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BHUVAN

**SYSTEM AND SOFTWARE
DESCRIPTION**

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**National Remote Sensing Centre
Indian Space Research Organisation**
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	<p>Abstract (with Keywords): This document provides the Bhuvan System Architecture and System design and implementation details. It also provides various data standards and specifications being used in the Bhuvan. The detailed Bhuvan software functions and features are listed in this document</p> <p>Keywords: <i>Bhuvan, Bhuvan-2D, Bhuvan-3D, System Architecture, System Design and Implementation, Standards, Specifications, Functions, use-cases, System security.</i></p>			

Contents

SI.No	Topic	Page Numbers
1	Introduction	1
2	System Architecture	1
3	System Design and Implementation	4
4	Standards	7
5	Functions / Features	9
6	Development Environment	12
7	Use cases and Outreach	12
8	System Security	12
9	Future plans	12

List of Figures

Figure 1 : Overall Bhuvan architecture – present

Figure 2 : Location of Data centers for Bhuvan Distributed systems

Figure 3 : Bhuvan Federated Servers

Figure 4 : Bhuvan landing page depicting major components

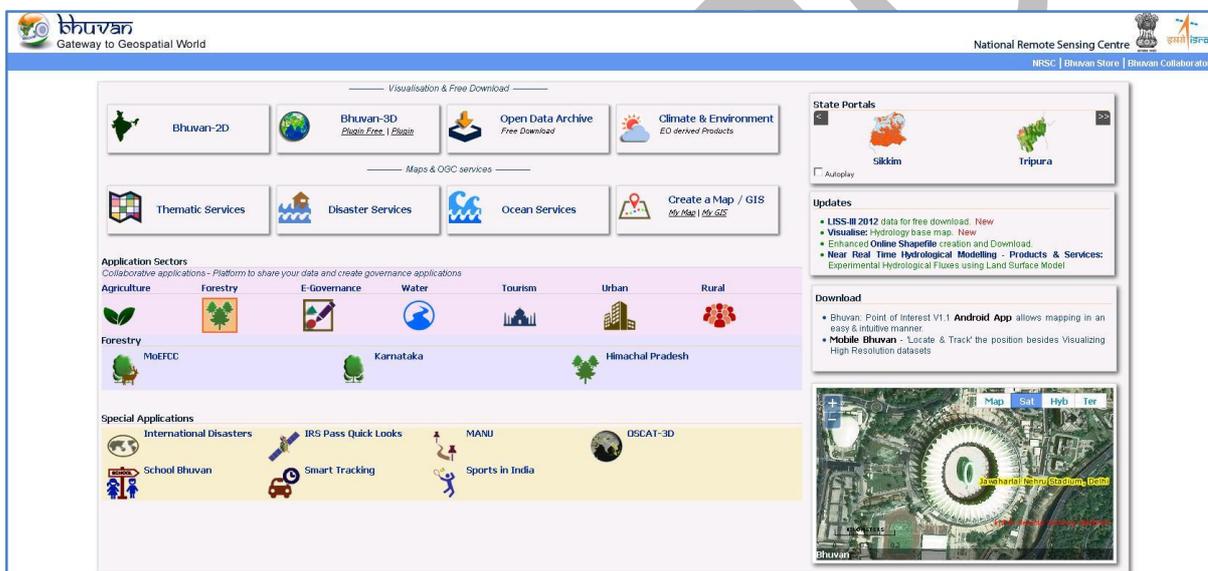
Figure 5 : Simplified Process Flow – Bhuvan

Figure 6 : Replication and load balancing of Databases

Bhuvan – ISRO’s Geo-Platform

“Browse, Visualise, Create, Analyse, Share and Host”

Bhuvan Software Design and Implementation



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ISRO, Hyderabad

<http://bhuvan.nrsc.gov.in>

12 August 2015

1. Introduction

Bhuvan (the name is derived from the Sanskrit word which means Earth), a Geoplatform of ISRO (<http://bhuvan.nrsc.gov.in>) was launched on 12 August 2009 by MoS, Prime Minister Office. Since its launch it has taken many steps forward to reach Users with wide range of services and applications. In this time frame, several major and minor releases are made with varied features and advanced analytical capabilities.

Design and development of Bhuvan has been evolved through Open Source Geospatial solutions following ISRO's Software design standards based on IEEE 12207 and all services are made available as OGC Complaint Web services while disseminating to the users towards interoperability. Thus, Bhuvan's versatile tools support development of interactive applications for visualisation, querying, analysis and becoming platform for users to share their ideas, create their custom applications, and make more versatile Earth Browser with participatory approach. Bhuvan has also been recognized by OGC as website of the month in December, 2010.

