A FRAMEWORK FOR UBIQUITOUS GEOSPATIAL INFORMATION INTEGRATION ON MOBILE DEVICE USING ORCHESTRATION OF GEOSERVICES

Arindam Dasgupta and S. K. Ghosh

School of Information Technology, Indian Institute of Technology, Kharagpur, India
adgkgp@gmail.com, skg@iitkgp.ac.in

ABSTRACT

Geospatial information is one of the essential information in our daily life for any type of decision making especially in emergency situation. But most of the organizations collect geospatial data for their own purpose in a proprietary way. The current development of geospatial information services emphasis on accessing and sharing geospatial data from the diverse data repository. Since the amount of geospatial data is large, distributed, and heterogeneous in nature and needs distributed computation for the generation of information, then it is impossible to get the required information in a single click. The integration these geospatial data repositories in an interoperable way and processing of those information will provide the ubiquitous access to geospatial information. The main focus of this paper is to develop a framework which could provide the user specific geospatial information at any location by processing of heterogeneous data from the diverse geospatial repositories. The framework utilizes geospatial web services of open Geospatial Consortium (OGC) standards to integrate the diverse data repositories in an interoperable manner. An orchestration engine has been adopted to incorporate business logic for chaining of data and processing services to generate user specific geospatial information. Two case studies have been presented to realize the orchestration of geospatial webservices.

KEYWORDS

Geo spatial web services, interoperability, service orchestration, service chaining

1. INTRODUCTION

The current development of geospatial information services emphasis on accessing and sharing geospatial data from the diverse data repository. Moreover, extracting geoinformation from web-based geodata is an important issue for applications in which decision makers have to integrate multiple sources to answer questions regarding a geospatial context. Most of the spatial data infrastructure involved in the retrieval and visualization of data through web services. It acts as a provider of large collection of distributed geospatial data inventories [1]. But accessing of geospatial data from that infrastructure and visualized it in form of geospatial map is not sufficient to provide valuable information in many situations. Moreover, to get user specific information, it is required to access different geospatial data repositories and then to processes those data through different stand alone applications. The user has to involve in processing of those data to generate information through the use of proprietary applications at client side. As computing power and network capabilities are improving gradually, processing of distributed spatial data towards information becomes one of essential features to fill up the deficiency of spatial data infrastructure.

Since the amount of geospatial data is large, heterogeneous in nature and needs more complex calculations for the generation of information, the generation of user specific information is impossible in a single click. Moreover, most of the geospatial information is needed, when the people are in move. This problem can be overcome by providing the geospatial information in the mobile device of user. But low resource capability of mobile devices prevents to create user

DOI : 10.5121/iju.2010.1306

specific information by processing the data at client side. To establish a processing service component between the client and the data service provider, it is possible to provide geospatial information in mobile device environment.

Such component has to be able to access globally distributed data and to provide the information in line with the already available standards. OGC proposed a standard for the Web Processing Service (WPS) specification as a discussion paper [2]. The processing service provides an interface through which different geo processing functions can be offered. According to the OGC, the WPS provides a platform which could access across the network to utilize pre-programmed computation model that operate on spatially referenced data. But this pre-programmed computation model does not provide user specific information in many situation. The idea is that this new OGC Web Service (OWS) shall act as a framework for integrating a variety of geo processing algorithms into a service-oriented-architecture (SOA) [3].By utilizing the service metadata capabilities and logical integration of geospatial services through the service orchestration engine it is possible to develop dynamic geo service chaining to provide user specific information.

2. RELATED WORKS

Geospatial information becomes most essential entity to the practice of decision makers. It helps decision-makers to manage their assets better, enables instant responses for time-sensitive decision making and improves the communication process across diverse agencies. M. Lutza et al. describes two types of problem which restrict to share and access of geospatial data from the diverse organizations [4]. One of them is non-interoperable geospatial processing systems which prevents sharing geospatial data. Another problem is insufficient message exchange patterns which restrict access to geospatial information. Geospatial interoperability faces types of problems which are syntactic heterogeneity and semantic heterogeneity. Alonso et al. analyses that the solution for providing interoperability among heterogeneous software systems in distributed and decentralized environments are web service technology [5]. The first steps in developing a Web service framework for heterogeneous environmental information systems are presented by L. Bernard et al. [6]. It uses the Web Service Framework, which allows users to create their own services by combining the existing ones. This framework uses a generic adapter which allows a technical encapsulation of different middleware technologies. To overcome the interoperability problem with geospatial data, Open Geospatial Consortium (OGC) has specified a framework of interoperable geospatial services [7].

