COASTAL OCEAN OBSERVING NETWORK – OPEN SOURCE ARCHITECTURE FOR DATA MANAGEMENT AND WEB-BASED DATA SERVICES

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Commission IV, WG IV/1

KEY WORDS: Coastal Ocean Observation, Ocean Data Management, Open Source, Visualisation

ABSTRACT:

The observations from the oceans are the backbone for any kind of operational services, viz. potential fishing zone advisory services, ocean state forecast, storm surges, cyclones, monsoon variability, tsunami, etc. Though it is important to monitor open Ocean, it is equally important to acquire sufficient data in the coastal ocean through coastal ocean observing systems for re-analysis, analysis and forecast of coastal ocean by assimilating different ocean variables, especially sub-surface information; validation of remote sensing data, ocean and atmosphere model/analysis and to understand the processes related to air-sea interaction and ocean physics. Accurate information and forecast of the state of the coastal ocean at different time scales is vital for the wellbeing of the coastal population as well as for the socio-economic development of the country through shipping, offshore oil and energy etc.

Considering the importance of ocean observations in terms of understanding our ocean environment and utilize them for operational oceanography, a large number of platforms were deployed in the Indian Ocean including coastal observatories, to acquire data on ocean variables in and around Indian Seas. The coastal observation network includes HF Radars, wave rider buoys, sea level gauges, etc. The surface meteorological and oceanographic data generated by these observing networks are being translated into ocean information services through analysis and modelling. Centralized data management system is a critical component in providing timely delivery of Ocean information and advisory services.

In this paper, we describe about the development of open-source architecture for real-time data reception from the coastal observation network, processing, quality control, database generation and web-based data services that includes on-line data visualization and data downloads by various means.

1. INTRODUCTION

Availability of ocean data in real-time is essential for spatial analysis and decision support system to provide ocean information and advisory services and also forcing models that lead to climate predictability, both short-term and long-term. Further, with the vast amount of data available, ocean models could be fruitfully utilized to undertake need based user projects for coastal and offshore applications.

A network of Ocean Observing System including both the open ocean and coastal ocean has been established in the Indian Ocean for providing operational ocean information and advisory services. The observing network provides data on various oceanographic and surface meteorological parameters in real-time that includes includes, HF Radars (surface currents), Tide Gauges (sea level), Wave Rider Buoys (wave), Moored Buoys (surface meteorological and oceanography), Current meters (surface and sub-surface currents) etc.

The use of open source tools are gaining wider acceptance for providing web-based services in the field of ocean sciences. Significant progress has been made in developing open source tools to integrate ocean observing systems; test and implement easy-to-use, open-source, OGC-compliant software; and creation of networked, interoperable, real-time data systems.

Our objective of the experiment is to exploit the potential of open source tools in developing Ocean Data and Information System - an end-to-end system comprising acquisition of met-ocean data from a variety of ocean observing systems (through different modes viz. satellite communication, e-mail, ftp, etc.), processing, integration, quality control and web-based data dissemination to the users for operational and research activities.

To bring out the awareness and as a ready reckoner to the coastal community to understand state of the ocean, dissemination is vital stage in data management, that too which is easy to visualize and comprehend. To accomplish this target effectively, Open Source WebGIS architecture is adopted to publish and share geo-spatial information from the coastal observing network on the internet. To provide cost effective solution, we relied on the UMN MapServer on top of the widely spread client server architecture LAMP (Linux, Apache, MySQL, PHP). The architecture includes UMN MapServer to serve the purpose of displaying and querying dynamic data spatially, which provides easy mechanism to implement WebGIS server solution based on Open Geospatial Consortium (OGC) standards including WMS (Web Map Service) that enables creation of web maps from the layers coming from multiple different remote servers/source; MySQL to manage database; and OpenLayers to put a dynamic map in web page. OGC is providing interoperability and standardized specifications to support geospatial to be shared by internet. In this paper, we describe the architecture of the system with the HF Radar data that is very complex in nature compared to other coastal observing platforms viz Wave Rider Buoys and Tide Gauges, Moored Buoys. The same architecture was extended for the data received from the other coastal observing platforms and their dissemination through web.

2. WEB GIS BUILDING STEPS

The present systems building steps follows the procedure mentioned in Brovelli and Magni [1], for an archaeological WebGIS application, which includes following steps:

- Data Acquisition
- Database design, software choice and installation of softwares
- Data processing
- WebGIS files implementation and data loading
- Performance tests and processing improvements

The first step is data acquisition at a single source through different modes from various observing systems. The database is designed based on the parameters received and their frequency. Interoperable software has been selected to support the system which can interact with each other for reading data from database and successfully publishing the geo-referencing data on web. The data is processed for structuring the information and setting software for its mutual interaction and web utilization. Loading the respective data and setting files to interconnect with each other as a single WebGIS system is done accordingly.