(<http://www.opengeospatial.org/pressroom/newsletters/201012/#C4>).

2. System Architecture

The Bhuvan application is a web based multi-tiered architecture with browser based client access over the public Internet. Very high Internet bandwidth for is provided for Bhuvan services through Internet Service Provider (ISP) via fiber Ethernet interface and required redundancies. The public IPs are issued by ISP in order to host the website and for various applications. There are a number of web servers and application servers hosting the required middleware and application software, connected with devices like routers and firewalls as essential part of the Bhuvan infrastructure. There are also additional servers to manage and facilitate the infrastructure including storage and network. Network mass storage (SAN and NAS) and high performance SAN shared file system also constitute a significant component in Bhuvan architecture. All servers and storage are connected by means of a Gigabit Ethernet network as well as Fibre Channel SAN switch based network. The existing Bhuvan architecture is shown in the following figure (Figure 1).

At the moment, the present systems architecture is hosted from NRSC consisting of following servers catering to varieties of applications, such as, *3D image rendering, Collaboration Service, Metadata, 2D applications, Web services, Database, FTP services, Storage management, Open Data Archival and download services, Authentication services, Geo-processing, Thematic data Services and Mapper and many more.*

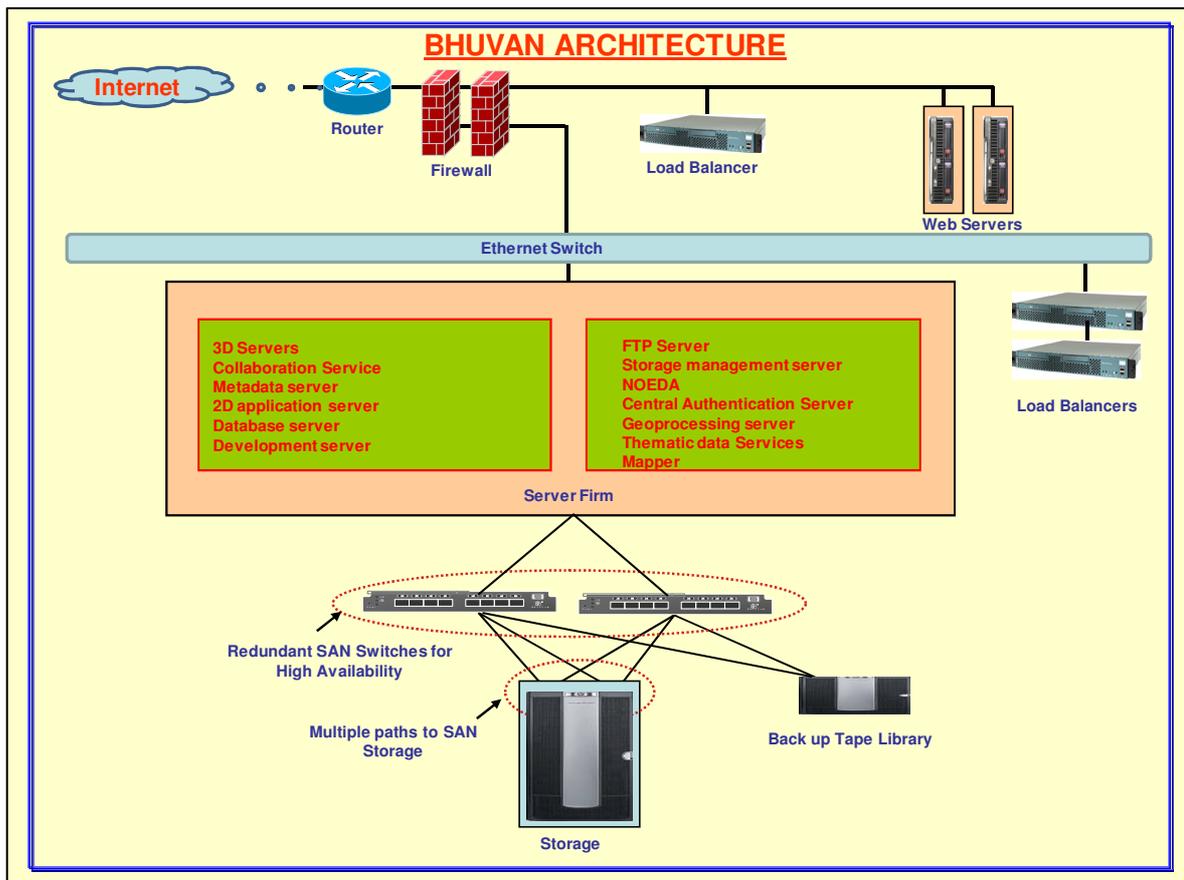


Figure 1 : Overall Bhuvan architecture – present

2.1 Initiatives

Starting with 3D visualization in Windows environment, Bhuvan has come out with various features and applications like platform and plug-in independent 2D, multi-lingual, online shape file creation, free data download, interoperable OGC web services, My Map, My GIS and many more based on user demand and requirements towards societal good and better usability. The successful showcasing of various visualization and thematic services has resulted in further demands on Bhuvan to provide platform to host various applications from user end. Hence, Bhuvan also now provides platform to users to host their applications through spatial mashups, starting with map centric application to user centric applications like Bombay Natural History Society (BNHS) for Important Bird Area (IBA) Mapping and Birds migration, Sarva Shikshya Abhiyan of Andhra Pradesh, Punjab Remote Sensing Centre (PRSC) for Tourism Web GIS for Amritsar City, Karnataka Forest Department for Online Forest monitoring etc.

