Community based Open Source Geographical Classical Data Analysis

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Abstract*: *The traditional Geographical Information Systems (GIS) have to be migrated to the internet eventually much like every other software today. The article has explored ways of utilizing the Open Geospatial Consortium (OGC) standards to come up with ways of achieving a workflow for the development of a service-based implementation of a customized Web Processing Service (WPS). The proposed concept has explored multiple workflows using various combinations of the publishing and development options and the simplest and the least resource intensive one has been identified as the outcome of this project. The workflow identified was then split into two section to make it even more simplify and adaptable, aiding development from the WPS that has to publish. The development process used for the final workflow is done without the use of a resource intensive IDE keeping in mind the major aim of the proposed model is to reduce the dependency on resource intensive software and services. The proposed model is built solely on open source platforms which are in tandem with second stipulation of proposed model is promoting community-based development. The proposed system provides the better execution time and retrieval time. The execution time is compared with similar system, open source Geographical system provide less execution time. The retrieval time is also reduced this indicated Quality of Service is increased.

Index Terms*: *Data Collection, Geographical Information System, Open Source, Road Map Analysis, Web Processing Service, Workflow.

I. INTRODUCTION

This model is tested multiple methods for development of a WPS using geotools which is a java library that was used for creating the project. Some functionality were used from the 520 North community archives, additionally future component is planned where in 520 North WPS clients will be used to give a WPS service in place of the WPS builder. 520 North WPS clients act as the go between framework for processing over an in-house or a third-party server. The objective of this project was to find a simplistic workflow for development of a WPS as well as publishing it as a service. The need for WPS in GIS is gaining importance due to the advent of cloud-based services as well as distributed computing. This is important as it brings along with it the promise easier collaboration as well as faster and unrestricted development options. This system however is bound to give rise to heterogeneity in the type of data that the system can process and to handle that the GeoServer has been employed [1]. Open source technology is gaining great popularity as more and more organizations are adopting it due to the multitude of benefits that it carries, it is becoming a part of the computing strategy. The proposed system workflow is modeled keeping in mind that the system will utilize only open source resources for the implementation of the workflow. The various components are gone into the implementation of the workflow [2]. GeoServer is developed on java as a software server which plays a major role in permitting the user to work on the server just as they would work on a desktop based GIS. Majorly designed with the characteristics of interoperability, it publishes the data using open standards and the source of data can be from any major spatial data source. Geoserver has developed as a method for simpler publishing as well as visualizing geospatial data, enabling the user to view complex shapefiles over the server. What makes it possible for GeoServer to have a request and response model as specified under the OGC, is that it uses the Spring Framework. This enables the system to give the users an API built on the spring-mvc-framework; in case of the GeoServer the API is a REST API [3]. GeoServer provides capabilities that allow for development of large number of functionalities one such is the WPS request builder is an extension that enables the developed WPS to be executed. To do this the administrator interface is used and under the demo uses the builder can be found for the same. The builder is used to demonstrate processes, and construct the examples of the given requirement. For using the request builder, the selection box appears with listing of all the available process additionally there are two buttons one of which is to submit the requests of the WPS requests and the second one displays the POST request looks like when used, these are the functionalities WPS Request Builder primarily. Dependence on the input and process selected leads to the change in display [4]. Apache maven was developed in order to help in packaging JAVA projects into project jar files, essentially serving as extremely effective project management. In development maven contributes by allowing seamless integration external packages and libraries. This is done by tapping into maven repositories while development of services, the external resources used in the artifact that are not available in the local repository are automatically downloaded, configured and integrated by either an integrated development environment (IDE) or can be done through systems command like

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"mvn clean install". The latter creates a snapshot of the java project and this can now be accessed like any other java library as it is in the form of a jar files. Maven is integral in the development of the Algorithm of a custom WPS and the POM file is later a very useful tool to get the algorithm online, however by using 52o North we can do the entire process without a POM file and all that is needed is a code made using the 52o North library functions [5]