The main goal of interoperable geospatial services is to establish a spatial data infrastructure (SDI). The SDI is used to facilitate and enable optimum utilization of distributed geospatial data by decision makers. Nebert et al. analyzed that it provides a platform for the optimization of the creation, maintenance and distribution of geographic information at different levels of organization and involving both public and private institutions [8]. Bernard et al. developed a research agenda for SDI in general [9]. The work outline the importance of granularity for GI processing, semantic aspects, organizational and implementation issues for SDI, economics of GI and differentiation of SDIs versus other information infrastructures.

The geospatial data provided by the SDI could be utilized to generate user specific geospatial information. Initial development of web-based geo processing services developed by major GIS companies. ESRI develop a product ArchInfo8.3 to provide the applications geo processing functionality to the ESRI client software [10]. But this geo processing service is proprietary such that only compatible client software is able to make use of the remote processing capabilities. OGC Web Processing Service (WPS) standards proposed an open source framework that offers a standard interface for GIS functionalities.

Kiehle et al. analyzed the drawbacks of web-based geoprocessing [11]. The work identifies that the lack of automatic service chaining capabilities for complex processes. This lack results from missing semantic capabilities in the process descriptions. Semantic descriptions would not only enable automated service chaining but also enable intelligent processing of data using for instance self-organizing nets.

Most recently in the business-to-business software domain, web services have achieved a wide acceptance. T. Andrews et al. identified that by using service composition technology with the use of BPEL an advanced architectural models of web services could be developed [12]. A similar process can be used in the mobile based software domain to access composite web services. A number of mobiles and PDAs consume simple Web Services today. The JSR- 172 provides a platform to access web services in mobile device environment on a Java Micro-Edition (J2ME) environment. M Gone et al. analyzed the use of BPEL in comparison to Web Services [13]. It states that current implementations of OGC services are some kind of hybrid Representational State Transfer (REST)-based services. Since BPEL requires SOAP services, so OGC services, which do not provide SOAP interfaces, need a wrapper, which acts as a proxy to the OGC services.

The orchestration of Web Services to complex processing chains is especially relevant for geospatial applications, since their complexity often requires the functionality of several geo processing services. These orchestrated sets of Web Services are often referred to as workflows or service chains. The suitability of the Web Service Orchestration (WSO) technology as a possible solution for disaster management scenarios has been evaluated by A Weiser [14]. It analyses and describes data format adaptation for OGC services with a proxy server acting as binary transcoding service. The proxy launches an OGC compliant request to the OGC service and receives the response from the service. Brauner et al. propose to use the Business Process Execution Language (BPEL) in combination with WSDL to execute such workflows [15].

3. OVERVIEW OF WEB PROCESSING SERVICES

Web processing Services provides any kind of predefined geo processing functionality which operates on spatially referenced data. The data and parameters required by the predefined processes may be provided by the client or accessed by the other geo spatial web services. These services may offer from simple calculation to complex computations into their web service interface. A geo processing server may offer multiple geo processing services through its web server interface. It also publishes their services to the common registry service. The main aim of the geo processing service is to process the geo referenced data from different spatial feature services at the processing server through the use of XML based communication protocol. Geo processing service provides an interface which specifies three mandatory operations that can be requested by the client. These operations are following.

- **GetCapabilities** – This operation allows a client to retrieve the metadata information and list the individual processes which are available on that server. The GetCapabilities response provides the name and general description of each process offered by the server.
- **DescribeProcess** – This operation allows a client to retrieve the detailed description of a particular process. It provides the information about any needed input parameters, their allowable formats, and the outputs. The input parameters domain may be simple data to complex GML file. Some of the input parameters may be induced from other services.

