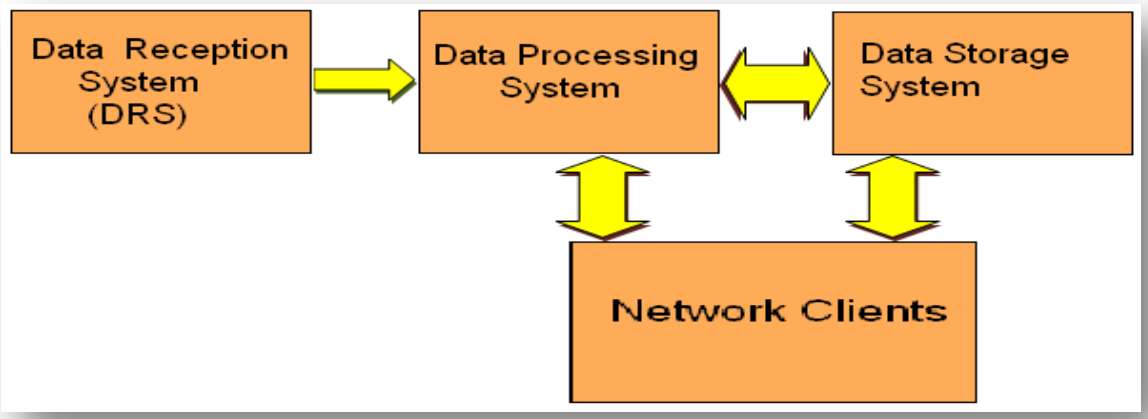
INSAT-3D METEOROLOGICAL DATA PROCESSING SYSTEM (IMDPS) and generation cloud imagery and derived products.

Indian Space Research Organization (ISRO) has taken up the responsibility of end-to-end reception and processing of INSAT-3D data and derivation of meteorological parameters with India Meteorological Department (IMD), New Delhi. An indigenously designed and developed INSAT-3D Meteorological Data Processing System (IMDPS) is installed and commissioned at IMD, New Delhi with a Mirror Site at Space Applications Centre, Bopal, Ahmedabad. IMDPS will cater to the processing of all data transmitted by the Imager and Sounder payloads.The data archival and dissemination is through IMD, New Delhi and Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) websites. The IMDPS system acquires raw data from serial data streams, process the data and generate various quantitative products from the processed data for operational utilization by various users. Additionally, the system will be capable of processing, ingesting and analyzing Automatic Weather Station (AWS) and Global Telecommunication System (GTS) data.IMDPS comprises of three major sub-systems –

System Overview:

The Requirements of INSAT-3D Meteorological Data Processing system (IMDPS) will be realized using specialized software and hardware. Following are the major sub-systems for processing of INSAT Meteorological Data. The main architecture of IMDPS system consists of Data Reception system, (DRS) Data Processing System (DPS), Data Storage System (DSS), Network Clients System (NCS) and Satellite Images Display System (SIDS)



Data Reception System (DRS): The Data Reception (DR-DAQLS) system is the front-end system for Data Acquisition and processing chain to capture, archive, displays the quick display and transferring the RAW,Meta data to the DP System for sub-sequent Processing. Each DR system receives the base band serial data stream of the satellite sensor from the corresponding RF-IF segment (from RF demodulator).Every sensor (Imager, Sounder, VHRR and CCD) base band data streams are handled independently. DR systems for each sensor stream are implemented in redundant configuration. The major functions like

- Frame synchronization,
- Frame and Format verification,
- Data Acquisition,
- Raw data archival,
- Processed Quick Look Display (P-QLD), HK display and logger,

- Data transfer to DP, Raw data Replay suits,
- Online BER measurement

The main functions like Data Acquisition and Raw data archival are implemented in these systems. The DR systems are connected to Data Processing System through TCP/IP network. Each DR system transfers a processed raw sensor image to the connected Data Processing computer immediately after the compilation of Image.

The Hardware elements of the DR systems are,
1. Bit synchronizer Units
2. Computer Interface Units (CIUs)
3. Data Reception Servers (DR Servers)
4. Raw Archival Disks
5. Display work station
6. LTO drive and media

Bit Synchronizer Unit

Bit Sync. Unit receives the base band serial stream from the Demodulator, and provides the Serial Randomized NRZ-L data along with synchronized clocks. It generates TTL serial data along with synchronized 0 deg clocks. This output is connected to the CIU unit for frame synchronization and other functions for base band data acquisition.

Independent bit synchronizer units are provided for all data streams with one to one redundancy for all chains. Bit synchronizer units are specified such that each unit can be used in any Satellite Sensor data chain. These units are rack-mounted units.
It also performs the functions of;
-Code conversion from NRZ-S to NRZ-L (for VHRR, SOUNDER)
-Clock hold in case of short period breaks in the data stream.
-Track and hold the output data to the specified frequency in case of disturbances in demodulator output

Frame Synchronizer Unit (CIU)

The CIU unit(s) receives the Serial Base band data with clock from the Bit Synchronizer(s). Multi format frame synchronization and data formatting functions are implemented as Computer Interface Unit (CIU) for IMAGER & SOUNDER data acquisition into DR Server. CIU is a microprocessor-based unit capable of supporting two independent data streams. Each of the two chains of the unit can be configured for de-commutation of data stream selected for any of the specified sensors through remote commanding from the main server. These units have following features and functions :

- Frame Sync Detection
- De-randomization of the serial data stream
- Serial to parallel data conversion on pixel word boundary
- Online data format checking

- Remote computer commanded automatic operations, online data transfer to DP
- Computer data acquisition interface.

Computers Systems for Data Reception

The DR systems are configured on HP Alpha server. Each of the servers have capability to acquire and process data in real time from two independent base band chains. Each server consists of

- Dual CPU configuration
- Dual data acquisition interfaces
- Dual system disk with operating system and DR system programs
- Data Archive Disks for each base band chain
- Physical memory 2-4 GB as per processing requirements of data stream
- Secondary archive drives LTO
- Giga Bit Network ports
- Power supplies.

Additional display workstations are present to support online PQLD. These are connected to the servers through network.

Description of DR software

DR software performs :

- Data Acquisition and CIU control and Ingest, with automatic transfer to “DP” computers.

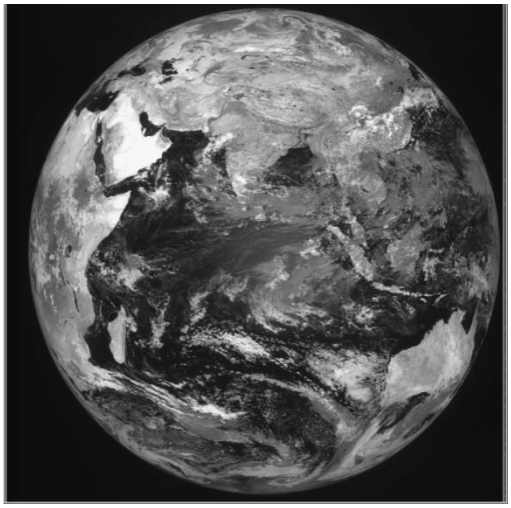
- Real time data acquisition and ingest with online status updates and alarms
- Online processing of raw data stream for band separation, telemetry stripping etc.
- Telemetry logger
- Band-wise Quick Look Display (partially processed) on Console and networked Workstations
- RAID based Raw Data Archival and management, with secondary archival (back-up)
- Raw data replay
- Automatic Generation of Level 0 data file of every scan and data transfer to DP computers

DR software suite implementation is such that each can be operated individually and independently in a very flexible manner (e.g. PQLD, TM processing, Ingest are all independent). The main data acquisition and ingest suite distribute the raw data to all other suites. DR software suite implementation are such that they can be operated individually and independently in a very flexible manner (eg. P-QLD , TM processing, Ingest are all independent) The number of application tasks like P-QLDs, HK plots, HK displays are automatically limited for a given Sensor data stream to avoid server resource crunch. The main Data acquisition and Ingest suits module is distributes the raw data to all other application modules.
DR software for a given DR-Main and DR-Redundant chain operate independently and exclusively with respect to one another. Two independent such suites (of different Sensor data streams) can be operated on each server.
DR software is implemented using C++, Fortran, System services of O/S, X-window GUI, on the OVMS server platform.

Processed Quick Look Display (PQLD)

PQLD is implemented in all DR systems for all processing chains. User interface is through GUI, which allows selection of the type of display mode. Displayed Images can be enhanced in real time using a set of provided LUTs. The displayed image is automatically saved. Stored images can be retrieved and displayed back. Multiple QLD screens can be activated at the same time with different modes.

A typical P-QLD for INSAT-3D for SWIR band is shown below.



Digital Recording (Raw Archival)

DR system acquisition software includes the suite for raw data recording in the form of a digital file for each base band chain. Raw archival is automatic, based upon the events (like scan on). Here, the digital data acquired in DR server is archived after frame synchronization and de-randomization to disk file on independent hard disk in real time without removing any part of the format (except the sync words). S/W is also available on the same DR server to replay archive files.