II. RELATED WORK

The GIS based systems that are available are mostly proprietary or are desktop based this causes an issue given that the modern development and even consumption environment has been gravitating towards a service based open sourced solution for most of the major products [6]. So, it would be a smart move to expedite this process, however is not an easy process. Due to the complicity of a GIS in terms of the way the data is stored to the way it is processed and displayed, the migration to a full-fledged web GIS can be a cumbersome task. Hence to make a workflow that can be used as a simple way of developing a WPS and then publishing it has to be made the project deals with creation of such a workflow [7]. Additionally, to handle the data heterogeneity as well as the issues pertaining to visually presenting it is also dealt with as a part of the project. The major outcome of the proposed system is to identify a workflow that can aptly fulfill the aforementioned requirements in the simplest possible way while using open source components to do it. This GIS is also used in smart city device to manage device location [8]. Handling larger GIS data is facing data storage problem, these kinds of problems to solve MLEwCE algorithm [9]. This data is stored in cloud server, online cloud data storage is also facing scheduling problem, this problem is to solve backfilling algorithm [10].

III. PROPOSED METHODOLOGY

The system workflow has been kept minimalistic; also the workflow is entirely implemented on open source platforms. The implementation is been done is stages and the stages include the data publication and the data processing phase. For both the stages the system relies a lot on the GeoServer in terms of backend support as the server provides an environment that can be used to carry out various actions that let users work on various GIS features. For instance, the user may use the map service and then publish a service of a map application alternatively the publishing of maps graphical form is also possible [11]. This can effectively convert a shapefile to an image file, or any other convenient format that one needs without the use of any traditional desktop software like ArcGIS or QGIS. This feature added to the availability of features like WPS build makes the GeoServer apt for the workflow [12]. So, the initial setup of the project begins with the configuration of the GeoServer, this is a simple process for which three components are needed namely the Apache Tomcat, GeoServer and the WPS extension for the GeoServer that is available in the archives of the Open Source Geospatial Foundation [13]. The three need to be configured in the order in which they are mentioned previously. The major step after downloading them is installing tomcat. Once that is done the GeoServer needs to be installed and configured to the tomcat port, put this in the webapps provided with all the GeoServer distributions must be copied to the directory of the webapps in the tomcat webapps folder. Post this directory must be created that will serve as the data directory for the GeoServer. The WPS libraries need to be now added to the collection of libraries that are packaged with the currently installed version of the GeoServer [14]. This process completes the server setup and at this point the GeoServer is ready to publish shapefiles and view them in the standardized formats [15]. The system wishes to remove heterogeneity of data and for this reasons the system requires the users to publish the data, instead to allowing it to be used directly from the data directory. This is to ensure that no form of data heterogeneity sneaks into the system, this kind of data is facing some security issues [16]. The modern device is use finger print security solutions [17]. The digital device is dealing with card less payment method like as NFC technology [18]. Essentially a workflow is a set of tasks that are ordered in a predefined sequence of processes, as well as the individuals using them. Every workflow is used as a way of achieving a specific goal, the basic premise of using a workflow to model the process is to simplify a process. In effect a workflow helps retaining the process-oriented fundamentals in an environment of object-oriented development by integrating the high-level and low-level designs into a singular model called a workflow [19]. This workflow-based development process has of late been more readily adopted as scientific workflows [20]. Due to the advent of the service based architecture workflow have gained popularity in the scientific arena, to the extent that now the scientific workflows have become a fairly standard practice with taverna being a shining example of the same. For the purpose of proposed workflow, the project has employed the Business Process Modelling Notation (BPMN). This choice has been made after analysis of the system requirements and the project constraints. The workflow itself is modelled using the Camunda Modeler, the reason for choosing this modeler over the rest is because it is open source as well as easy to use. Additionally, the modeler has a direct XML conversion tool for the workflow. So, in essence the modeler provided the BPEL equivalent of the visual representation of the workflow. BPMN provides a certain set of features that in the case of the project fit perfectly for the creation of the model for implementation. The system was envisioned to be one that could in time over the years with the help of a community of developers come up with functionalities that would dwarf the established software products like the ArcGIS and the GRASS GIS. The system has been implemented using GeoServer which allows for other to easily adapt it to their requirements as it is easy to tailor to the needs of individual users which also add to the list of its merits. From the given workflow, it explains about the how the process is selected according to the process requested and then the result generation take place with validation of it which is split into two parts- storing of result and rejection of output with a display error and after the result is displayed, the whole process is terminated as the final step.