After successful realization of above spatial mashups, various new services are also currently being implemented in Bhuvan (more than 64 Projects) to cater the requirements as a outcome of 'Effective use of Space Technology' in various ministries and Governance portals for state governments:

- Ministry of Road Transport and Highways
- Ministry of Culture

- Indian Railways
- Space based Information Support for Decentralised Planning (SIS-DP) project
- Augmented Irrigation Benefit Programme (AIBP) project
- National Urban Information System (NUIS) project/ Ministry of Urban Development etc.

The above represents only a small fraction of the demand or the growth potential. It is envisaged that there would be huge growth in hosted services down the line even as richer functionalities (which are under development) are deployed in Bhuvan.

2.2 Distributed node setup

In view of the above, considering the need to enhance the Bhuvan infrastructure to meet the increased demands of the current and to cater to the future growth. Based on the requirements, the Bhuvan distributed architecture design is evolved and its overview schematic is given in Figure 2. At the moment specific services are operational from Regional Remote Sensing Centres (4 centres) of NRSC and NESAC, Shillong. Distributed architecture enables improved services and at the same time efficiency of services from Bhuvan. This concept is planned to grow across the country with more external nodes of Bhuvan for distributed computing and services.

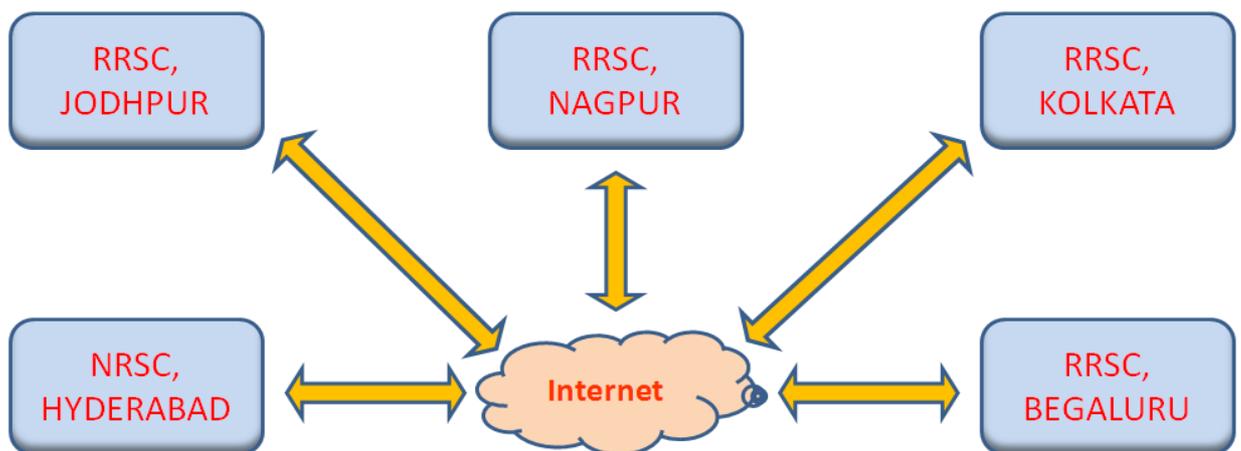


Figure 2 : Location of Data centers for Bhuvan Distributed systems

2.3 Bhuvan Scale up Infrastructure & Federated Servers

Bhuvan federated servers from state/central government departments from the country are in pipeline for further leveraging the hosting capability besides high availability and sharing the computational load. A Major Infrastructure upgrade is being planned in the near future that will have 100s of servers, very large storage and a scaled up data centre concept which will be ready in phases during 2015 and 2016.