Data Processing System (DPS): The Data Processing System (DPS) is main component of the IMDPS system. The raw data from DRS is transferred to the Data Processing System via TCP/IP network. The main function of DPS is to process the data received from DRS and give the desired products. The DPS consists of 7 main severs having 5 DELL PE 6850 servers (INSAT-3D Imager, INSAT-3D Sounder, INSAT-3A CCD, INSAT-3A VHRR and KALPANA-1 VHRR servers), a DELL PE 2950 server (Image Analysis Server) and 2 HP xw6400 servers (Ancillary Data Processing System & CCD application server). All the raw data from DRS is processed in these servers & the desired products are obtained. After processing the data is transferred to an external storage system for storing the data.

There are mainly seven data processing servers in the system which is being used for processing the data received from the satellites. There are namely 7 main data processing servers;

a. INSAT-3D Sounder Server
b. INSAT-3D Imager Server
c. INSAT-3A CCD Server
d. INSAT-3A VHRR Server
e. KALPANA-1 VHRR Server

} DELL PE 6850

f. Database Management Server
g. Image Analysis Server

} DELL PE 2950

The first five servers are DELL Power Edge 6850. The DELL PE 6850 servers installed consists of the following parts:

- An internal storage 5 FC SAS disks of 146 GB each at 15k rpm, internal storage can be further expanded to 1.5 TB.
- Each server consists of four dual core 64-bit Intel Xeon 3.2 GHz processors.
- Consists of 8 MB of cache & 8 GB ECC DDR-2 memory (further expandable to 32 GB).
- It also consists of a RAID controller having RAID support for RAID 0, 1 and 5, but a RAID 1+RAID 5 configuration is being used.
- These servers run on a 64-bit Red Hat Linux operating system.
- Each server consists of 6 LAN cards for network connectivity.
- It also consists of a 24x DVD/ CD-RW drive.
- The servers are Red Hat clustered.

The other 2 servers i.e. DBMS Server and IAS server are DELL PE 2950 servers. The DELL PE 2950 servers installed consists of the following parts:

- An internal storage of 3 fibre channel SAS disks of 146 GB each at 15k rpm, internal storage can be further expanded to
- Each server consists of two dual core 64-bit Intel Xeon 2.0 GHz processors
- Consists of a 4 MB cache and 4 GB ECC DDR-2 memory
- It also consists of a RAID controller having RAID support for RAID 0, 1 and 5 but a RAID 1 + RAID 0 configuration is being used
- These servers also run on a 64-bit Red Hat Linux operating system
- It also consists of a 24x DVD/ CD-RW drive.
- These servers are Oracle v.10 clustered.

DELL PE 6850 Server

DELL PE 2950 Server

Clustering of Servers

All the servers are clustered via an external clustering switch; the main function of clustering is to provide redundancy i.e. if any of the servers fails the work load of the failed server can be taken up by any other servers so that there is no network downtime and reducing availability issue.

Two LAN switches are provided to establish network connection and provide redundancy. Also, 6 LAN cards present in each server these LAN cards are paired in groups of 2, in this group one LAN card is connected to 1st switch and other LAN card is connected to 2nd switch so that if any one of the 2 LAN cards fails the connection can be established by other thus providing redundant connection. Thus a total of 3 switches are present in the server rack i.e. one is clustering switch and other two are LAN switches.

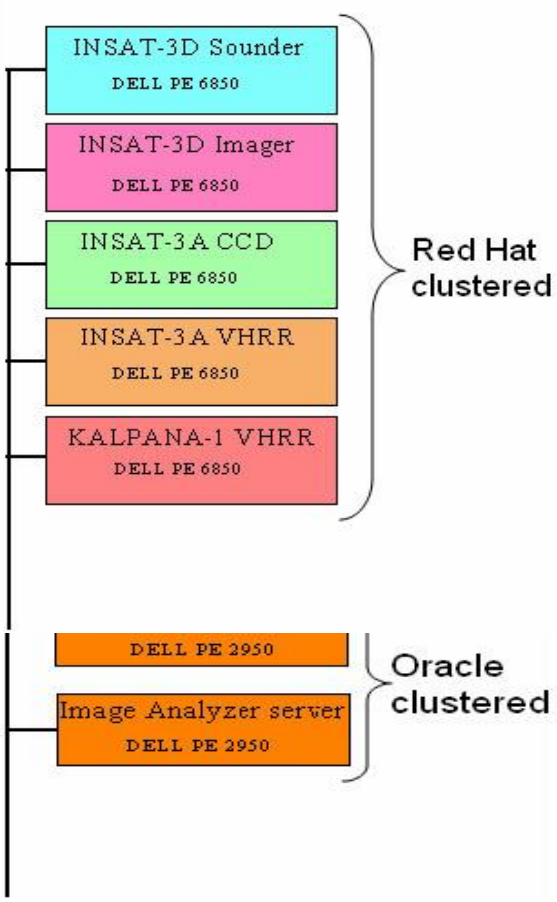


Figure showing server clustering

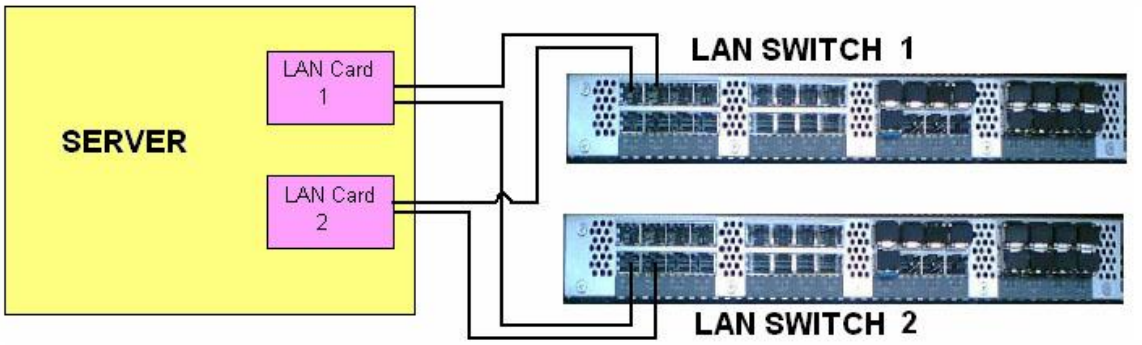


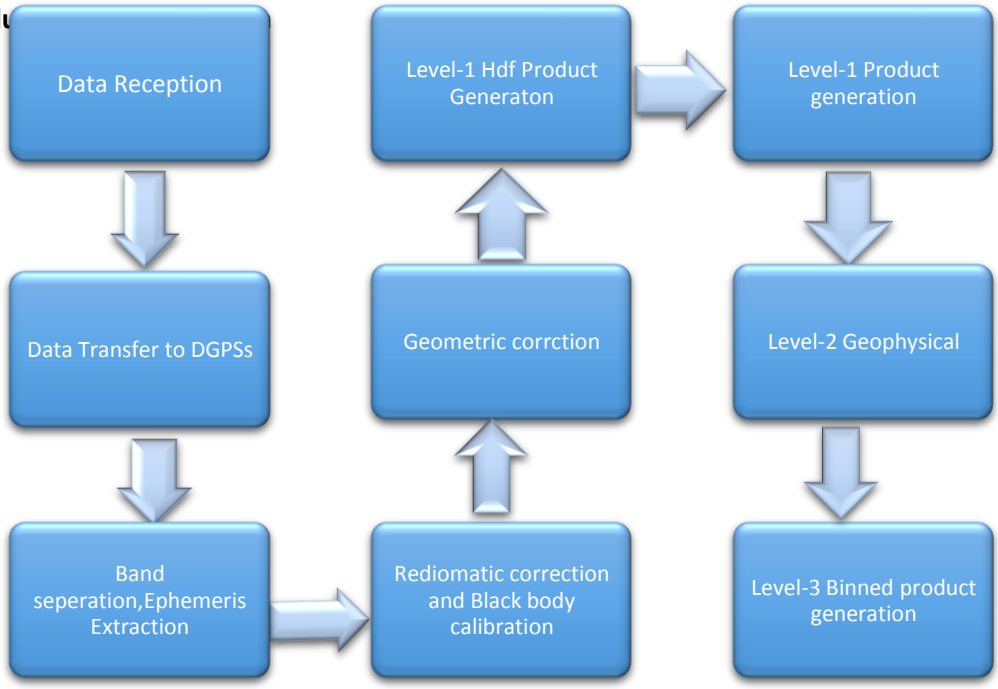
Figure showing the interconnection of LAN cards

The overview of system involved in processing of INSAT data on 24 x 7 Kalpana-1 ,INSAT-3A and INSAT-3D data being received in an automated way and Meteorological Data Products are getting generated in near real time. The DPS system will acquire raw data from serial data streams, process the data and generate various quantitative products from the processed data for operational utilization by various users. Additionally, the system will be capable of processing, ingesting and analyzing Automatic Weather Station (AWS) and Global Telecommunication System (GTS) data. The Data Processing System (DPS) cater the requirements of processing INSAT-3D Sounder, INSAT-3D IMAGER, INSAT-3A VHRR, CCD and KALPANA-1 VHRR data. The DP System performs radiometric correction and geometric correction on the raw image data received by the DRS. The pre-processed images and other ancillary information will be archived on the central storage. The Data Processing System uses these data sets from the central storage for retrieval of various meteorological parameters. Further the system configuration has multiple servers, which will handle other conventional types of data and AWS data with customized software packages.