3. DATA SOURCES, ACQUISITION, PROCESSING AND LOADING

The network of coastal observing systems in the seas around India is shown in Figure 1 to Figure 3. HF Radars has been installed in five coastal states consisting two sites in each states four in Bay of Bengal coast and one in Arabian Sea coast. These HF radars transmit the data in real-time to the data centre.

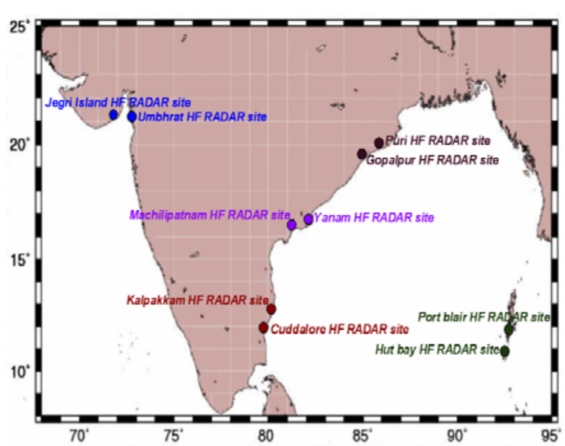


Figure 1. Locations of HF Radars

HF Radar data i.e. total current vector file in ascii format has been acquired through scheduled FTP every hour, which contains spatial currents parameters. The main parameters in this data consists of : Longitude, Latitude, U component, V component, U Standard Deviation, V Standard Deviation, Covariance, X Distance, Y Distance, Range, Bearing, Velocity and Direction. Among these the most important parameter for publishing data into web are Longitude, Latitude, Velocity and Direction. Along with these different cartographic symbols, e.g. Arrow to represent the speed and direction of current on map and base maps has to be acquired for providing the webgis functionalities.

The locations of the Wave Rider Buoys installed along the Indian coast are shown Figure 2. The data on various wave parameters are transmitted in real time to the data centre at hourly interval.

Figure 2. Locations of Wave Rider Buoys

The locations of the tide gauges are shown in the figure 2. The data on the sea lever at hourly interval was received offline and archived at the data centre.

Figure 3. Locations of Tide Gauges

4. WEB GIS COMPONENTS

The WebGIS system includes following six open source components:

- MySQL, a database server
- Java, a programming tool to process data
- UMN MapServer, a map engine
- Apache WebServer, as a web server
- OpenLayers, to put dynamic map on web
- Web browser, to view
- MapServer and other web facilities

The Univeristy of Minnesota (UMN) MapServer is an open source platform that serves the purpose of displaying and querying dynamic data spatially. It supports several OGC web specifications, including WMS (Web Map Service), nontransactional WFS (Web Feature Service) and GML (Geography Markup Language). MapServer is not a stand-alone system; it basically needs to be run on web server such as Apache WebServer. MapServer consists of three different components

- The CGI program
- The template files
- The Mapfile

CGI program provide standard protocol to interfacing browser and web server, it reads and processes both the map file settings and the template file, user defined variables and returns the processed outputs as maps, variables or values and query results shown in the template files. Every CGI output is a temporary image or value updated at each CGI work session.

The Mapfile is the heart of MapServer. It defines the relationships between objects, points MapServer to where data are located and defines how things are to be drawn. This is a built-in object oriented scripting language in MapServer, which defines how to create and use the maps and their layers. OGR connection (by OGR library) is used to connect the database in MySQL and web GIS.

Template files are used to define the look of a MapServer CGI application interface and to provide the results of the query. They guide the presentation of results, either as a text or as map, to the user. Common HTML page tags are provided by the MapServer and can thus be viewed in web browser.

OpenLayers is a free JavaScript which makes it easy to put a dynamic map in any web page. Capable to display map tiles and markers loaded from different source/servers. OpenLayers has been developed to further the use of geographic information of all kinds.

5. MYSQL & DATA PROCESSING

Database in MySQL is designed to support geo-referenced data from HF Radar in a tabular format. Database is segregated into different tables based on station and year indexed by observation time for faster response. The basic naming convention for tables are t_TOTL_[station]_[year], eg. t_TOTL_Anco_2010; and the table description is given in the following table.