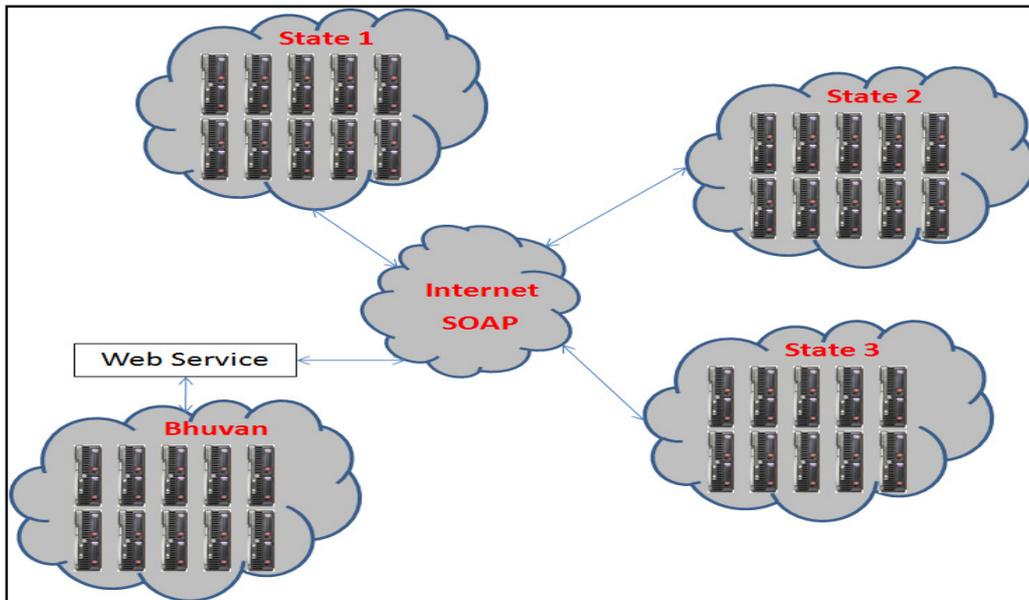


Figure 3 : Bhuvan Federated Servers

3. System Design and Implementation

Starting with visualisation services in Plug-in based windows application in 2009, Bhuvan now is evolved as a Geo-platform by having In-house and Indigenous development using Open Source Geospatial Solutions.

The user-friendly, web rich Bhuvan 3D requires good amount of system resources and bandwidth to have rich user experience besides the native plug in to accelerate the visualization. By analyzing the feedback from different user community, it's understood that users with limited system resources and bandwidth require an alternate system to visualize this rich Indian Earth Observation Visualisation System. Thus, the requirement of Bhuvan 2D is emerged and design is evolved in 2010. While designing the Bhuvan 2D, the following criteria's is given very high value to meet the user requirements.

1. Plug-in independent application to make a smooth entry to the application and avoid the download time of plug-in.
2. Cross Platform and browser compatibility
3. Minimum system resources.
4. OGC compliance Web Services (WMS/WMTS/WFS/WPS) towards interoperability.
5. Open Source Geospatial Solutions towards nullifying the initial and maintenance costs of the COTS packages.

To fulfill the above requirements, Bhuvan 2D has been developed using the very robust Open Source Geospatial solutions to organize the satellite imageries and map data along with myriad information geographically with no server - side dependencies in an easy way. Widely-used general-purpose scripting language and A high-performance, feature-packed Open Source javascript library are used for making dynamic, interactive and rich Web application. Thus, the entire development and deployment of Bhuvan 2D is

accomplished using open source solution. This modular framework is evolved as various other applications like NRSC Open EO Data Archive and Thematic Services in 2011 and Collaborative applications towards Geoplatform like Amritsar Tourism GIS and Karnataka Forest Applications in 2012 and Governance in 2014 having CERT-IN certified for application security. From visualization services to platform enabling users to host applications, following are the major components of Bhuvan as shown in Figure 4.