The main Data Processing System will accept real time data of multiple streams from Data receiving system. The Radiometric calibration as part of data pre-processing is carried out based on the extensive ground calibration data supported by ground and on-board calibration techniques, which tracks changes in the instrument response due to in orbit thermo-mechanical environment, radiation effects and aging.

The geometric correction, re-sampling is performed on the radiometric corrected pixel-data based on static and dynamic models of the instrument and satellite as well as orbit and attitude parameters available simultaneously with the imaging data and produces various levels of data products. A further precision/improved accuracy is necessary which requires in registering the image-pixels on fixed lat-long grids would be achieved through image navigation and registration algorithm
in an automatic/interactive approach.

Data Produ



The Data Products Software will provide capability for generation of products on the user requested media and in the required formats HDF and also in the generic binary format. The software corrects the data for:

- Servo Errors
- Radiometric Errors
- Geometric Errors
- Boundary Overlay
- Provision for Interactive Adjustment during product generation to improve the Navigation accuracy is provided.
- Annotates and generates the jpg files for printing
- Generates the HDF file for the full scene acquired
- Generates a default sector product and its HDF file
- Generates Internet Products
- Generates Satellite Imagery Display System (SIDS) products
- Generates Low Resolution Image Transfer/High Resolution
- Image Transfer (LRIT/HRIT) products
- Updates the metadata to the Database
- generating bulk products

Sector Generation Software (SecGen)

- This package generates Sector Products from VHRR both K1 and INSAT 3A and also from CCD data of INSAT 3A.
- There are two options of generating the sector products

(i) Invoking a GUI

(ii) Using a shell script – this option is useful for

The various types of products generated by the Data Products System are

- LEVEL - 0 (Raw) – for internal use and archival
- LEVEL - 1 (Full Globe)
- LEVEL - 2 (Sector)
- LEVEL - 3 (Geo-Physical)

Image and Mirror Motion Compensation (IMC/MMC) have been incorporated in INSAT-3D. However the effect of this will be reflected only in the mirror position. This will be available as part of Auxiliary data to Data Products System. The DTM will contain twenty samples of the fast scan mirror positions for every frame. Polynomial fit through these twenty points and this curve will be used to interpolate the fast scan mirror positions at other locations. Similar interpolation will be done to calculate the slow scan mirror positions.

Another new element in INSAT-3D is the half yearly yaw flip– the satellite will be rotated by 180 degrees once in six months. The DP software is taken care for the yaw flip. The information will be available in the form of yaw angle and using this product will be generated in the 'upside' mode. At the end of the processing, there will be one process which will orient the images properly with respect to true North.

Parameter Retrieval (PR) and Meteorological maps from INSAT Data Various Geo-Physical parameters will be retrieved with INSAT-3D/INSAT-3A/Kalpana-1 Meteorological data on an operational basis in Near Real time and Meteorological Image data Products will be generated and Geo-Physical Maps will be disseminated automatically

For each of the parameters/application activity, an Algorithm Theoretical Basis Definition (ATBD) document are generated which spelled out the various input requirements, processing approach, outputs to be generated and the expected accuracies of the output. These Geophysical parameters and products will be derived and ingested into the operational weather forecasting activities at IMD. In addition, some of these parameters, particularly the AMVs from the imager, as well as the temperature and humidity profiles from the Sounder will be ingested in numerical weather forecast models in real time for accurate weather prediction.

PAYLOAD	**Geo-Physical Parameters and Derived Products**
IMAGER	Outgoing Long wave Radiation (OLR) Quantitative Precipitation Estimate (QPE) Atmospheric Motion Vector (AMV) Upper Troposphere Humidity (UTH) Sea Surface Temperature (SST) Land Surface Temperature (LST) Water Vapor Wind Vector Insolation Snow Cover Fog, Forest Fire, Smoke and Aerosol Identification Tropical Cyclone Position and Intensity Estimation
SOUNDER	Temperature, Humidity profiles and Integrated Ozone Geo-potential Height (GPH) Layer Precipitable Water Total Precipitable Water Lifted Index (LI) Wind Index (WI) Dry Microburst Index (DMI) Potential Temperature Differential Ozone estimate

The following table gives the geophysical parameters which will be retrieved from INSA-3D Imager & Sounder channels:

No.	Parameters	Input channels
1	Outgoing Long-wave Radiation (OLR)	TIR-1, TIR-2,WV
2	Quantitative Precipitation Estimation (QPE)	TIR-1, TIR-2,WV
3	Sea Surface Temperature	SWIR,TIR-1, TIR-2, MIR
4	Snow Cover	VIS, SWIR,TIR-1, TIR-2
5	Snow Depth	VIS, SWIR,TIR-1, TIR-2
6	Fire	MIR, TIR-1
7	Smoke	VIS, TIR-1, TIR-2, MIR
8	Aerosol	VIS, TIR-1, TIR-2
9	Cloud motion vector (AMW)	TIR-1, TIR-2, VIS
10	Water vapour winds (WVW)	TIR-1, TIR-2, WV
11	Upper Tropospheric humidity (UTH)	TIR-1, TIR-2, WV
12	Temperature, Humidity profile & Total Ozone	Sounder all channels
13	Value added products from sounder products	Sounder products
14	Fog	SWIR, MIR, TIR-1, TIR-2
15	Normalized Difference Vegetation Index	CCD
16	Flash Flood Analyzer (FFA)	TIR-1, TIR-2, VIS
17	HSCAS	-
18	Tropical Cyclone	-

Long Outgoing wave Radiation (OLR)

The outgoing long wave radiation is a crucial parameter for studying many areas in the field of atmospheric Sciences. The OLR has been used traditionally for radiation budget studies of the Earth atmospheric system. The OLR also has been used for the atmospheric circulation studies over tropical region. This is mainly due to the fact that in the tropics, the OLR is largely modulated by cloudiness. In particular it varies with the cloud top temperature, and consequently, low values of OLR indicate major convective system. OLR is derived using TIR1, TIR2 and WV radiances of Imager.

Rainfall Estimation

Rainfall { Qunatitative Precipitation Estimate (QPE) } from INSAT-3D Imager channels is derived based on two methodologies: (i) Rainfall Estimation by Precipitation Index (PI) and (ii) INSAT Multispectral Rainfall Algorithm (IMSRA). The half hourly imageries of TIR1, TIR2, and WV Imager channels are used to determine quantitative estimates of precipitation.

High-Resolution Rainfall Measurements (Hydro- Estimator: HE)

Hydro-estimator provides pixel-scale, half-hourly precipitation measurements over land and oceans. Imager observations in TIR1, TIR2 and WV channels combined with Numerical Weather Prediction (NWP) forecasts are used to estimate high spatial-temporal resolution rainfall estimates.

Sea Surface Temperature (SST)

Sea surface temperature is derived from split thermal window channels (TIR1, TIR2) during daytime and using additional mid IR window channel (MIR) during nighttime over cloud free oceanic regions. The most important part of the SST retrieval from IR observations is the atmospheric correction, especially over tropics. This correction is determined through a suitable characterization of tropical atmospheres in

Radiative Transfer (RT) Model to simulate the brightness temperatures of INSAT-3D channels and then generating the regression coefficients for SST retrieval.

Atmospheric Motion Wind Vectors (AMV)

Spatio-temporal analysis of meteorological events is an important part of routine Numerical weather analysis. Given a pair of remotely sensed images, captured at a fixed time interval (typically, 30 minute), the objective is to derive motion vectors associated with the cloud mass. Suitable tracers are identified in WV, TIR1, TIR2 and VIS band imageries and tracked in subsequent half-hourly imageries to determine Atmospheric Motion Vector (AMV). Water Vapour wind Vector (WVWV), IR wind, VIS wind (Day only) & MIR (Night only) will be generated and these wind estimates are very important parameter in NWP models.

Upper Tropospheric Humidity (UTH)

Upper Tropospheric Humidity (UTH) is an estimate of the mean relative humidity of the atmosphere between approximately 600 hPa and 300 hPa. UTH is basically a measure of weighted mean of relative humidity according to the weighting function of the water vapour channel. Therefore, UTH is more likely a representative of the relative humidity around the atmospheric layer where weighting function of water vapour channel peaks.

Snow-Cover Mapping

The snow-mapping algorithm uses a grouped-criteria technique using the Normalized Difference Snow Index (NDSI) and other spectral threshold tests to identify snow on a pixel-by-pixel basis, and to map snow cover in dense forests. The NDSI is useful for snow mapping, as it reflects more in the visible than in the short-wave IR part of the spectrum. In addition, the reflectance of most clouds remains high in the short-wave IR, while the reflectance of snow is low.

Fire Identification

One of the most important critical elements of the forest fire management system in the country is the real time detection of fire and its progression monitoring; study the rate, direction and quantitative estimation of fire spread. Geostationary satellite like INSAT-3D with imager data of 4x4 km in MIR, TIR1 and TIR2 will help in detecting and monitoring of large scale forest fires in Indian subcontinent.

Smoke Identification

Smoke is a form of particulate matter, which contains liquid or solid particles of the size ranging from 1-200µm. It is formed by combustion or other chemical processes. Smoke plumes can travel over hundreds or even thousands of kilometers horizontally and also reach up to stratosphere under certain atmospheric circulation conditions. Thus smoke can have an impact far beyond the region of fire activity. Smoke plays a major role on the radiation balance of the earth-atmosphere system. Identification of smoke on satellite imagery is a prerequisite to study and retrieve physical, chemical, and optical properties of smoke. Smoke can be detected from high spatial resolution imageries from INSAT-3D Imager channels.