This workflow makes it possible for the WPS to process data and display outputs. The figure 2 is explains the process of uploading and publishing of data in GeoServer which is done with adding data to new stores and then the data file uploading request is sent to the server which helps in data upload with particular configuration and ends with publishing of the data according to configuration and terminating the whole process. The above two in tandem form what can be considered the architecture of the system if it were being analyzed according to a traditional software engineering model for development.

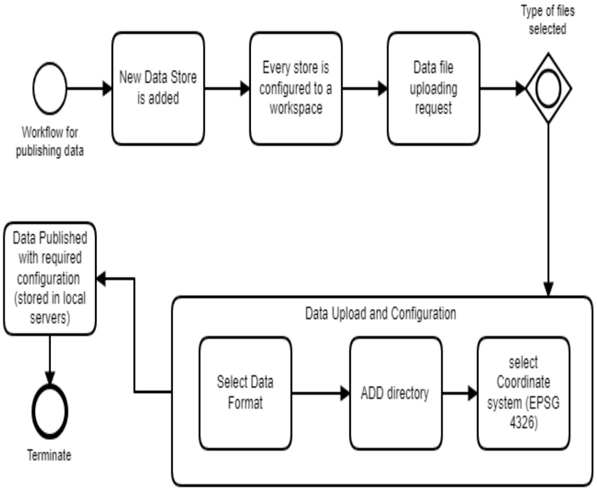

Type of files selected
Workflow for publishing data
New Data Store is added
Every store is configured to a workspace
Data file uploading request
Data Published with required configuration (stored in local servers)
Data Upload and Configuration
Select Data Format
ADD directory
select Coordinate system (EPSG 4326)
Terminate

Figure.1 WPS functional workflow Model

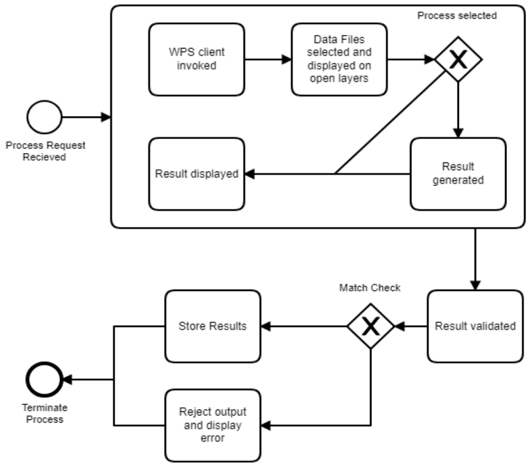


Figure.2 Workflow for publishing Model

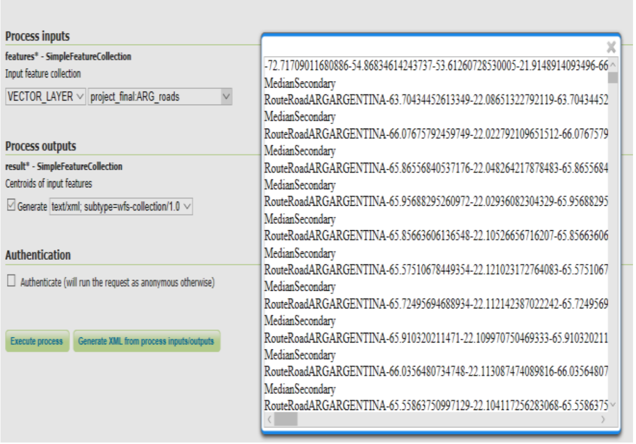
The Camunda modeling process enables use of sub process in the modeling phase itself; this makes the initial design phase itself more object oriented as compared to the other methods of modeling. This process also ensures that the workflow modular, enabling scaling up of the model without much effort which would mean from the street view strait up till the global views. This also makes it more apt to be used with GIS solutions as well as with public utility management system that involve monitoring all components form the street view till the state or national views. In case a GIS based tool, a local portal is created for users, the system falls completely in the purview of the BPMN modeling and no additional high-level view of it is needed. There are growing community based softwares that are allow modeling in the BPMN format this makes it possible to implement the model in an open source environment as well. WPS, WFS, WMS among other SOA based tools can also be integrated for the dashboard processes and if this done using open source GIS features and tools the BPMN model is the best suited to the making a model that will easily incorporate the modifications brought about such additions.