- Visualization and Free Download
- Maps & OGC Services
- Applications
- State Portals
- Crowd Sourcing

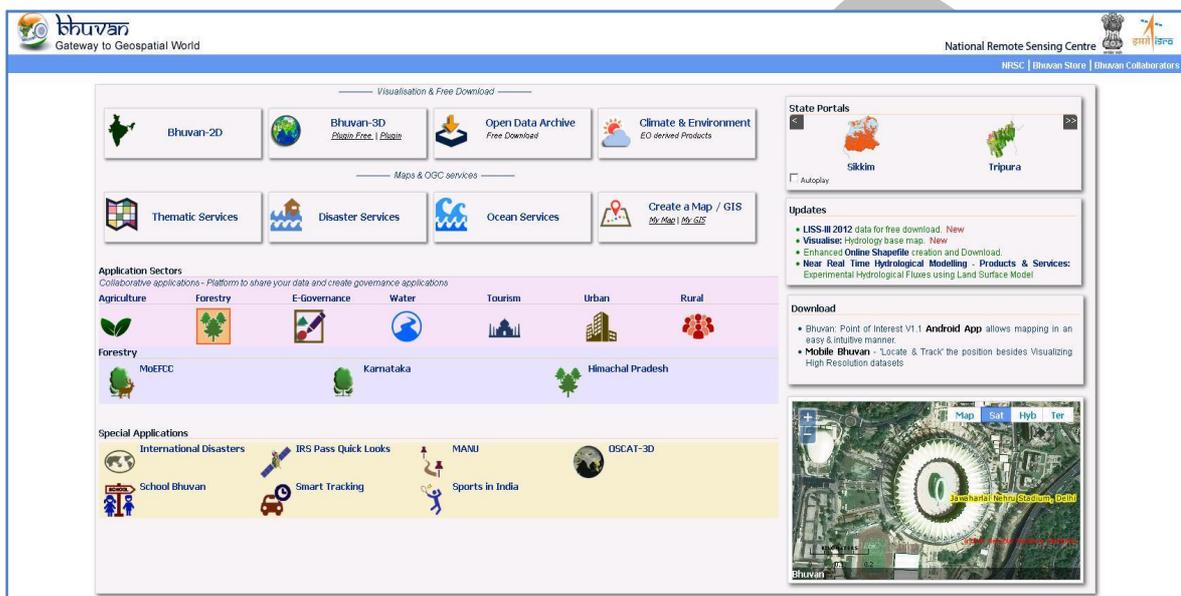


Figure 4 : Bhuvan landing page depicting major components

3.1 Deployment and System Processes

Effective deployment of Bhuvan requires a multi server configuration where the robust, interoperable, advanced data server, application server and web server are required as individual identities and installed and configured in network architecture with appropriate caching mechanism and security to provide the high available services to the users. Some of the services are also enabled under SSL - Secure Sockets Layer to provide secure connection between internet browsers and websites.

3.1.1 Browser Application process

In system architecture and process flow of Bhuvan, there are two major components i.e. Server side process and Client side process. In the server side process, web server, application server and database servers are configured, while in client side configuration, a simple web browser along with network connection is required to access Bhuvan. All these server side components are configured for best performance having high availability from cluster (Vertical and Horizontal) of servers with proper multi-threading, compression, caching, expiry etc.

Figure 5 describes how different components of Bhuvan are linked through the simplified process flow.