Aerosol Optical Depth (AOD)

Aerosols play an important role in numerous aspects of human life. Aerosols have large-scale effects, such as their impact on climate by redistributing solar radiation and interacting with clouds. Aerosol information is also critical for atmospheric correction algorithms for multi-spectral satellite sensors and military operations. The climate effects of atmospheric aerosols may be comparable to CO2 greenhouse effects, but with opposite sign and larger uncertainty. When in the lower troposphere, aerosols cause poor air quality, reduction of visibility, and public health hazards. Satellite remote sensing provides a means to derive aerosol distribution at global and regional scales. Aerosols can be detected from high spatial resolution imageries in optical bands from INSAT-3D

FOG

Fog affects visibility near the surface and hence is an important parameter for aviation, transport on land and sea. Night time fog detection is done by looking at the 10.8 and 3.9 µm channel brightness

temperatures. This technique relies on fog pixels displaying higher brightness temperature differences as compared to clear pixels and those covered by other clouds.

Product Monitoring and Management System (PMMS)/Process Scheduling Server (PSS)

The Product Monitoring and Management Software (PMMS) have an interface with the Database management system and Process Scheduling Server (PSS), which runs on all configured Data processing systems.

The PMMS is capable of displaying the current processing status as well as the status of products already processed on configured data processing system. The GUI automatically updates the status of the process and displays the status by using proper coloring scheme. This software also has capability to display all sub-sampled data associated with the product for all acquisition for the operator-selected date. Operator is also provided capability to display images associated with the final product in full resolution as part of product visualization.

The Software requirements can broadly be classified under following categories

- Management
- Report Generation
- Monitoring
- Visualization

Process scheduling server is for Management of Products, Processes and Product Scheduling.

Data Dissemination Software (DDS)

It disseminates the generated Internet Products, SIDS products and LRIT/HRIT products to designated systems

Following Data Dissemination modes are planned as part of data dissemination activity

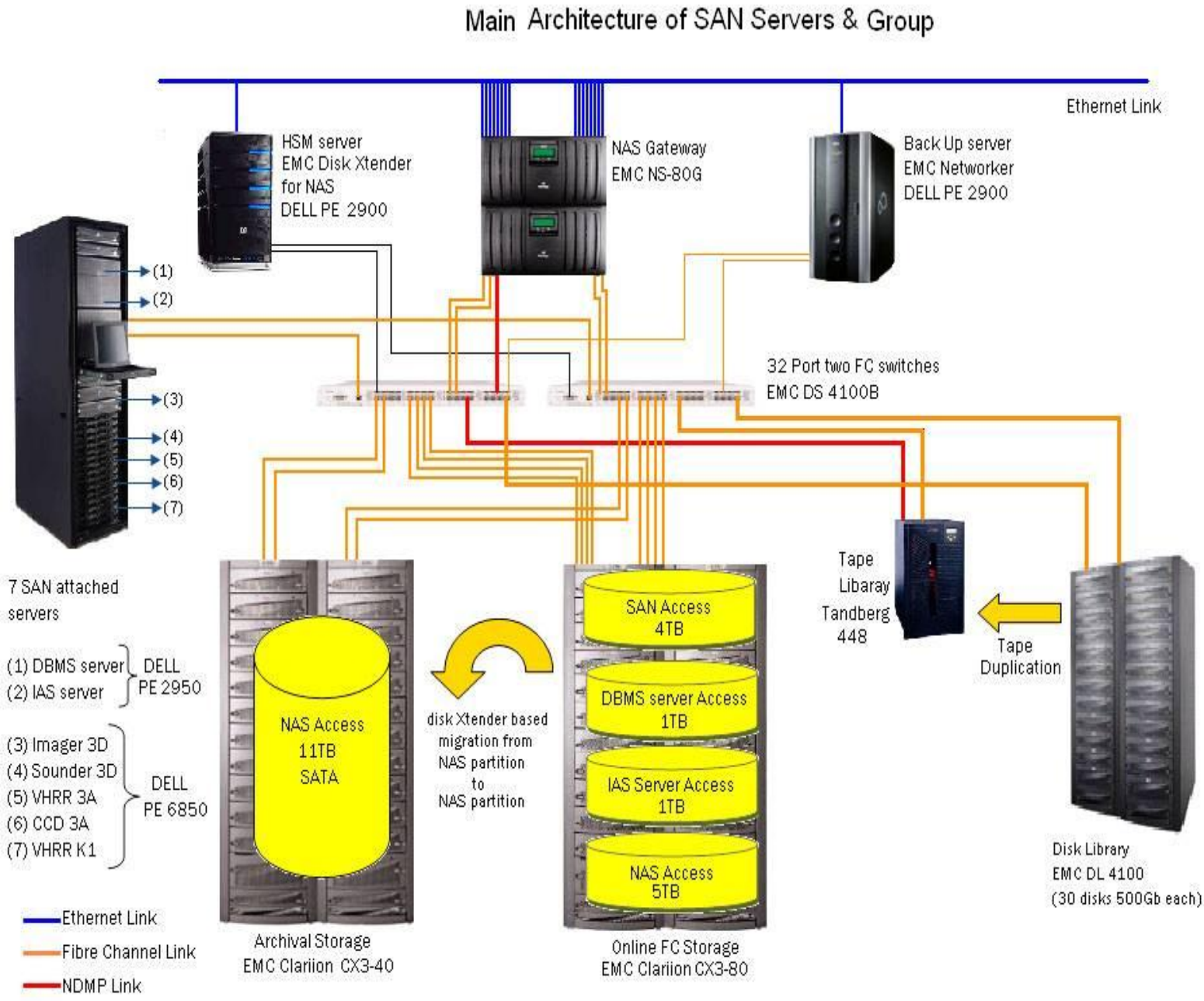
- Transfer of Imager to the web site.
- Conversion of products to GTS format and transmission to Meteorological communications computer.
- Encoding of products and AWS data in WMO format and transmission to Meteorological Communications Computers (MCC).

DBMS: The Database Management System will use ORACLE 10g as a backend Database server and will contain Metadata of all processed products available on the central store. This database will also contain information about the permanent databases such as GCP and boundary database, Ingested Auxiliary Data i.e. data from GTS and AWS and other information, which will be used during the Data Products

IMDPS Storage Infrastructure

The processed data volume of all scan of all channel of INSAT-3A (VHRR, CCD), KALPANA-1 (VHRR) and INSAT-3D (Imager & sounder) is works out to be approx. 4 GB per hr. during imaging duration. Assuming 20 hrs. imaging duration per day the data volume for one month would be around 2.4 Tb. To cater to this data storage requirement an 11 Tb SAN online and 11 Tb Archival SAN along with NAS gateway, 11Tb disk library and 48 slot LTO based tape library (DLT 400/800 GB media) are used in IMDPS storage system. The storage infrastructure consists of various parts as shown below in the table:

System Name	Model no.	Quantity
11 TB SAN EMC (online FC storage)	EMC CX3-80	1
11 TB Archive SAN	EMC CX3-40	1
32 Port SAN Switch	EMC DS 4100B	2
NAS Gateway	EMC NS-80G	2
Disk Based Tape Library- 11 TB	EMC DL 4100	1
LTO based Tape Library	Tandberg 448	1
Backup Server	DELL PE 2900	1
HSM Server	DELL Power Edge 2900	1



All the components of the storage infrastructure are now explained below: **Storage Area Network/Online SAN Storage** (used in IMDPS system)

In IMD, an EMC CX3-80 model is being used as a SAN server which is used to connect all the storage devices with the main data processing servers. This SAN server is made the Online FC storage which stores all the live data from the 3 satellite (i.e. KALPANA-1, INSAT-3A, INSAT-3D).

An EMC CX3-80 model is being used here which is one of the most powerful midrange storage arrays, it provides high expandability and a higher application performance. The EMC CX3-80 shares the same hardware and software architecture as the CX3 model 40 & model 20 but with faster processors, high capacity, greater connectivity and greater throughput.

