Conceptualization and development of Sericulture Information Linkages and Knowledge System (SILKS)

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Abstract: A geoportal titled 'Sericulture Information Linkages and Knowledge System' (SILKS) has been conceptualized and developed using Open source GIS as a single window decision support system to provide spatial and non-spatial information for selected 108 districts in the country and hosted in the public domain at http://silks.csb.gov.in. SILKS portal currently hosts data services for 900 sets of spatial layers consisting of potential areas for expansion of sericulture development in a single window access system. SILKS is supported by16 non-spatial modules on sericulture planning, farmers advisory and other services specific to the district. Analysis has been carried out to measure the response time coming from SILKS web pages taking into account the number of requests and variable data sizes. The geoportal has been re-configured to get overall acceptable and fast response time. Within a short span of about two years, the geoportal has been able to make significant impact particularly in north eastern region and a number of sericulture expansion activities have been initiated based on the information provided through the portal.

Keywords: Open source GIS, Spatial data, Sericulture, SILKS

1 Introduction

The information derived from the geo-spatial data has become an indispensable input for planning and management of natural resources. The Geographic Information System (GIS) with its ability to collect, manipulate, manage, store and analyze spatial data has become an important tool for a GIS analyst (Demers, 2008 and Longley et al., 2010). But, the final spatial map products must be quickly disseminated to large numbers of users for their various usages in planning and decision making process. The web based open source GIS via internet provides an ideal platform to share these geo-spatial databases as services (Burdziej, 2012; Nash et al., 2008) to millions of users effortlessly with minimal cost (Yin and Feng, 2009). Though there are numerous web-mapping tools available, very few are complete scalable application frameworks for integrating and managing geo-spatial data services.

Sericulture as an allied agriculture activity plays an important role in rural economy in our country. The country has a unique distinction of producing all four types of natural silk namely Mulberry, Tasar, Eri and Muga. Central Silk Board (CSB) has been pursuing the application of satellite remote sensing (RS) for sericulture development ever since the launch of the first operational remote sensing satellite, IRS-1A in 1988 (Navalgund et al., 1991). CSB and ISRO in collaboration with the concerned State Sericulture/Textiles Departments applied the technology of RS and GIS for mulberry acreage estimation, garden condition assessment and for finding suitable areas for introducing sericulture in non-traditional States (Nageswara Rao et al., 1991; CSB, 1994). Despite the fact that silk industry is an age old practice, intervention of ICT and modern geospatial techniques in sericulture are still at the nascent stage. There is ample scope for improving the production and quality of silk through expansion of sericulture to new potential areas, supporting the farmers with up-to-date scientific information through appropriate dissemination system with the intervention of geospatial tools and web technology (Alesheikh et al., 2002). The paper describes the conceptualisation and development of a geoportal titled Sericulture Information Linkages and Knowledge System (SILKS) to integrate sericulture related information into a single window access system using open source GIS. Spatial information on potential areas for expansion of sericulture in 108 priority districts in 24 states has been integrated along with corresponding non-spatial information for all these selected districts. Based on the existing and future potential of sericulture expansion information system on mulberry is made available for 108 districts, Tasar for 53 districts, Eri for 47 districts and Muga for 48 districts.

SILKS portal contains 16 non-spatial modules and has information on silkworm productions, rearing techniques, disease management, cocoon processing, sericulture marketing, advisory services for farmers etc. All the geospatial data and other data of SILKS are managed using effective database management system for their archival, storage and querying. State-of-art hardware architectures are deployed for hosting this application. The databases are updated frequently with integration of recent data taking into account of feedbacks received from the users.

2. Development of SILKS

The primary objective of developing SILKS is to host and create data services for 900 sets of spatial layers consisting of potential areas delineated for silkworm food plants and other spatial layers in a web based single window access system (Kamel and Honda, 2006; Yin and Feng, 2009; Singh et al., 2012). Further each SILKS is supported by16 non-spatial modules on sericulture planning, farmers advisory and other services specific to the district. The spatial databases were checked for database schema standardization, projection and other database anomaly before importing into postgreSQL environment. Separate databases were created for each district for ease of database management and their updation. The non-spatial modules were managed separately.