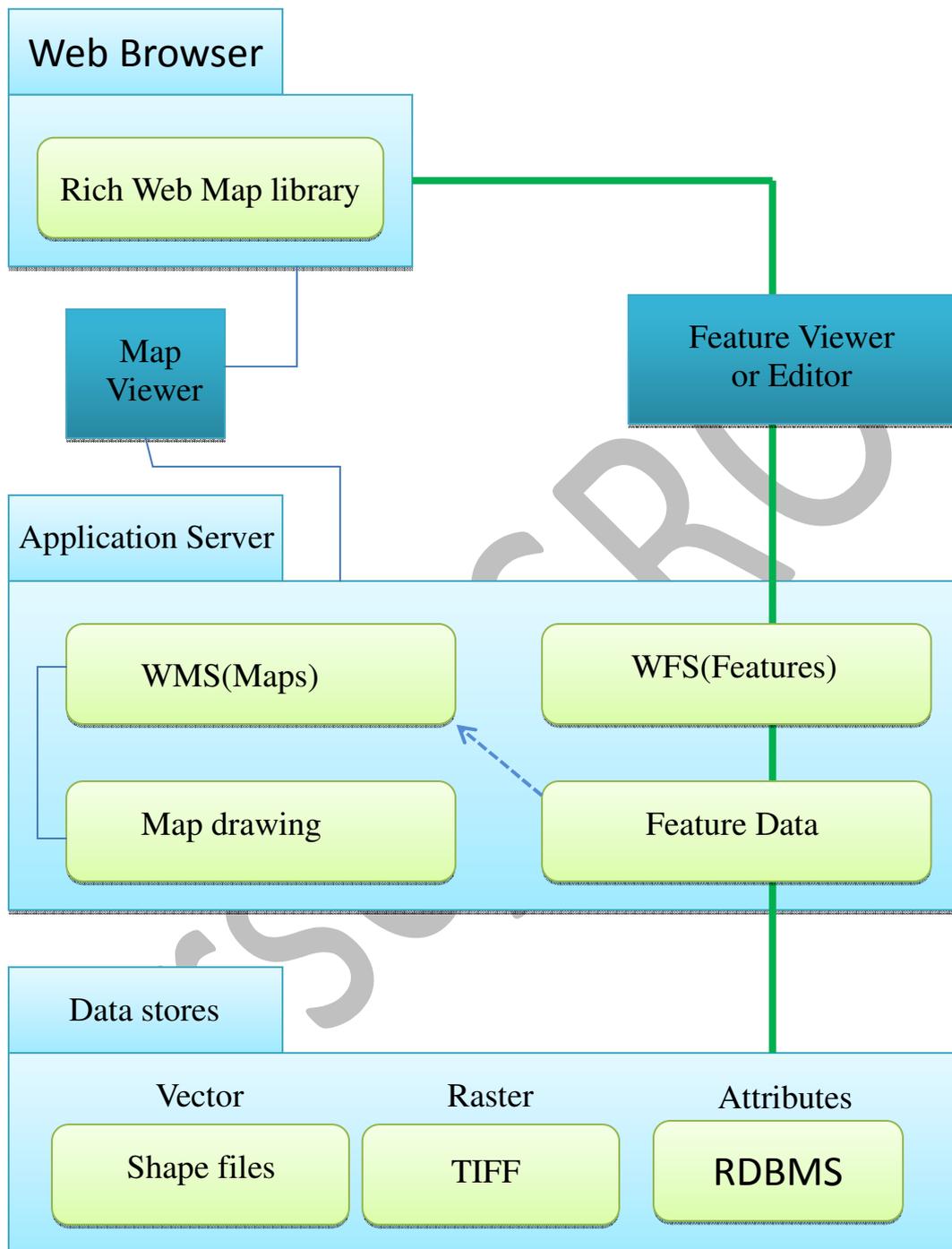


Figure 5 : Simplified Process Flow – Bhuvan

In the current development of Bhuvan application, all Raster and vector Layers are published as Open Geospatial Consortium (OGC) - Web Map Service (WMS) and Web Map Tile Service (WMTS) having queryable option for better rendering with Styled Layer Description (SLD). For online editing and dynamic processing, privileged users are also enabled Web Feature Service (WFS) for online editing. The TileCache library can speed up access to your WMS by factors of 10-100, or more and handle more requests per second.

3.1.2 Mobile data process

The dataset sent by the mobile app reaches Bhuvan server where it is organized in a well designed enterprise database management system. Cluster of Geo-RDBMS with indexing and tuned with better performance parameters are exploited to store the spatial components of Geodata from the crowd to ensure High Availability, Load Balancing & Replication.

The non-spatial datasets are stored in a well structured file system with proper configuration for better read/write operations. Scheduled compression of files is done besides mobile level compression and the file structure is maintained in such a way to avoid more number of files in the same folder. This ensures reduction of latency of read and ensures quick display on the webpage.

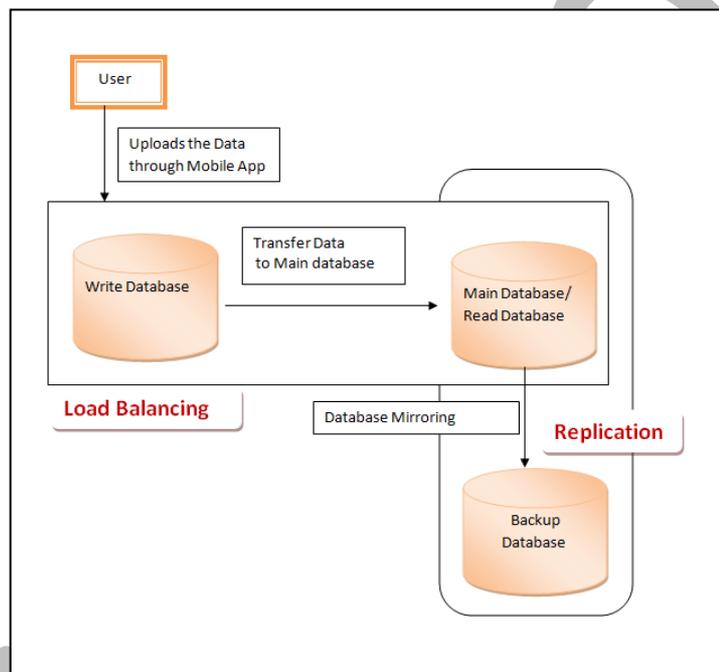


Figure 6 : Replication and load balancing of Databases

4. Standards

Large volume of Geospatial datasets (Raster and Vector) along with non-spatial datasets were created and organized during the development and deployment of Bhuvan. These huge amounts of spatial data in both Vector and Raster format were organized in centralized server to facilitate the network based applications development.