The EMC CX3-80 model installed in the IMDPS system has the following hardware configuration:

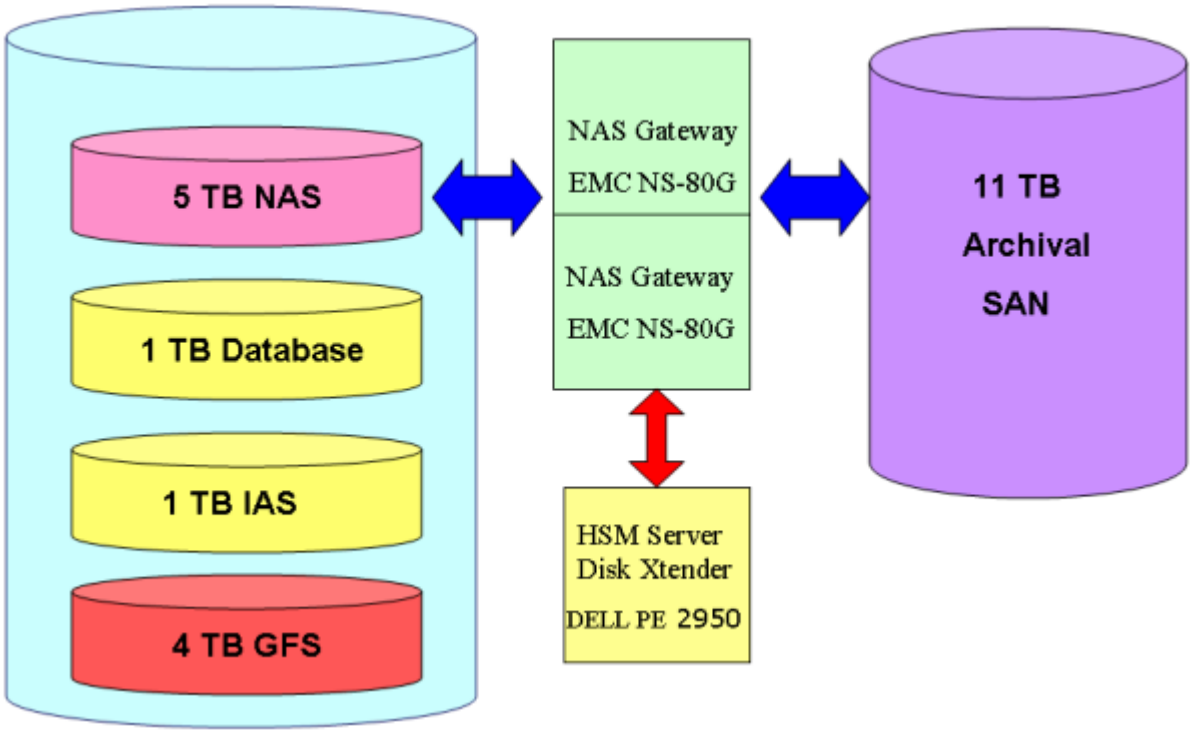
- It is made the main online storage, with a useable storage capacity of 11 TB which is further expandable to 144 TB with 300 GB FC drives & up to 238 TB with 500 GB SATA II drives.
- It consists of 59, 300 GB FC SAS disks drives at 10k rpm configured in RAID 5 configuration with 4D + 1P and also supports RAID 0, 1, 1/0, 3, 5 and 6 configuration.
- The CX3-80 storage system consists of 2 redundant active-active storage controllers.
- It consists of 16 GB cache and 8 nos. front end 4 Gbps FC ports and 8 nos. back-end 4 Gbps ports (i.e. an end to end bandwidth of 4 Gbps).
- The system consists of 4 disk arrays; the system is high scalability i.e. up to 32 disk array enclosures can be connected to a single CX3-80.
- It supports various operating systems like Microsoft Windows 2000 Server, Windows Server™ 2003, Linux, Solaris, VMware, AIX, and HP-UX, but a Linux operating system is being used in IMDPS SAN System.
- 7 servers are directly connected to SAN, the system can support 8 directly connected servers and 256 SAN connected servers
- The whole 11 TB SAN is subdivided into 4 parts for storage purposes by other servers.
- It consists of two Hot-swappable power supplies and a standby power supply which ensures power failover protection
- SAN CX3-80 communicates with other appliances via SAN switches.

EMC CX3-80

Partition of SAN

The main online 11 TB storage SAN is divided into 4 parts which is used for storage by different servers. The partitions are as follows:

1. 4 TB- used by the 5 main data processing servers.
2. 1 TB- used by Database Management System server (DBMS)
3. 1 TB- used by Image Analysis Server.
4. 5 TB- used by NAS gateways which act as storage for Network attached storage.



11 TB SAN Partition

SAN Switch

A SAN Switch is a fibre channel switch used to establish connection of SAN server with other components. An EMC Connectrix DS-4100B is being used as a SAN switch in the IMDPS system. The EMC Connectrix DS-4100B combines up to 32 port of 4 Gbps performance with high availability and scalability to support mission critical Storage area networks. It is also available with 16, 24 or 32 ports. The DS-4100B meets the need of a broad range of networked storage application including storage consolidation, backup and cluster environment.

The DS 4100b installed at IMDPS has the following specifications:

- It has 32 universal ports with 16 port base and 8 port increments.

- It can be cascaded up to 24 switches,
- It has redundant power supplies, redundant fans and hot swappable optics,
- It has a full line switching speed of 4.25 Gbps,
- Three type of ports are used i.e. F_Port, E_Port and FL_Port and has an operating temperature of 0-40^0 C.

In the IMDPS system this switch is being used to connect all the devices to each other. Two DS-4100B switches are being used to make the connections redundant, as SAN Switches are being used to make connections, therefore a SWICHED TOPOLOGY is used. All the connections via the SAN switch are through high speed fibre channels with a bandwidth of over 3 Gbps.

EMC DS-4100B

NAS gateways (used in IMDPS system)

The 5 TB partition of the Online SAN FC storage is being used by another device which is known as NAS Gateway. An EMC NS-80G model is being used as a NAS Gateway, which is made the NAS storage system controller. The main function of the NAS gateway is to serve files to the network clients through an Ethernet link. The NS-80G gateway is comprised of one or more autonomous server called the X-Blade and a back end clarion storage enclosure. The X-Blade controls the data movement from disk to the network. Every NS gateway consists of two to four X-Blades.

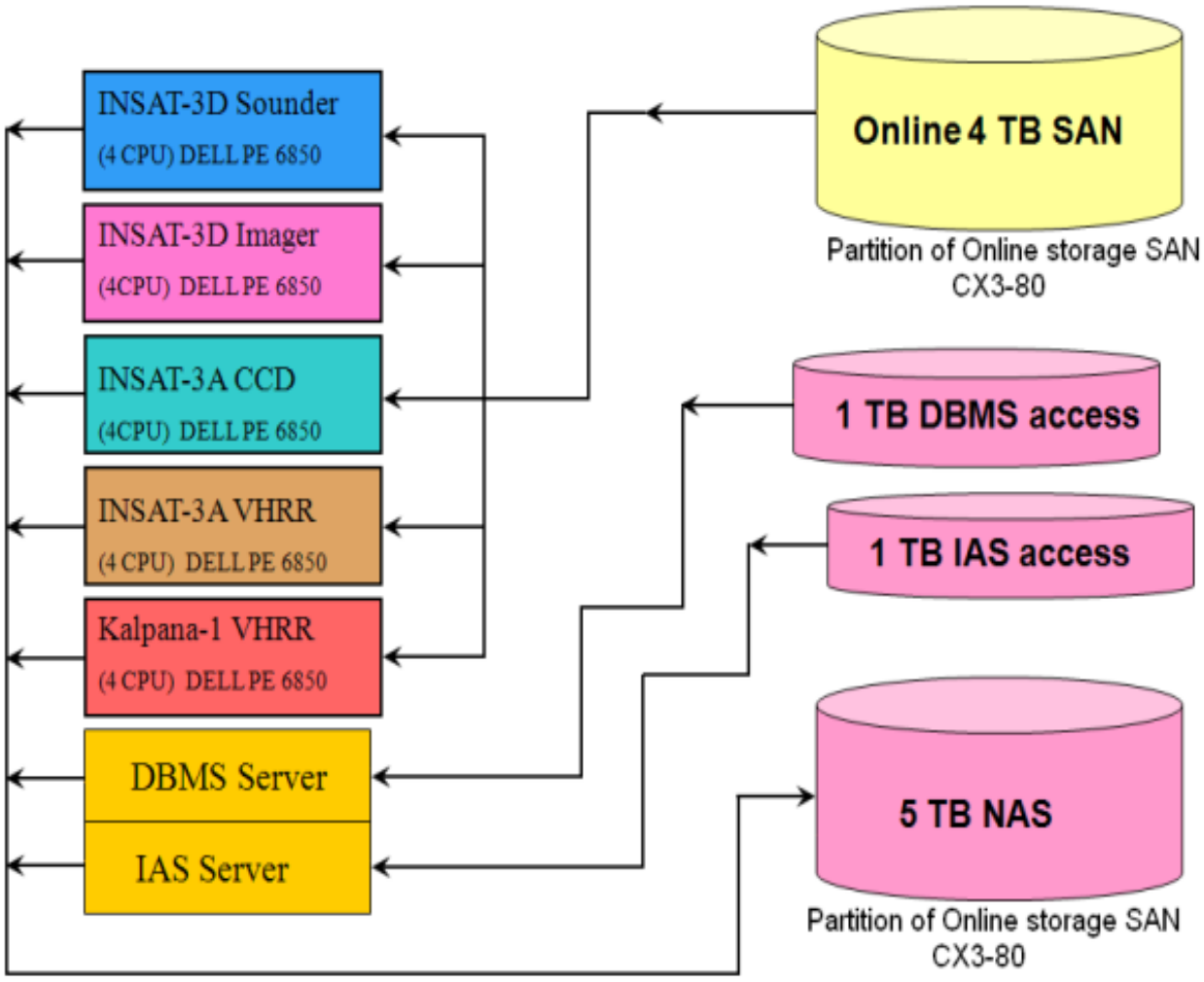
EMC NS-80G

The EMC NS-80G installed at the IMD consists of the following specifications:

- The EMC NS-80G consists of two X-Blades,
  Each X-Blade comprises of the following parts:-
  - It consists dual Pentium 4 CPU's with redundant data path
  - It has a 4 GB double data rate RAM,
  - It also has 2 FC ports for switch connectivity,
  - It also consist 2 FC ports for tape connectivity.
  - Network interface:
    -Six 10/100/1000 base T port
    -Two optical Gig-E ports
  - It has multiple power supplies and multiple Gigabit Ethernet port and is designed to support multi- protocol network file access.
  - It also consists of control stations and data movers.