Field	Type	Null	Key	Default
station_id	varchar(10)	YES	MUL	NULL
observation_time	datetime	YES	MUL	NULL
longitude	decimal(12,7)	YES		NULL
latitude	decimal(12,7)	YES		NULL
speed	decimal(8,3)	YES		NULL
direction	decimal(8,3)	YES		NULL

Along with this main table maintains all the raw data received from HF Radar with following description:

Field	Type	Null	Key	Default
station_id	varchar(10)	YES	MUL	NULL
observation_time	datetime	YES	MUL	NULL
datafile	longblob	YES		NULL

The data extraction tool developed using Java, organizes and stores the location and currents information into database from the data received through scheduled FTP at hourly intervals

Similar procedure has been adopted for the data received from wave rider buoys and tide gauges.

MySQL interaction with MapServer

Mapfile LAYER object of MapServer plays the important role to interact with MySQL database. Layer is a combination of data and styling, in the form of attributes and geometry using CLASS and STYLE derivatives. To read data from MySQL database the MapServer should be compiled using OGR support. The following parameters have to be specified with CONNECTIONTYPE OGR derivatives to read vector data from database.

- the connection parameters, viz name of the database, user name and password.
- the name of table and its geometry column
- the filter with the syntax user for a SQL query WHERE clause.

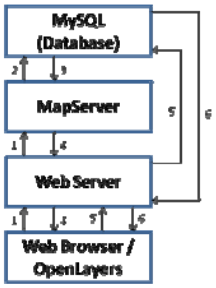
The other important derivatives used in layers are CLASS, STYLE, SIZE, COLOR, ANGLE and EXPRESSION

- CLASS is used to classify the vector data based on speed of currents, where EXPRESSION specifies to which CLASS the feature belongs to.
- STYLE with SIZE to map the data with specified size depends on speed, COLOR to map data with specified color and ANGLE to map symbol “Arrow” in the direction of currents.
- ANGLE rotates the symbol in counter clockwise. Thus angle attribute is adjusted to specify angles in compass direction.

OpenLayers interaction with MapServer

OpenLayers.Layer.MapServer instances are used to display data from MapServer CGI instance. Whereas MapServer also exposes its CGI functionalities in WMS mode. Thus OpenLayers.Layer.WMS instance is preferred over OpenLayers.Layer.MapServer, since MapServer layer can lead maps to not work properly due to mis-configurations and projection issues [3].

WebGIS Structure and Functionalities



1. Request for map view
2. MySQL data loading setting
3. MySQL georeferenced data return
4. Map results displaying
5. Data download request
6. Data return

Figure 4 : Data Flow

Figure 4 represents the data flow of user interaction with MapServer, which accesses georeferenced data from MySQL database and publish the maps on browser via WebServer.

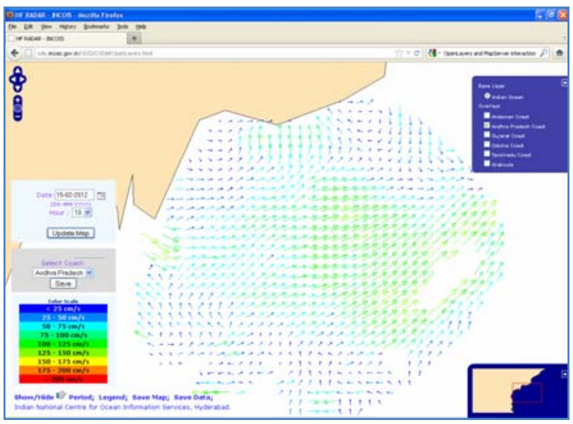


Figure 5. Visualisation of the surface currents from the HF Radar

By means of this data flow, the system is providing basic GIS functionalities for map browsing with features to select different location, pan, zoom and downloading data and maps in different image format (Figure 5). Further, the time series data can be visualised on the fly in graph formats as shown in Figure 6.

Figure 6. Time series graph of Significant Wave Height from a Wave Rider Buoy.

6. CONCLUSION

The system developed using the open source technology is cost effective way to integrate near real time data from Coastal HF Radar, Tide Gauges, Wave Rider Buoys etc. into a WebGIS and for providing easy access to the data and visualization of complicated data sets on-the-fly. The system is being tested for integration of the oceanographic data from the remote sensing satellites.

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ACKNOWLEDGEMENTS

The authors wish to thank Dr. S.S.C. Shenoi, Director, INCOIS and Dr. Shailesh Nayak, Chariman, INCOIS Governing Council for their keen interest and support in the ocean data management and web-based data services.