Mbps

WAN: 64 Kbps

Relative Speed: $10\text{Mbps} / 64\text{Kbps} = 160$

Packet size (Bytes)	Number of Packets	Volume (MB)	LAN (KBps)	WAN (KBps)	Relative Ratio (LAN/WAN)
256	4096	1	714	3.18	224
1024	1024	1	755	3.18	237
1500	700	1	752	2.97	253
4096	256	1	640	2.88	222

4.1.2 Round Trip Time

Round Trip Time was computed by sending 100 packets of 64 byte on the Network. Unix ping utility was used for the purpose of computing round trip time.

Packet size: 64 Bytes

Time On LAN (min/avg/max) : 2/2/2 ms

Time On WAN (min/avg/max) : 537/538/544 ms

Relative Speed (WAN/LAN) : 269

4.1.3 Number of hops

Data Transfer Rate on network also depends on the number of hops between two computers connected on network. This parameter is very critical when satellite links are used. On any satellite link there is some delay (approximately 270 ms) involved in communication.

Number of Hops on WAN (VSAT Link): 4

Number of Hops on LAN: 1

4.1.4 Performance of X over Network

This study was carried out in view to explore the possibility of using X as delivery mechanism for NRIS-LNP. X-window system designed as network transparent windowing system is now extended for World Wide Web in Broadway (X11R6.3). X-window system as originally designed for LAN needs very high bandwidth network. As compared to other WWW protocols, it is very slow on WAN.

X-window system is based on Client-Server model & communication between client and server is done in terms of X-request. Different X-requests give different performances on network. So it is difficult to arrive at a single parameter for performance of X-window on LAN/WAN.

Requirement for NRIS-LNP is to connect various nodes for GIS applications. For benchmarking, some commonly used GIS operations were selected. Each operation is tested for 5 seconds & each test is repeated thrice. Following table shows number of operations performed per second on LAN/WAN and on LOCAL machine.

Work Station : SGI O2

LAN : 10 Mbps Ethernet

WAN : 64-kpbs VSAT-LINK

LOCAL : SGI O2

WAN(1)	LAN (160)	LOCAL (-)	Operations
540	770000 (1426)	1190000 (2204)	10x10 rectangle
388	22000.0 (56.70)	22300.0 (57.47)	100x100 rectangle
540	987000.0 (1828)	1780000.0 (3296)	10-pixel line segment
540	346000.0 (640.74)	392000.0 (725.93)	100-pixel line segment
370	190000.0 (513.51)	220000.0 (594.59)	10-pixel solid circle
252	22500.0 (89.29)	392000.0 (725.93)	100-pixel solid circle
1740	1180000.0 (678.16)	1270000.0 (729.89)	Char in 80-char line (6x13)
142	102000.0 (718.31)	118000.0 (830.99)	Copy 10x10 from window to window
89.6	3970.0 (44.31)	4010.0 (44.75)	Copy 100x100 from window to window
29.3	7610.0 (259.73)	9120.0 (311.26)	Put Image 10x10 square
0.3	230.0 (766.67)	305.0 (1017)	Put Image 100x100 square
960.0	751000.0 (782.29)	794000.0 (827.08)	X protocol No Operation

5.0 Analysis

Due to lack of the facility establishment for all types of network, the pilot project could concentrate on the performance evaluation of the available VSAT based WAN and LAN connectivity. The net result is the requirement of up to 64 Kbps bandwidth for the low volume data exchange and minimum of 2 Mbps to exchange the information in X-mode. This X-mode of operation requires implementation of the applications shells developed for NRIS users without re-implementing these shells over a WEB. This will permit the execution of a shell as it is from a remote system while giving the user a feeling of accessing the same program from local system.

Few Indian state governments also have plans to connect state capitals with district head quarters by private high-speed digital network through fiber optical cables. In case this becomes a reality we will have very fast network for digital information exchange.

The advancement in telecommunication infrastructure is currently limited to major cities only, but if this trend continues we can hope to get these services almost in every district head quarters in most of the Indian states.

6.0 GIS Access Mechanism Options:

The communication between a server and client in an Internet type of situation, for interactive applications is done through gateway programs. Currently most GIS vendors have come with products called Internet Map Servers for providing the link, and interactive sessions. However other methodologies such as Common Gateway Interface (CGI), JAVA Servlets, CORBA and BROADWAY protocols have been experimented with successful results. The applicability of a particular methodology depends upon the network bandwidth that is available.

Different WEB implementation methodologies such as CGI-c, Servlets, CORBA, BROADWAY – the X emulator over a web, have been tested to decide the best approach for NRIS project. Suitability of any particular technology depends on target systems as well as network infrastructure available. Acceptability of any of these technologies can be determined on the basis of the following criteria. CGI is best suitable for simple query based system but it suffers from drawbacks of multiple invocations. ISAPI does not have this drawback but it is proprietary with Internet Information Server (IIS). BROADWAY approach is quite promising but it demands high network bandwidth. Servlets are persistent across multiple invocations and can be used for distributed computing but the only limitation is development platform remains limited to JAVA. CORBA objects are persistent across multiple invocations. CORBA is best suitable for distributed computing applications because of its language as well as platform independence.

The methodology to be adopted for the NRIS Intranet will be finalized on the basis of the functionality provided by each of the approaches, ease of programming, resources available, portability etc. Keeping in view the array of advantages the Servlet approach provides, it can be concluded to be most suitable. Using JAVA Servlets NRIS shell functionalities were successfully implemented both on UNIX and Windows NT. Servlets can be used in future NRIS scenario for distributed computing. Since there is no startup overhead for multiple user requests Servlets are comparatively faster in multi user system. Also, every GIS vendor now provides WEB ready GIS on a variety of platforms with the Internet Map Server Interface (IMS). Currently each of these packages is being evaluated in the respective environment for the execution and complete functionality of the NRIS shells. Here again, in a heterogeneous environment where different state nodes can have different GIS and IMS, the exchange of information across the nodes will have to be studied.

7.0 Acknowledgements:

The authors express their sincere thanks to Mr. A.K.S. Gopalan, Programme Director NRIS, Mr. A. R. Dasgupta, Project Director NRIS, for their constant encouragement and valuable suggestions throughout the course of this work. The authors are also thankful to the cooperation extended by team members of the NRIS Linkages and Networking Program and all members of the NRIS Systems and Integration Program whose help in the intricacies of ARC/INFO micro coding language is a part and parcel of the success of this work.