- It supports a network speed of up to 2 Gbps.
- To eliminate any single point of failure the NS-80G gateway offers n+1 redundant load sharing PS, battery backup, environmental controls, redundant storage & network components.
- The NS-80G installed consists of dual data mover and one control station.
- NS-80G works on NFS protocol.

Data Flow through Servers



The above figure shows a block diagram of the data flow from different partition of SAN online storage to the servers.

All the raw data from the three satellites namely INSAT-3A, INSAT-3D & KALPANA-1are fed into the main online SAN. From this main online SAN storage all the data which need further processing is given to the 7 servers depending of the type of data.

For example, when a data request is being made by any of the server, it takes data from the specified partition in the Main online storage SAN and transfers it to the specified server via a SAN switch. After processing the server sends the processed data to the SAN partition which is being used as NAS, the processed data is then here stored for future use.

Archival SAN System

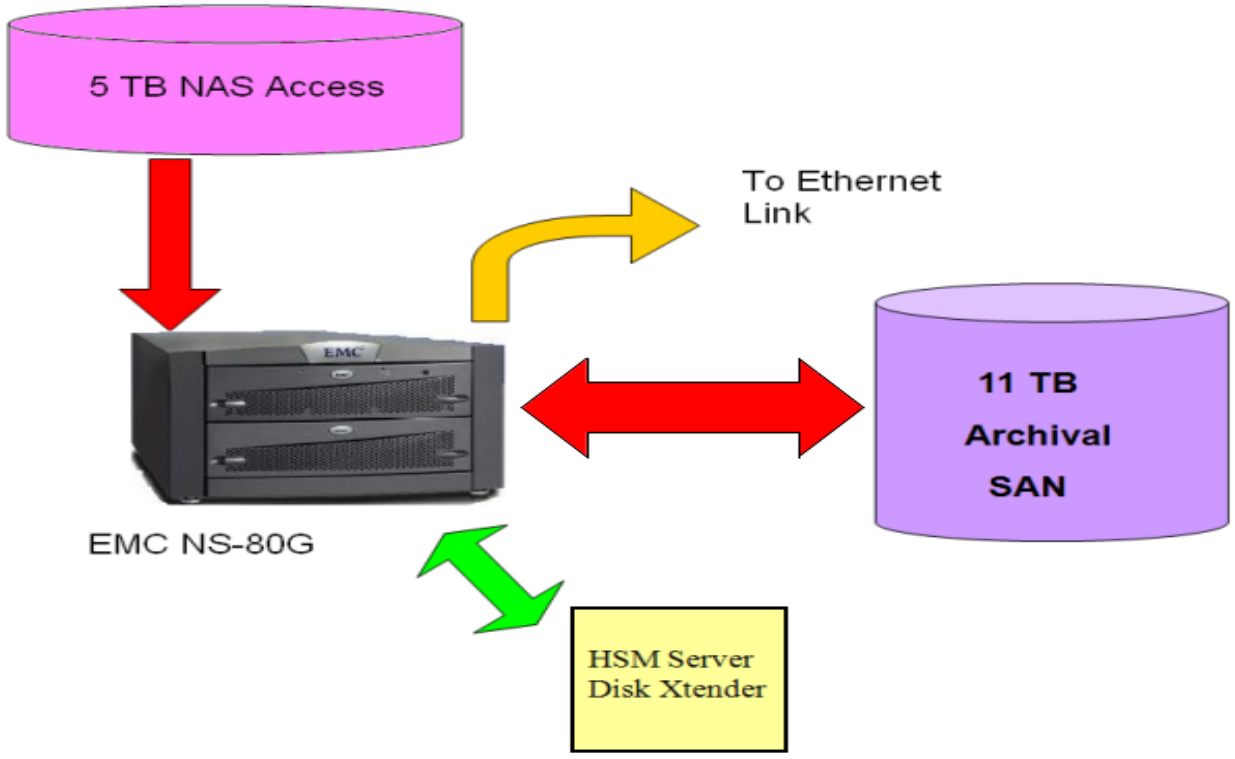
An archival storage system is used for storage of data which is no longer in use by any current running applications but can be useful for future use. At IMD, Archival SAN storage system is placed next to the main Online FC storage SAN. The Archival SAN storage uses an EMC CX3-40 model, which has the same architecture as that of a CX3-80 model.

The Archival SAN system installed at the IMD consists of the following specifications:

- The archival SAN has a useable storage capacity of 11 TB which can be further expandable to 72 TB with Fibre Channel (FC) drives and 172 TB storage capacities with high capacity SATA drives.
- The CX3-40 consists of 34, 500 GB SATA disks at 7200 rpm with 4 GB fibre channel interface and has an 8 GB cache
- The disk drives have been configured in RAID 5 configuration with 4D + 1P disk and also supports RAID 0, 1, 1/0, 3, 5 and 6 configurations.
- There are two storage processors per CX3-40 model; each storage processor has four 4 GB fibre channel optical ports.
- It supports various operating systems like Microsoft Windows 2000 Server, Windows Server 2003, Linux, Solaris, and HP-UX but a Linux operating system has been used in IMDPS Archival SAN.
- It consists of two Hot-swappable power supplies and a standby power supply which ensures power failover protection.
- It has back end connectivity for 240 disk drives but only 34 disks have been used in IMDPS system.
- The archival system is used by NAS gateways which carry out the necessary data archival.
- The data is fed into the archival system from the 5 TB NAS via NAS gateways by the use of an external server known as HSM server.

EMC CX3-40

Movement of Data to Archival SAN



The figure shows movement of data from the 5 TB NAS to 11 TB archival SAN.

After the servers have processed the data the processed data is being fed into the 5 TB NAS after a certain period of time and as per a predefined schedule all the inactive files are moved to an external storage system which is known as Archival SAN System. The data movement takes place via a NAS gateway with the help of HSM server.

The network clients can access this data via the NAS gateway which is connected to a high Ethernet link, thus a NAS gateway makes it possible for the network clients to access the data which is stored in NAS.

HSM Server or Disk-Xtender for NAS

A HSM server is a server which is being used for migration of data from the 5 TB NAS to 11 TB archival SAN system and retrieves the files when needed. HSM server introduces corrective archiving policies to remove inactive data from scheduled backup which reduces the backup window, recovery times and cost of tape media when backing up to tape libraries. A Disk Xtender for NAS automatically migrates inactive data when policy thresholds are met.

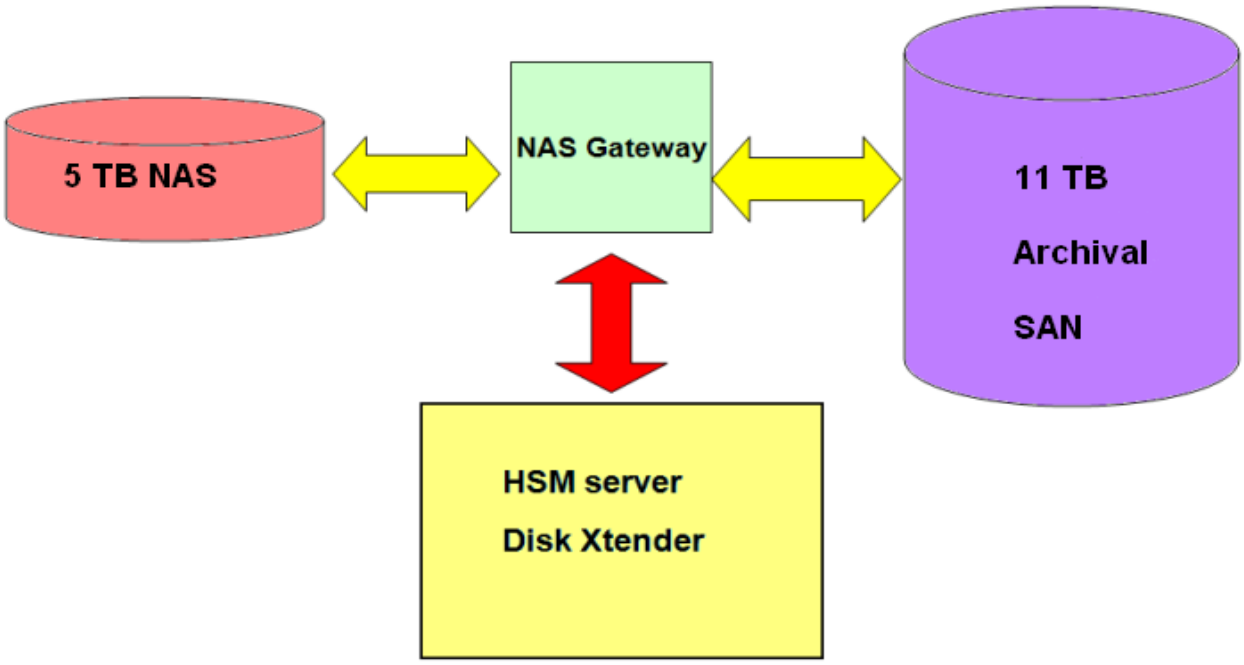
By moving inactive or infrequently accessed files from your primary NAS system, you can achieve a lower total storage cost and shorten backup and recovery process.