- **Execute** – This operation allows a client to execute a selected process which is implemented by the geo processing server. In response to the service an XML document is returned. The document may contain the output produced by the server or status information of the processing service. In this way, the client could get the status of the process.

4. PROPOSED FRAMEWORK FOR PROCESSED GEOSPATIAL INFORMATION FROM THE HETEROGENEOUS GEO DATA SOURCES

The main aim of the proposed architecture is to provide shared geo spatial information by logically integrating geospatial web data services. It provides a single entry point for access to derived geospatial information for complex decision making. In order to generate information from heterogeneous dataset, it is required to integrate the various sources of distributed data into an Enterprise GIS platform. The essential need of geospatial data is based on ubiquitous access of derived information for decision making. But the required information may not be directly delivered on the fly by accessing the spatial data services. To retrieve the essential information, the user has to download the relevant spatial data to the local server and apply the proper algorithms to process the download data to generate essential information. But this type of long methodology is not suitable while user is moving and also during emergency decision making. Because the limitations of resources constrained mobile devices restrict to download huge amount of geo spatial data and process those data through different preloaded algorithms to generate required information.

To overcome such type of problem some spatial system implements service chaining mechanism to generate information for spatial analysis. Since the chaining of services is predefined, such types of services are not flexible to resolve intended information in most of time. To realize web-based geoinformation, on the fly geo processing of distributed heterogeneous type data are essential. It allows accessing of geoinformation from anywhere and scaling the processing effort in a distributed way over the Web.

To provide flexible geo spatial information service, only spatial data infrastructure is not sufficient to provide ubiquitous information system to construct an Enterprise GIS. To establish a interactive Enterprise GIS system it is required to develop a spatial processing infrastructure. A separate Web processing services module has to be developed along spatial data services. Each service interface defines different atomic geoprocessing services which could be accessed by any type of client or other web services. At the backend of web processing server contains the library of required geoprocessing algorithms. Each processing service should be implemented as self describing and self organizing, so that, it can access supported spatial data from the relevant web feature service.

The focus of the proposed framework is to provide complex geo-processing services. Therefore, to access complex information, it is required to aggregate relevant processing services from the different locations. The interface of the processing services provides the technical possibilities of web services orchestration. The orchestration defines the way of creating business process by accessing relevant atomic web services in a logical manner. The accessing logic is implemented by a meta-language for business processes, called Business Process Execution Language (BPEL) standardized by W3C. The atomic processing services are selected and accessed in such a way, so the system can provide higher level complex processing services. WSDL is a standard for the description of processing service interface. The Orchestration Engine (OE) interacts with the relevant WSDL interfaces of to implement the business logic.

The Business Process Execution Language (BPEL) provides framework to develop an Orchestration Engine. But the use of BPEL in the OGC based geospatial web services for service orchestration lacks the WSDL documents. However, Stollberg et al. pointed out several problems in the use of BPEL together with OGC geo spatial web services, concerning such as communication protocols and the transfer of raw binary data [16] . OGC does not provide any documentation for composition of spatial web services to construct an Orchestration Engine as an alternative approach to BPEL standards. Moreover, the OGC web services do not support the Simple Object Oriented Protocol (SOAP) which is essential for orchestration of W3C based web services. OGC Web Services are REST based and support http GET and POST requests with key-value-pair or XML encoding of request parameters [17]. But W3C Web Services use SOAP and the interfaces are described via WSDL.

The proposed framework utilizes the standards of the OGC Web Processing Services to overcome the limitations of orchestration of OGC web services. In principle there are no restrictions on what can be implemented using the WPS interface. The specification primarily describes the concrete implementation of geo-processing methods and does not entirely exclude its use as an orchestration service. Therefore it is possible to use a WPS for aggregating participating OWS.

The orchestration of web services can be archived by use of flexible chaining of processing services. The chaining of processing services is done by feeding the output of a web service as input into another web service. By changing and manipulating the order of services different categories information could be generated. A web service configuration file is required to maintain order of accessing processing services for each complex geo processing services.