Implementation of the overall SILKS following the design specifications has been carried out after selecting a testing environment. Testing was required for each component of SILKS framework that was implemented both in the database and at application coding levels.

The general framework for SILKS deployment on the web is shown in Figure 1. There are two instances of database running in parallel – PostgreSQL is used to store and maintain all the geospatial related data for all 108 districts. Mapserver is the core of entire applications and hold important Mapfiles for each district-wise SILKS. The SILKS Single Window Access is the gateway to all 108 SILKS sub-portals. The portals are made available in 12 languages viz., English, Hindi, Telugu, Kanada, Assamese, Bengali, Mizo, Manipuri, Khasi, Garo, Ao Naga and Sumi Nagato facilitate more users with diverse linguistic background.

For multilingual conversional and translation, Wordpress plugin qTranslateXis used to maintain dynamic multilingual content on SILKS portal.

The SILKS server has been set up on a high availability having two servers running under cluster mode connected through different IPs via a network switch which is then uplinked to CSB Server network.
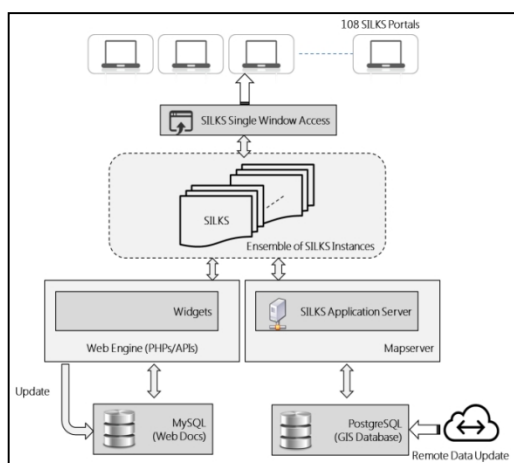
2.1 Architecture and platform used

The SILKS adopts thin client server architecture where all clients share their processing or computations with the same server. The main aim being high quality rendering of huge numbers of spatial data on the browser, several server tools were surveyed for possible consideration and finally Mapserver was chosen as it supports display and querying of large number of raster, vector and other database formats, including shapefiles, PostGIS and ArcSDE geometries, OPeNDAP and Arc/Info coverage files.

Figure 2 shows the application architecture for the SILKS. First, the user makes a request having Mapserver parameters. The Apache HTTP web server, upon receiving the parameters, invokes the Mapserver engine. The Mapfile inside the Mapserver defines the basic and query template and tells how the maps will appear on the browsers. The Mapserver can connect to both local PostgreSQL data as well as external OGC data services from remote servers. The re-projection of the incoming data can be done on-the fly as per the projection defined in the "projection object". The Mapserver will then processes the data as per the parameters and returns images in the desired map output format defined in the Map file.

The SILKS server contains initialization scripts to create SILKS instances. The purpose of the server is to initialize a template and mapfile and then launching of SILKS application. The SILKS application is an open source platform (Song et al., 2004) built based on Chameleon PHP/Mapscripts framework.

PHP scripts provide access to mapping-related "widgets" and functions. CWC2 (Configurable Web Mapping Client Components) tags are added to HTML template pages. These tags provide a simplified method for adding mapping content to a web application. The CWC2 based Chameleon framework has been used for building user interface web mapping. Figure 3 shows the way few of the tags are put into a template page. Chameleon widgets can implement mapping tools such as zoom-in, zoom-out, panning, legends or displaying of map coordinates. The customized widgets are then added into the template file. Figure 4 shows how the additions of MapDHTML widget into the template file.
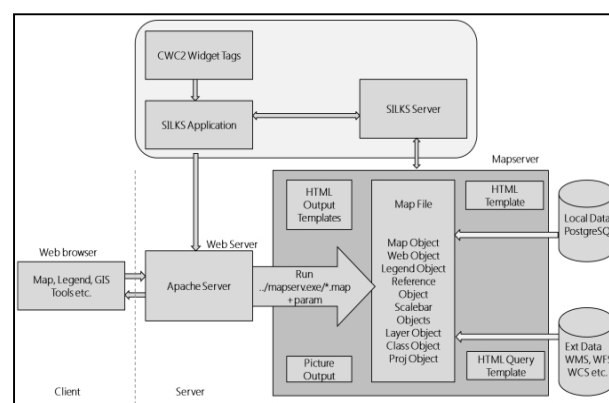