The HSM server installed at the IMD has the following specifications:

- The HSM used is a DELL Power Edge 2900 server.
- It consists of two 2.0 GHz dual core 64-bit Xeon processor.
- It has 4 MB of cache and 4 GB of ECC DDR2 memory.
- It has an internal storage: 3* 146 GB SAS disk at 15k rpm (further expandable to 1.5 TB).
- It supports RAID levels: RAID 0, 1 & 5.
- It also has a Serial Attached SCSI (SAS) storage controller of 3 GHz and 3Gbps data transfer rate.
- It also consists of a DVD/CD-RW combo drive with 48x maximum speed.
- It has embedded Ethernet dual ports with 2 LAN cards.
- It has redundant power supply and operates on a Red Hat Linux operating system.

HSM Server/ Disk Xtender for NAS

Data movement & Archival Process by HSM Server



A HSM server is used for migration of inactive files & folders in the 5 TB NAS to an external 11 TB Archival SAN. HSM server is also known as Disk Xtender for NAS. The main purpose of HSM server is movement of data files from 5 TB NAS to 11 TB Archival SAN and to carry out necessary archival of data files when requested. The movement of data takes place via NAS gateways which is also used for the necessary archival of data files.

For example, after the predefined schedule a 1 GB file is to be moved from 5 TB NAS to 11 TB archival SAN, the HSM server starts the data migration and the file is transferred to the 11 TB archival SAN.

After the file movement is complete the HSM server creates a small link (approx. 100-200 Kb) in the 5 TB NAS for that file with its original file name so that during archival the user or administrator can simply click on that link & the file may be archived.

Disk Library (Virtual Tape Library)

A Disk Library is used to meet the demanding backup and restore requirements of midsize-to-large enterprise. An EMC DL 4100 virtual tape library is being used because of its faster backup and restore, improved service levels and energy efficiency and data de-duplication technique.

EMC DL 4100 Disk library

An EMC 4100 disk library installed at IMD have the following specifications:

- It consists of 30 500 GB SATA disks with a useable 11TB of storage capacity.
- The EMC Disk Library DL4100 gives up to 674 TB of compressed capacity.
- It also gives a boosted backup performance with aggregate sustainable performance of up to 1.5 Gbps
- The data de-duplication option eliminates redundant data from backups thus reducing backup time.
- The disk library supports a data compression in the ratio 2:1.
- RAID 5 protections ensures that a disk failure does not cause data availability issue.

Tape Library

A tape library is used to provide extended backup storage. A Tandberg – magnum 448 Tape Library is used for backup purpose. A Tandberg 448 is an LTO based tape library with 48 tape drive slots, each tape drive has a normal capacity 400 GB and a compressed capacity of 800 GB. It also consists of 3 cleaning cartridges.

Tandberg 448 Tape library

Backup server

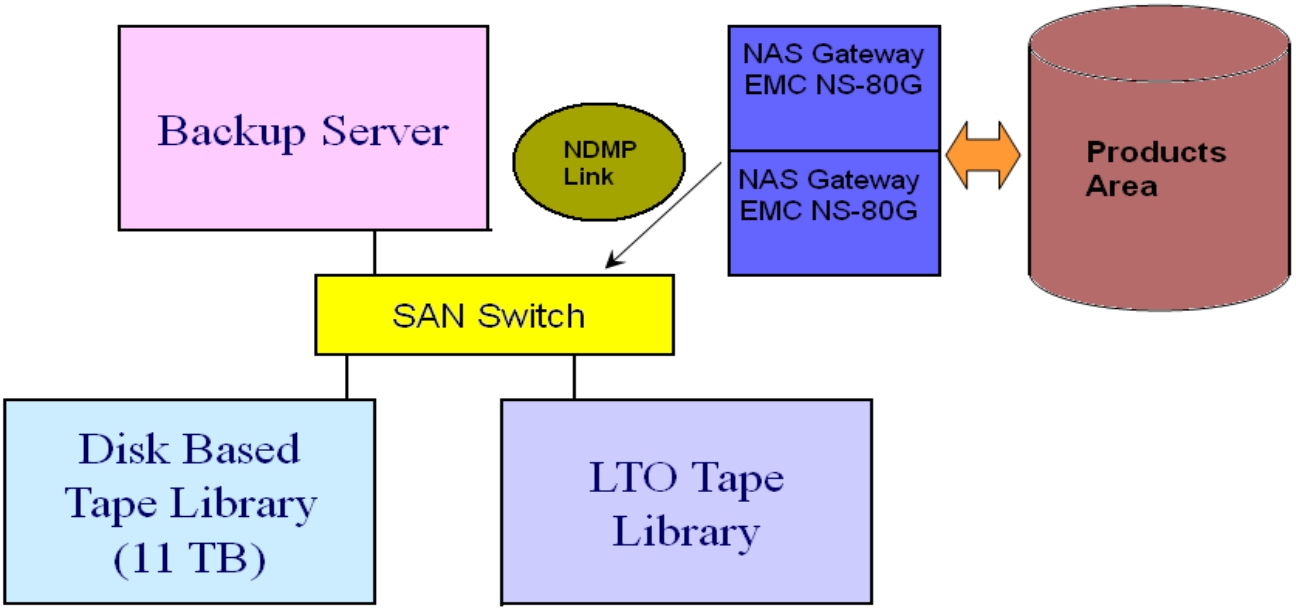
A DELL PE 2900 server is being used as a backup server for backup purposes. It takes backup information from disk and tape library and feeds into the archival SAN.

The backup server has the following configurations:

- It is a DELL Power Edge 2900 server.
- It consists of two 2.0 GHz dual core 64-bit Xeon processor.
- It has 4 MB of cache and 4 GB of ECC DDR2 memory.
- It has an internal storage: 3* 146 GB SAS disk at 15k rpm (further expandable to 1.5 TB).
- It supports RAID levels: RAID 0, 1 & 5.
- It also has a Serial Attached SCSI (SAS) storage controller of 3 GHz and 3Gbps data transfer rate.
- It also consists of a DVD/CD-RW combo drive with 48x maximum speed.
- It has embedded Ethernet dual ports with 2 LAN cards.
- It has redundant power supply and operates on a Red Hat Linux operating system.


Backup Server (DELL PE 2900)

Backup Process

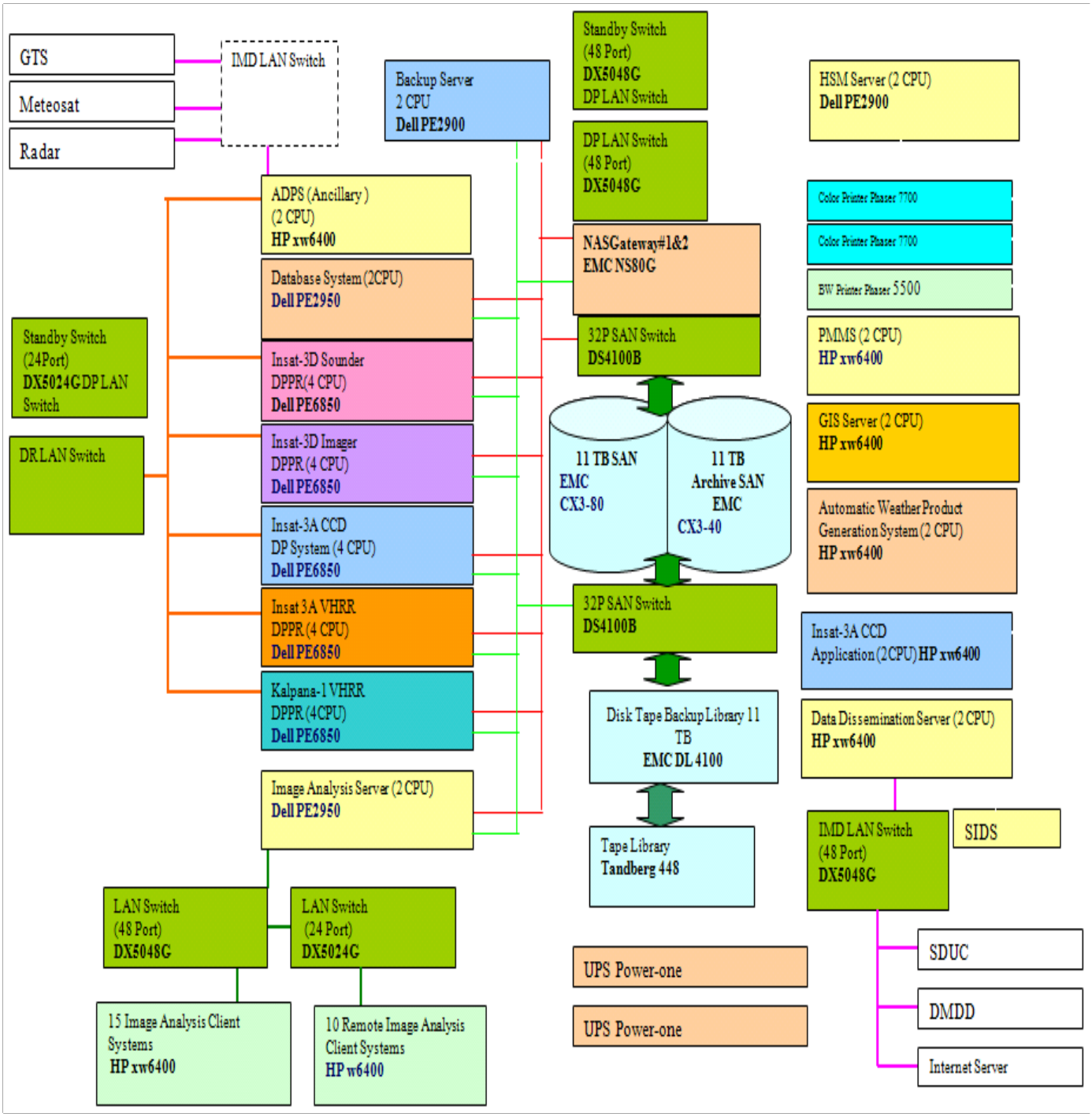


A backup server (DELL PE 2900) is used for backup process. The main elements used for backup are as follows:

- A backup server
- Disk library
- SAN switch
- NAS gateway
- Tape library &
- A product area

During backup necessary information regarding backup is taken by the backup server from disk library and tape library. After all the information is gathered the backup files are given to product area which in this case is the Archival SAN system. The backup server communicates with the disk & tape library via a SAN switch and the files are fed into the Archival SAN system with the use of NAS gateways (connected to the SAN switch via NDMP link)

Data Processing System and Storage System Architecture


GTS
Meteosat
Radar
IMD LAN Switch
Backup Server
2 CPU
Dell PE2900
Standby Switch
(48 Port)
DX5048G
DP LAN Switch
DP LAN Switch
(48 Port)
DX5048G
HSM Server (2 CPU)
Dell PE2900
ADPS (Ancillary)
(2 CPU)
HP xw6400
Database System (2CPU)
Dell PE2950
NASGateway#1&2
EMC NS80G
Color Printer Phaser 7700
Color Printer Phaser 7700
BW Printer Phaser 5500
Standby Switch
(24Port)
DX5024G DP LAN
Switch
Insat-3D Sounder
DPPR(4 CPU)
Dell PE6850
32P SAN Switch
DS4100B
PMMS (2 CPU)
HP xw6400
DR LAN Switch
Insat-3D Imager
DPPR (4 CPU)
Dell PE6850
11 TB SAN
EMC
CX3-80
11 TB
Archive SAN
EMC
CX3-40
GIS Server (2 CPU)
HP xw6400
Insat-3A CCD
DP System (4 CPU)
Dell PE6850
Automatic Weather Product
Generation System (2 CPU)
HP xw6400
Insat 3A VHRR
DPPR (4 CPU)
Dell PE6850
32P SAN Switch
DS4100B
Insat-3A CCD
Application (2CPU) HP xw6400
Kalpana-1 VHRR
DPPR (4CPU)
Dell PE6850
Disk Tape Backup Library 11
TB
EMC DL 4100
Data Dissemination Server (2 CPU)
HP xw6400
Image Analysis Server (2 CPU)
Dell PE2950
Tape Library
Tandberg 448
IMD LAN Switch
(48 Port)
DX5048G
SIDS
LAN Switch
(48 Port)
DX5048G
LAN Switch
(24 Port)
DX5024G
SDUC
UPS Power-one
DMDD
UPS Power-one
Internet Server
15 Image Analysis Client
Systems
HP xw6400
10 Remote Image Analysis
Client Systems
HP w6400

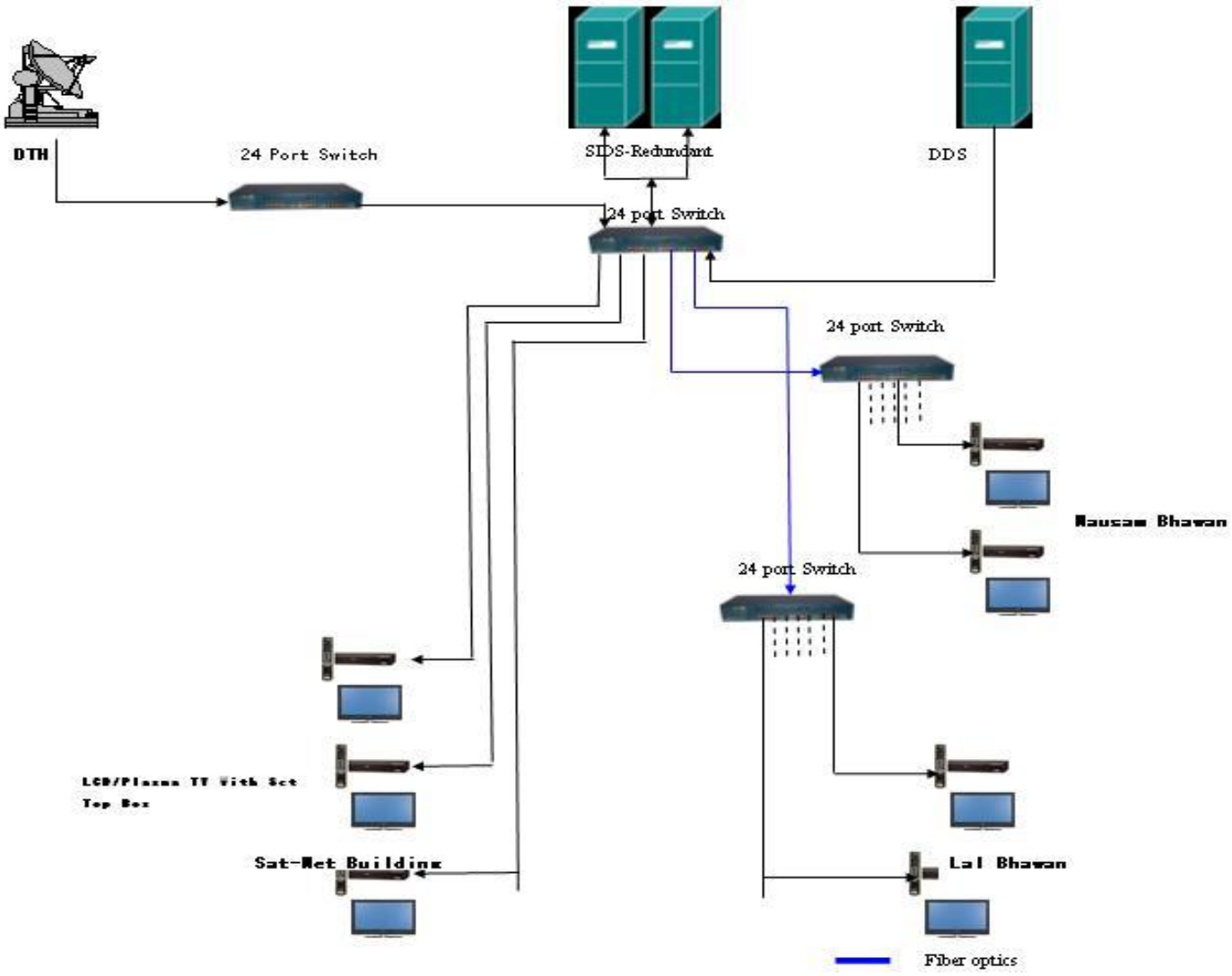
Network Clients System To cater the requirement of user 25 image analysis client workstations, one data dissemination server, one product monitoring and management system and one AWPGS server are used as a network client and continuously interact with data processing system and data storage system.

Satellite Image Display System (SIDS)

The Satellite Image Display System (SIDS) is one of the sub systems of INSAT-3D METEOROLOGICAL Data Processing System (IMDPS). It consist of two HP XW6600 workstation, TV Display 26"/42",24 port gigabyte Ethernet LAN switch, Ku BAND DTH (Including Antenna LNBF & Receiver with remote control) ,Client Set-top box.The prime objective is to receive the images from Data Dissemination Service system (DDS) and transmit to TV receiver available at 25 different locations within the IMD campus. Transmission of signal from SIDS (head-end) system to LCD TV receiver (user end) will be through LAN cable network. SIDS system interacts with DDS to receive the images for transmission.
The Satellite Imagery Display System (SIDS) as the name suggests, is an images display system capable of:-

- Receiving images from 19 different folders of DDS and transmitting these to TV receiver (LCD).
- Transmitting images (of different satellite and sensors) to 19 channels and 1DD news channel.
- Display of animated images as a video for showing the movement of clouds.
- Functioning automatically and work (fetching data from DDS and sending to TV receiver set at user end) without any user intervention.

SIDS will have adding features of scheduling the image delivery system in terms of setting time interval for searching and sending/ replacing by latest image at server end on start and stop, crop, adding annotation and scrolling text.


DTH
24 Port Switch
SIDS-Redundant
DDS
24 port Switch
24 port Switch
24 port Switch
Nausam Bhawan
LCD/Plasma TV With Set Top Box
Sat-Met Building
Lal Bhawan
Fiber optics