IV. RESULT AND DISCUSSION

The major decision is the choice between possible system implementations that can deliver the system requirement. After much analysis of the subject there were three major contenders for the model and they are given as follows.

WPS plugin builder on Quantum GIS, It is the QGIS is an open source desktop based GIS software tool that has come up a popular alternative to ArcGIS and GRASS GIS, it comes with the plugin builder option that can be used to develop WPS service by setting up the plugin builder. This implementation needs the QGIS to interface with the WPS client over a server, after the server connection is made the WPS services can be accessed. After the setup and configurations are made the user can access the predefined as well as custom made WPS that are uploaded to the server and the process is executed by QGIS, the output can be viewed directly on the QGIS output prompt. This allows the configuration of multiple servers that can run a WPS for the user, the issue with this system is that QGIS is considerably more difficulty to us and the has a labeling interface that is fairly complicated. Which is why is not considered for the implementation of the workflow of the project. WPS request builder on GeoServer, It is the WPS request builder is a demo feature that GeoServer has rolled out with the GeoServer 2.4, this has enabled the developers to create project in java using various maven repositories and then using the clean build command package it into a jar file that can be directly pasted in to the lib section in the GeoServer server webapp directory. On the next server restart the WPS is added to the WPS request builder and the functionality can be access after the GeoServer login through the demo builder feature. This is the method that has been chosen of the implementation of the workflow for the simple reason that amongst the three it is only one that allows the development of a fully-fledged web based GIS and is thereby the only method that meets the goals of the project. Additionally, it must be observed that this implementation is the simplest due to the lack of external dependences on external software like the QGIS. Framework based on WAMP and Q GIS, it is the WAMP based framework would entail the use of a three tiered architecture that would use WAMP in combination with ALOV to form the logic tire while the presentation tier would be made by the user of various PHP scripts and the data layer or tire would in turn use a Relational DataBase Management System (RDBMS) like PostgreSQL or MySQL. On close inspection PostgreSQL would be a more suitable choice at is lends some spatial support in the form of the PostGIS which is a tailor-made database extension for the PostgreSQL and allows the queries to cater to the needs to geospatial data.

Thus, it would be the preferred RDBMS for a system such as the one the project wishes to emulate. However this implementation would not be able to fulfill all the system requirements as without the JSP that can be used when using the Apache Tomcat the system will not be able to directly implement the entire GIS and due to this the Tomcat based implementation has been picked for the implementation of the workflow. The figure 3 is an output of the buffer feature collection WPS on a sample data set obtained from WorldMap, which is developed by the Center for Geographic Analysis at Harvard University. This is how WPS outputs look like if they are generated in the Web Feature Service (WFS) format, which is another OGC standard. Similar WPS can be developed and they can be employed by analysis and processing of geospatial data over the web by the use of workflows like this one.



Process inputs

features* - SimpleFeatureCollection

Input feature collection

VECTOR_LAYER project_final:ARG_roads

Process outputs

result* - SimpleFeatureCollection

Centroids of input features

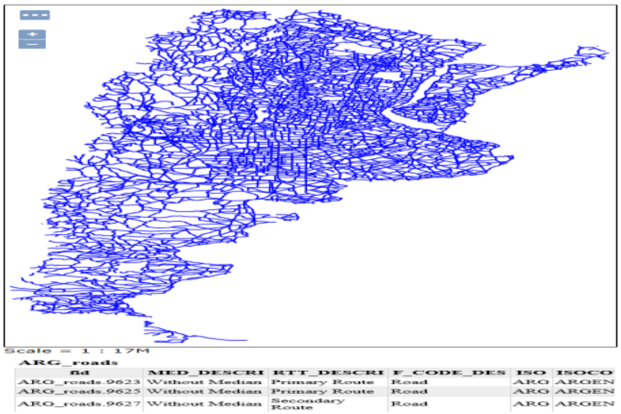
☑ Generate text/xml; subtype=wfs-collection/1.0