Figure 1: General SILKS hosting framework

Figure 2: SILKS application architecture

```
<cwc2 type="Query" visible="true"
imagewidth="24" imageheight="24"
imagetip="Identify Feature" PopupWidth="500"
PopupHeight="600" Toolbar="false"
Status="false" Menubar="true" RADIUS="3"
MAXFEATURES="5" toolset="Navigation"></cwc2>
```

Figure 3: Adding CWC2 widgets

The database server is critical for smooth running of the application. All the spatial data are stored as PostgreSQL tables. These tables are then called by MapServer using the map file PostGIS connection. Each PostgreSQL table has been previously provided with a Geometry Column, in which every record has its spatial description. PostGIS 1.5 has been used as a back-end spatial database for GIS to PostgreSQL.For developing other web pages and forms, PHP and HTML was used for web editing tools and Javascripts for scripting tools to interact with the clients.

```
<CWC2 TYPE="MapDHTML"
      VISIBLE="true"
      WIDTH="400"
      HEIGHT="300"
      ALLOWRESIZE="true"
      MARQUEECOLOR="#FF3333"
      MARQUEEWIDTH="2"
      MINSCALE="1">
</CWC2>
```

Figure 4: Adding MapDHTML widget into the template file

3 Results and discussions

3.1 Optimization of software configuration
The smooth operations of entire application depend largely on perfect and seamless working of the components defined in the overall architecture. Several issues were encountered and judiciously examined and used while developing SILKS. Listed below are some of the important considerations that were considered for optimal performance of our application.

3.1.1 Mapserver Mapfile: The overall performance of SILKS depends on proper creation of the mapfiles as these files are read every time a layer or map is requested. Some of the points that have been considered while preparing a mapfile for SILKS are: (a) the projections in the mapfiles are defined inline rather than using an EPSG code so that considerable resources are not wasted for database lookup. Otherwise, developer must put only minimum required projections definition records in the Proj.4 EPSG database;(b) The status of the layers in the mapfiles are marked as OFF specially for the remote WMS layers or very large local raster data. This way, the unnecessary layers are turned off so that it takes lesser time for the application to load initially. The parameters MINSCALEDENOM and MAXSCALEDENOM are used to set the availability of the layers at different zoom scales. The SILKS Mapserver does not process the layers if the current zoom scale lies beyond the layer's MINSCALEDENOM and

MAXSCALEDENOM range saving overall processing times of the application. This helps to control visibility of different layers as per acceptable spatial resolutions of the layers;(c) proper ordering of the Classes is also important as each of these Classes is processed as per the order in the mapfile. The most commonly used Classes are defined at the top level so that, the server does not have to waste time looking for a match; (d) The Symbols and Fontset file lists the entire raster symbols and fonts used in the mapfile. Only raster symbols and fonts were included in the symbols and fonts file respectively to be used in our application.

3.1.2 Tileindex: For large vector data, *ogrtindex* tileindex tool was used to tile several datasets into one layer and this in turn makes the application to load maps faster. The tileindex will load only those tiles or datasets falling under current map view resulting in great savings in terms of loading time for large volume of datasets. Two keywords were used in the mapfile for tiling process, TILEINDEX and TILEITEM, the former sets the path to the index file and later specifies the field in the shapefile that contains the sub filenames referenced by the index file.

3.1.3 PostGIS: The SILKS databases are stored in PostgreSQL supported by PostGIS. To enhance overall performance of the application, the necessary GIST indexes on the geometry column with each record having an indexed primary key have been created. The following is the command to create GIST index.

```
ALTER TABLE eri ADD PRIMARY KEY (gid);
CREATE INDEX eri_the_geom ON eri (the_geom)
USING GIST;
```

Then, the data in every table is organized using CLUSTER command so that, PostgreSQL reads the indexed data efficiently. Further, the PostgreSQL is allowed to use more memory for caching by increasing the *max_buffers* in the *postgresql.conf* file.