The spatial resolutions of raster data sets stored in Bhuvan varied from 500 m to 1 m. The image sizes of these raster data sets are very high. Therefore, the web rendering of these heavy size raster data sets with traditional web mapping techniques is not very effective. So development of Asynchronous Web services and image tiling techniques (predefined standard size with Bhuvan & NRSC/ISRO watermarks) are the advancements in Web-based GIS applications/visualisation to tackle the performance and bandwidth issues in the multi-user environment.

4.1 Raster data specifications

Horizontal & Vertical	WGS-84
Projection / Coordinate System	GCS
Color Composite	NCC
Tile Indexing	Open Series Map of Survey of India
Tile Overlap	>20 pixels
Enhancement	Localized Enhancement
Format	Geotif
Radiometric Resolution	8bit

Terrabytes of data consisting of Multi-resolution, temporal, sensor raster data are stored with above specifications besides 30 products of large amount of data are stored with above specifications.

4.2 Vector data specifications

Projection: Geographic

Datum: WGS 84

Format: Shape File/Geo-RDBMS.

Gigabytes of data consisting of large number of themes of variable scales are stored with above specifications.

4.3 Attributes

Format: Geo-RDBMS.

More than 8 million data consisting of various dynamic like AWS and monitoring data sets like Crop, Disaster are stored with above specifications.

4.4 Metadata

NSDI – Consists of overall 10 fields i.e. 9 mandatory fields and 1 additional field on “Data Quality” for vector and raster datasets.

WMO - consists of overall 13 fields for Meteorology (weather and climate), operational hydrology and related geophysical sciences.

4.5 Data Sharing

Towards enabling Interoperability, all the datasets stored in the centralized servers are shared as web services (XML, OGC Web Services). There are around 46 OGC standards at present including WMS, WMTS, WPS, WFS, WCS, GML, KML, City GML, Open LS etc. Bhuvan Services are shared to the users as WMS, WMTS, KML and WFS for specific users.

5. Functions / Features

As a Geoplatform, Bhuvan provides versatile tools support development of interactive applications for visualisation, querying, analysis, share their ideas, create their custom applications, and make more versatile Earth Browser with participatory approach.

5.1 Tools available in Bhuvan -2D, NOEDA, Thematic Services, Projects

I. Visualization Tools

1. Fixed Zoom - In
2. Fixed Zoom- Out
3. Rubber Zoom - In
4. Rubber Zoom – Out
5. Navigation map as overlay (Hybrid view)
6. History Previous Extent (Go Back to Previous Extent)
7. History Next Extent (Go to Next Extent)
8. Zoom To Initial Extent
9. PanZoomBar
10. Controls to move top, left, right, bottom.
11. Adjustable Transparency tool
12. Identify(Information on Mouse click /hover)
13. Time series visualization with slider and swipe capability
14. Opacity tool
15. Interactive user inputting system with multi-slider
16. Satellite, Map and Hybrid view towards intuitive visualization
17. Terrain View
18. Virtual grouping of layers and visualization

II. Draw Tools

1. Point
2. Line
3. Polygon
4. Online Shapefile Creation (Point , Line, Polygon)

III. Measure Tools

1. Distance
2. Area

IV. Analysis Tools

1. Statistics (State wise, District wise, Area of Interest)
2. Clip &Ship(Get Data through FTP after signing MOU)
3. Custom Query Shell
4. Interactive Drawing(Rectangle, Polygon)
5. Swipe Tool

V. General Tools

1. Send Mail
2. Embeddable HTML
3. Status Bar (On MouseHover of Map display of Lat,Lon)
4. WMS Manager
5. Search (Search by Lat,Lon and Place name)
6. Search Nearby Places (Proximity Analysis)
7. Get Directions (Routing)
8. Add Layer (Adding of WMS Layers, Uploading of Shapefiles and Publishing as WMS Layers)
9. Print based on view extent with Scale and legend (Layout)
10. Show/Hides Panel
11. OGC web Services (WMS, WMTS) to the users.