Authentication

□ Authenticate (will run the request as anonymous otherwise)

```
-72.71709011680886-54.86834614243737-53.61260728530005-21.9148914093496-66
MedianSecondary
RouteRoadARGARGENTINA-63.70434452613349-22.08651322792119-63.70434452
MedianSecondary
RouteRoadARGARGENTINA-66.07675792459749-22.022792109651512-66.0767579
MedianSecondary
RouteRoadARGARGENTINA-65.86556840537176-22.048264217878483-65.8655684
MedianSecondary
RouteRoadARGARGENTINA-65.95688295260972-22.02936082304329-65.95688295
MedianSecondary
RouteRoadARGARGENTINA-65.85663606136548-22.10526656716207-65.85663606
MedianSecondary
RouteRoadARGARGENTINA-65.57510678449354-22.121023172764083-65.5751067
MedianSecondary
RouteRoadARGARGENTINA-65.72495694688934-22.112142387022242-65.7249569
MedianSecondary
RouteRoadARGARGENTINA-65.910320211471-22.109970750469333-65.910320211
MedianSecondary
RouteRoadARGARGENTINA-66.0356480734748-22.113087474089816-66.03564807
MedianSecondary
RouteRoadARGARGENTINA-65.55863750997129-22.104117256283068-65.5586375
```

Figure.3 WPS Sample Data Collection



ARG_roads

fid	MED_DESCRI	RTT_DESCRI	F_CODE_DES	ISO	ISOCO
ARG_roads.9623	Without Median	Primary Route	Road	ARG	ARGEN
ARG_roads.9625	Without Median	Primary Route	Road	ARG	ARGEN
ARG_roads.9627	Without Median	Secondary Route	Road	ARG	ARGEN

Figure.4 Repository of Roads and Classical Geographical Analysis

This workflow is apt for a local server based implementation, however it can be adapted to the requirements of a larger organization or a community. The other part of the workflow is publishing the data to GeoServer, thereby lending it a certain level of homogeneity as it possible to convert this data to multiple formats. The GeoServer makes it possible for the data to be converted to the formats that are visible above this makes it a unique system that can help the interfacing of multiple application for various users simultaneously. The GeoServer also allows the creation of users on the server with different roles, additionally the roles in themselves may not be restrictive the administrator of the server can define new rules that match up to the requirement of the system. The figure 4 is obtained for a free repository of roads and for classical geographical analysis of this kind of data it would need for a researcher to install and learn how to use a desktop based GIS application or system. The proposed system will however allow the user to publish the data or have an administrator of the server publish it and the user can then directly use the GeoServer "Layer Preview" option to view the file in any format that is needed. The use OpenLayer also allows for browser-based retrieval of the data associated to the visual data of the spatial files, so the point data can be displayed on clicking the associated visual data. The comparative analysis made against a few identified systems has rated the system as is described in the following comparative performance analysis.

Table 1. Retrieval Time Comparison

	Indian_ Water (ms)	ARG_ ROADS (ms)	Rus_ Rail (ms)	AUS_ ADMIN (ms)
QGIS	9.8	11.6	11.8	10.2
SAGA GIS	13.2	14.2	14.8	13.8
Proposed System	12.2	11.4	12.2	11.2

The figure 5 datasets used has been taken from the DIVA-GIS open repository of country wise data, the analysis goes on to show that the proposed system can compete with the preexisting desktop-based systems.

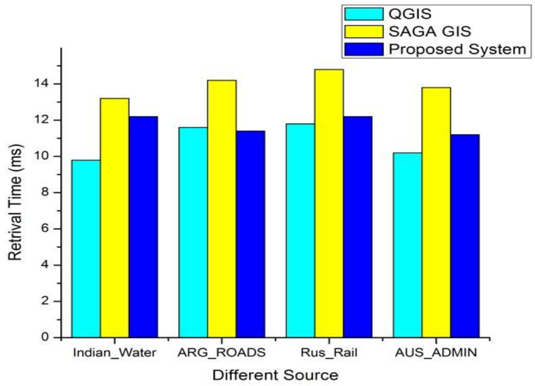


Figure.5 Retrieval Time Analysis

Table 2. Execution Time Comparison

	Indian_ Water (ms)	ARG_ ROADS (ms)	Rus_ Rail (ms)	AUS_ ADMIN (ms)
QGIS	7.6	8	8.2	7.4
SAGA GIS	8.2	8.6	8.6	8.2
Proposed System	8	8.4	8.6	8.2