3.2 Analysis of SILKS response time
Getting fast response time is critical for the success of any web based mapping application. SILKS delivers large volume of spatial data on the web. The analysis of the response time for different map user types is important to understand the overall performance of SILKS and modify the design and configurations suitably. Caching plays an important role in enhancing the response time of web pages, rendering and display of map data on the client's browsers. This is especially true and suitable for application involving many consecutive requests and delivery of large volume of geospatial data over the web. Few experiments were performed to observe the number of requests and data size against the response time to test effectiveness of the system for main modules of SILKS.

Case-I: Loading SILKS home page
SILKS home page contains HTML Markups, plugins from CMS coupled with several Java scripts and images. Figure 5 (a and b) shows response time for

loading of the home page without caching and with caching, respectively.

With caching enabled the number of requests for each data size reduces to nearly half of the number and size required to be fetch originally set without caching. Further, the response time is also less in case of caching.
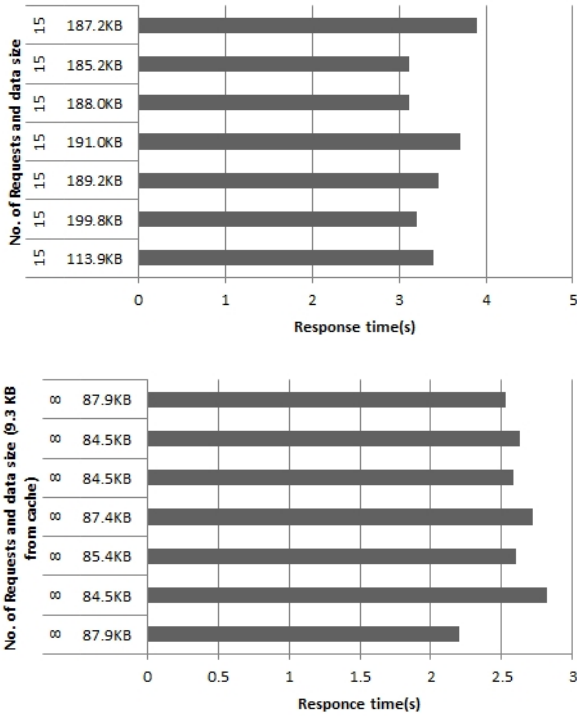
caching, the response time decreases to almost 36%. Also, there is reduction in the number of overall request sent to the server.

Figure 5: Response time of the home page (a-top) without and (b- bottom) with caching

Case-II: Loading SILKS district portal
Each district of SILKS contains HTML markup, images, plugins from CMS and modules for different services. The response times are at least 50% better with caching. It also has Java applets for client side execution of secondary map layers such as utility and other layers and therefore the overall size of data request is more.

Figure6 (a and b) shows response time for loading district portal without caching and with caching, respectively. The caching becomes very important with the increase in data request size. The response times almost reduces to 50% with caching enabled even though the numbers of requests are primarily same in both the cases.

Case-III: Loading of SILKS WebGIS module
Every SILKS WebGIS module contains separate GUI interface with the necessary GIS tools and spatial layers coming from PostgreSQL database. For testing, only two spatial layers were made active since enabling all the layers will take more loading time as explained above.

Figure 7 shows response time for loading of SILKS WebGIS module with and without caching. With
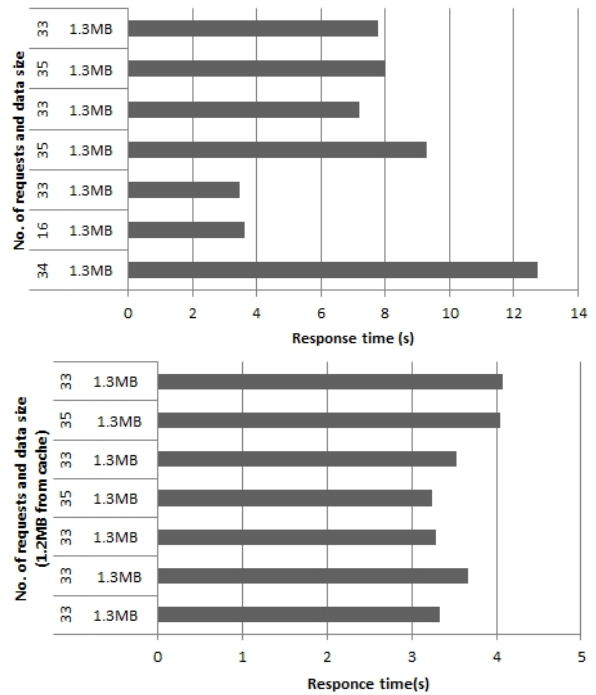