5.2 Tools available in Bhuvan -3D

I. Visualization Tools

1. Fixed Zoom - In
2. Fixed Zoom- Out
3. Navigation Map from Rediff Maps
4. Controls to move top, left, right, bottom.
5. Identify(Information on Mouse click /hover)
6. Fly -In
7. Fly-Out
8. Jump -In
9. Jump -out
10. Fly -Around
11. 3D city models
12. Info tool (Lat, lon and elevation)
13. Head up display (HUD)
14. Navigation Controls
15. Tilt Slider (control to rotate globe)
16. North Indicator
17. Opacity
18. 2D & 3D switch based on extent and altitude

II. Draw Tools

a. Standard

1. Marker
2. Free Hand Drawing

3. Image Overlay

b. 2D Objects

1. Point
2. Line
3. Polygon
4. Regular Polygon
5. 2D Arrow
6. Circle
7. Free Hand Drawing
8. Online Shapefile Creation (for Line, point, Polygon)

c. 3D Objects

1. Box
2. Cylinder
3. Sphere
4. Cone
5. Pyramid
6. 3D Arrow

d. Urban Design

1. Road builder with trees
2. Junctions
3. Traffic lights

III. Measure Tools

1. Distance
2. Area
3. Query on Terrain
4. Vertical Distance
5. Terrain Profile
6. Contour Map

IV. GIS Tools

1. Threat Dome
2. Buffer
3. Find Objects
4. Video on Terrain

V. General Tools

1. GPS Tool (Live track and play back)
2. Search (Search by Lat,Lon and Place name)
3. Add Layer s(Adding of WMS Layers, Shpefiles, KML files, WFS Layers, fly files, Elevation, Imagery layers) and save option as Public and private layers
4. Print (View based screenshot)
5. Show/Hides Panel
6. Sign – In (Central Authentication)
7. Add Content (Volunteered Geographic Information)
8. Developers Tool (Sharing API)

9. Communities (Collaboration through Text, Voice, sharing of Terrain)
10. Add Album(Photos)
11. Shadow
12. News (Live feed from Times of India)

6. Developer Environment

Service oriented Architecture (SOA) of Bhuvan in which application components provide services to other components via a communications, typically over a network. The principles of service-orientation are independent of any vendor, product or technology towards interoperability. This enables bhuvan as a platform to users to bring out versatile applications through participatory GIS.

Application framework is shared with users to have a rapid application development having OGC web Services and host through FTP like Nashik Police Application, Search & Rescue for Disaster, NDRF, NUIS, GAIL etc.

7. Use cases and Outreach

Since its advent, Bhuvan is being referred in several forums, journals, blogs for its usage. There are more than 60 applications developed using bhuvan application framework and hosted for various users covering NGOs (BNHS), Central Ministries (MoWR, MoEF&CC, MHA etc), State Governments (Punjab, Karnataka, Andhra Pradesh, Telangana) to name a few. Bhuvan receives about 5 million hits per month having about 30 thousand cumulative monthly unique visitors and crosses free data download of about 3.5 lakhs.

In collaboration with academic institutes for the benefit of users in 2011, 5 one day workshops have been conducted and 7 one day workshops have been conducted in 2012 and benefitted by approximately 2500 users covering students, researchers, educators, NGOs, Government and Industry officials etc. Apart from the exclusive Bhuvan workshops, as part of the RAY workshop, approximately 250 town planners were trained and approximately 3000 planners were trained as part of NUIS workshop for master plan preparation, three 2 days bhuvan training in 2015 with total 75 participants and Customised Bhuvan training programme for ENVIS officials of 26 officers, also Bhuvan capabilities are regularly exhibited as part of the various conferences in Geospatial domain held in India.

8. System Security

All Infrastructure, Data and Application are ensured with proper security mechanism towards high availability. Multi-tier server applications are hosted by hardening operating systems with firewall to avoid any intrusion; Raster and Vector datasets are cached and served to the user by avoiding direct access; application developed are CERT-In certified for security.

9. Future Plans

Many more value added functions and features are planned that will be added from time to time. Particular interest of ISRO/DOS would be to provide such functionalities to common man to engage in participatory approach coupled with tools for scientists to solve simple problems easily and interactively. To state few that is planned in near future

are Online Geo-processing towards interoperability as Web Processing Services(WPS) for realizing Bhuvan as one-stop versatile ISRO's Geo-Platform, Uniform High resolution data (1m) for entire nation, Distributed Architecture for Bhuvan to improve the user experience, Comprehensive Knowledge Archive Network (CKAN) for all Indian Earth Observation Datasets for discovery to evaluation and exploitation, Robust Bhuvan API for customized add-on's / apps, Robust RS Data Archive and Dissemination System to access land cover change for local to global systems (Enhanced NOEDA), Enhanced Bhuvan Thematic Services to cater various themes, Disaster Information & Management Support ,Customized Bhuvan Mobile apps to cater various user needs towards user centric map applications etc.

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