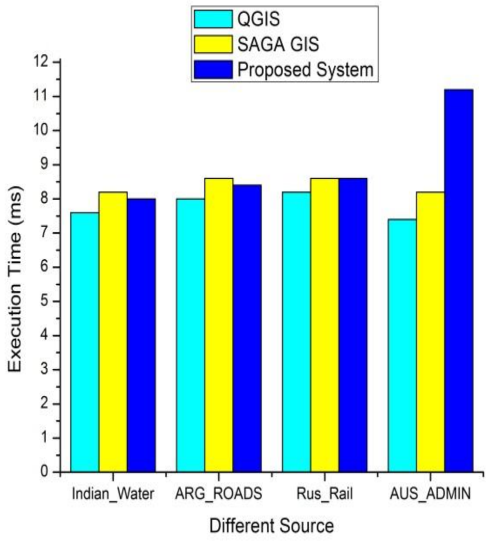


Figure.6 Execution Time Analysis

The figure 6 is another testament to the impressive performance of the proposed system. The systems have been tested five times per dataset and the average of the results has been taken for the plot in both the aforementioned graphs. The above two tests indicate that the proposed system even in its infancy is competent enough to compete with the traditional GIS tools. Additionally a third parameter namely system memory is also used for the comparisons.

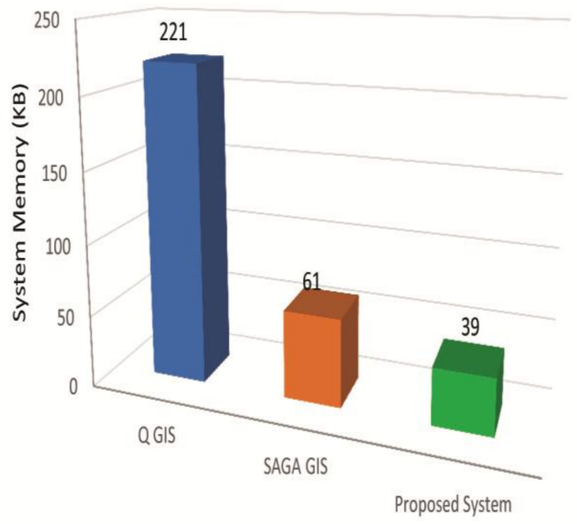


Figure.7 Shared Memory Analysis

Table 3. Shared Memory Comparison

	System Memory (Mb)
Q GIS	221 MB
SAGA GIS	61 MB
Proposed System	39 MB

The figure 7 parameter used for the comparison of our system with the desktop GIS, in perspective of the user is the system memory. The proposed system here outdoes the other systems due to a browser-based implementation and the user system is not as burdened. Additionally, there can be further improvements in the proposed system as is discussed in the later section of the paper to improve the performance of the system.

V. CONCLUSION

The proposed method is successfully tested the workflow for publishing and using WPS over GeoSercer additionally the project has also demonstrated that data standardization can be done by publishing data to the GeoServer before processing. The proposed system has tested GeoServer to be a successful way of ensuring interoperability for this workflow as it allows the data to be converted to multiple files which allows it to be used elsewhere in whatever format is needed. The proposed method has identified the Apache Tomcat in combination with GeoServer to be the most effective workflow for the creation of a full-fledged GIS system that can successfully compete with any desktop based GIS. .

VI. FUTURE SCOPE

The workflow in itself is a fairly refined one and while all workflows can be refined, the major change is needed in the way the WPS is used by the end user. The WPS request builder is a good tool however is not as intuitive and user friendly as one would like a GIS tool to be, so the system can be improved by adding a WPS client like the 520 North WPS client that would by and large make the user experience better and the developer experience easier. The system also has little to no control on the WPS overwhelming the server it is running on and there needs to be additional functionalities put in to prevent the system from overloading. One of the available solutions to this problem is to change the GeoServer configuration under the WPS security options, but this is not a very efficient solution. So, by adding new constraints like limiting the size of the input or by finding new stopping conditions that optimize the resource consumption of a WPS the system resources may be conserved and the system overload prevented.

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