Figure 6: Response time for loading SILKS district portal (a-top) without and (b- bottom) with caching
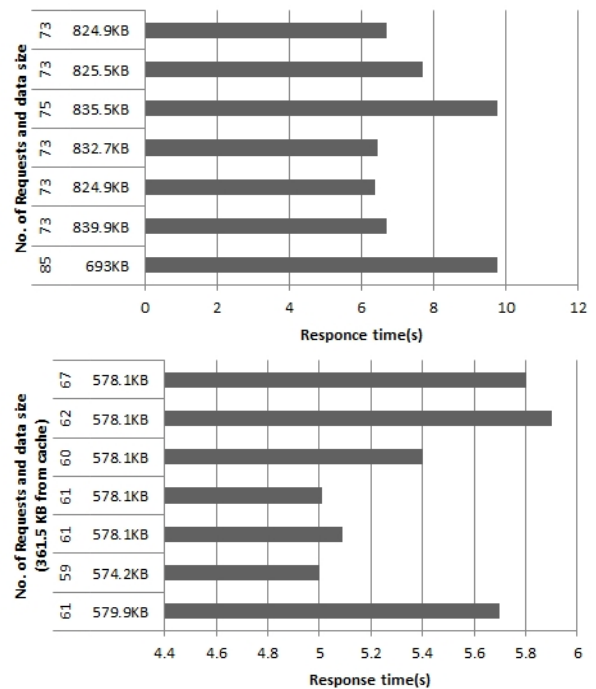

Figure 7: Response time for loading of SILKSWebGIS module (a-top) without and (b-bottom) with caching

Case-IV: Map data request
Requesting a map to the server involves series of steps such as, (a) the establishing of map data connection with the PostgreSQL database server; (b) executing query based on the extent of the map; (c) adding

symbology and other styling as per definition in the mapserver mapfile and (d) rendering the map image on the browser based on its template. Because of these steps, the number of total request sent to the server and size of data is large. Here, caching is important and must for users with systems having low/medium network bandwidth who frequently access the SILKS webGIS module.

Figure 8 shows response time for loading of map data requestwith and without caching and with caching.

With caching, the data size and number of request drastically reduces, which then facilitate for quick and efficient delivery of maps and hence lesser response times.

As observed from different analysis for various stages in the SILKS, caching is primary important for those active users who frequently access and interacts with the maps, use the application for longer durations and does map analysis. The homepage screenshot of SILKS district portal showing potential suitability sites along with major non-spatial modules is shown in Figure 9.

The SILKS follows robust web application architecture and has inbuilt necessary web components for management and effective dissemination of large volume of geospatial database on web for sericulture planning and expansion activities. Analysis carried outreveals the acceptable response time (Barber, 2005) for
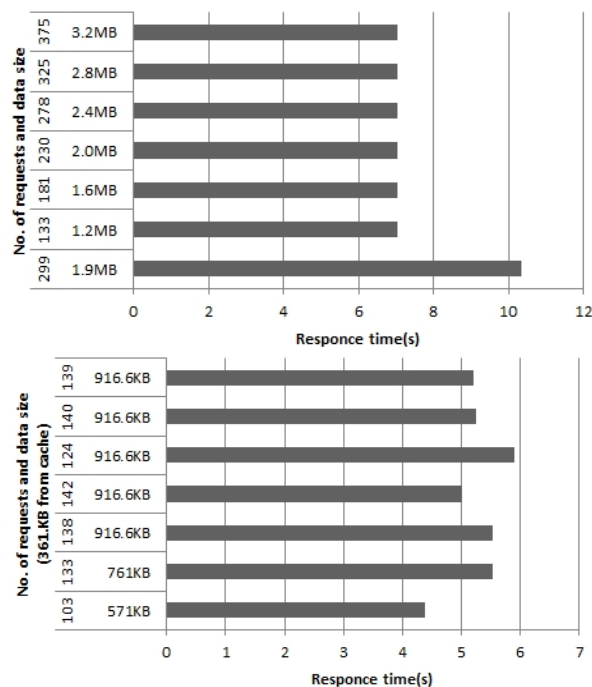

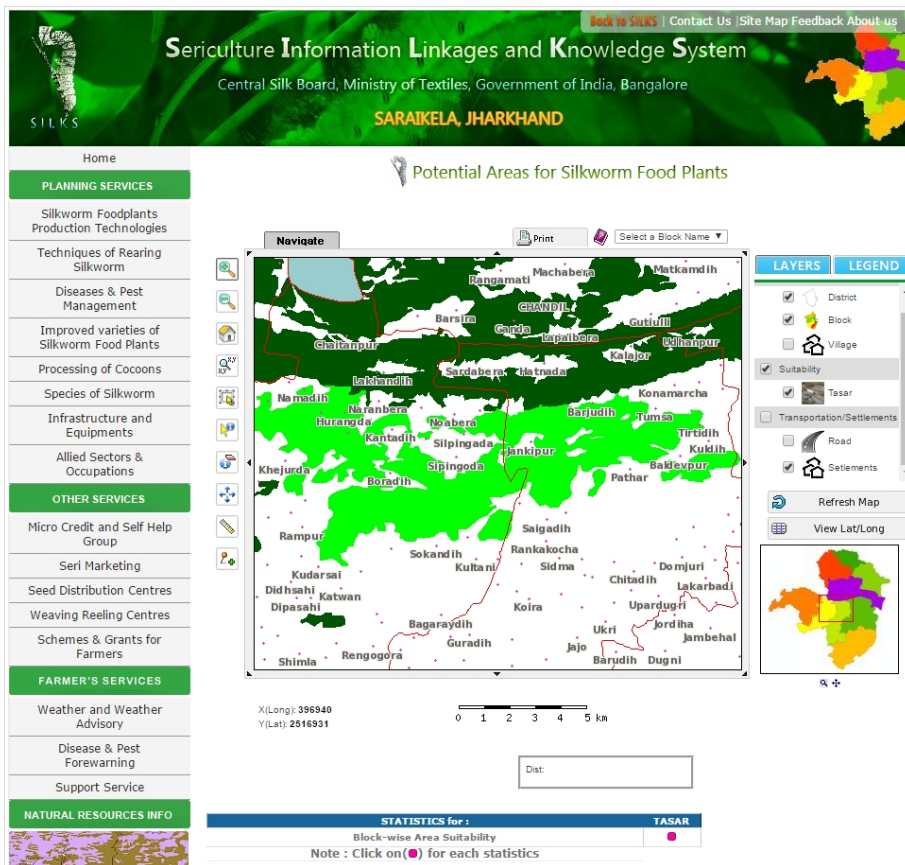**Figure 8: Response time for loading ofmap data request (a - top) without and (b - bottom) with caching**

Figure 9: SILKS portal for Saraikeladistrict, Jharkhand
(**Source** : http://silks.csb.gov.in/saraikela/potential-sites-for-silkworm-food-plants/)

data of different sizes and varying requests. Prior storage of pre-cached data will significantly reduce the required number of request made to the server and overall data volume fetched. This way, SILKS can run faster with fewer consumption of network bandwidth.

The current SILKS server system is based on traditional web model. The overall system performance could be enhanced through the use of multiple map server clusters and load balance scheduler (Guo, 2012). The entire framework including components of SILKS can further be upgraded as per new OGC standards and technologies (OGC, 2016) to support additional data services and tools, fast map rendering, more interactive and user friendly interface etc.

Within a span of about 3 years, SILKS portal has recorded more than 28500 hits reflecting its wide use through internet. A case study made by Central Silk Board in NE region reveals that potential areas identified for sericulture development has been found to be quite helpful by different stakeholders and providing support for development of sericulture in the region. An additional area expansion of about 8500 ha of food plants has been reported since 2013. Efforts are being made to ensure regular updation of information in the geoportal. Each of the stakeholders of the sericulture sector needs to play an active role in utilizing the services of the portal.

4. Conclusions

The SILKS follows robust web application architecture and has inbuilt necessary web components for management and effective dissemination of large volume of geospatial database on web for sericulture planning and expansion activities. The current SILKS server system is based on traditional web model. Within a span of about 3 years, SILKS portal has recorded more than 28500 hits reflecting its wide use through internet.

Acknowledgements

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