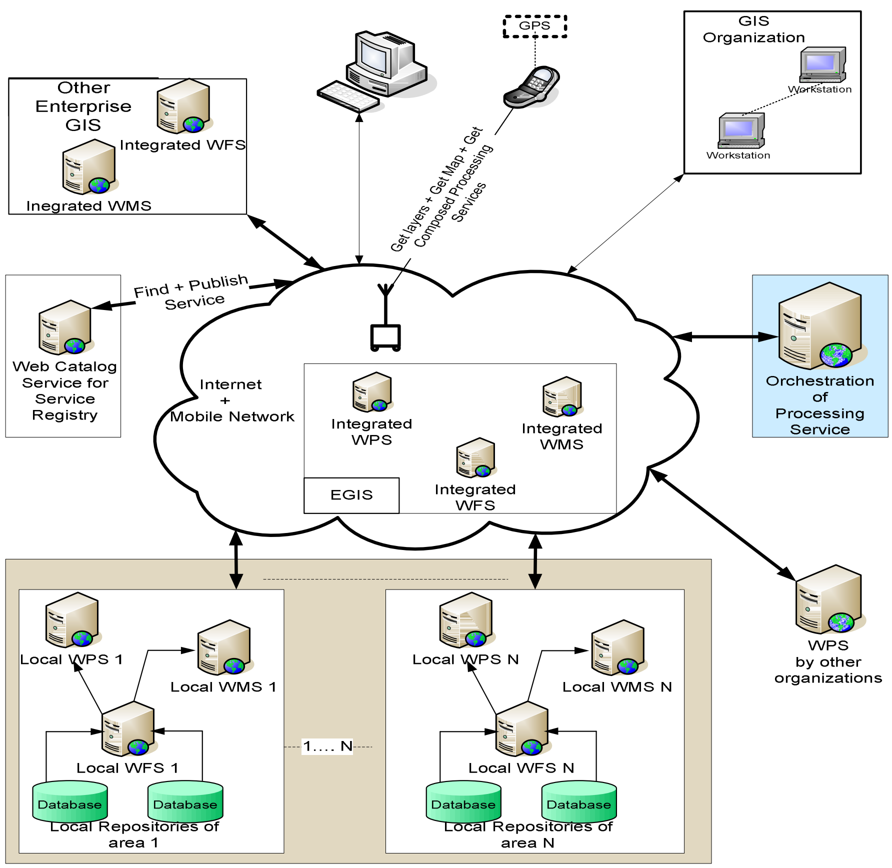

Figure 1. System architecture for processed information service

Considering the requirement of processed information in mobile device especially for emergency decision making, the proposed architecture as figure 1 is divided into following module.

4.1. Spatial data service

The local service providers would run a data service to provide the original data according to their proprietary format. Frequently, the heterogeneity of data source types makes difficult the reuse of algorithms that are tightly coupled with the specified file format, database vendor. The data repositories are located in the different regions and supervised and maintained by local private or public sectors. Since the size of geo spatial data are huge, it is difficult to convert and move. In order to provide uniform data services, a web feature service is implemented to retrieve data from local data repositories. With an intermediate layer between the user and the data source, a uniform loosely coupled data service can be provided. The intermediate layer has to be able to access any potential source type. As the current spatial data source types such as ESRI Shapefile, Spatial PostGis, Oracle Spatial is huge, complex and can grow indefinitely, so that, the user has to be able to extend the access capabilities of the layer. By introducing the concept of web feature service, the accessing of disparate spatial data repositories is possible any situation, even if the types of data sources are unknown.

4.2. Geospatial processing service

Accessing of geo spatial data, visualization of these data, ability to search for spatial data through the catalog service will not provide the desired information in many situations. However, sophisticated and recognized standards for distributed spatial data processing, leading to generate user specific information, are still missing. OGC recommends some processing service specification to take into account during development of standardized Web processing service interface . It may provide functionality of simple calculations to complex computations into its service interface. According processing service framework the web processing service module should be incorporated between data service and user of the processing service consumer as depicted in figure 2. In the way the data processing service will take a vital responsibility of any spatial data infrastructure (SDI). Since the SDI is capable of integrating several data sources of heterogeneous origin.

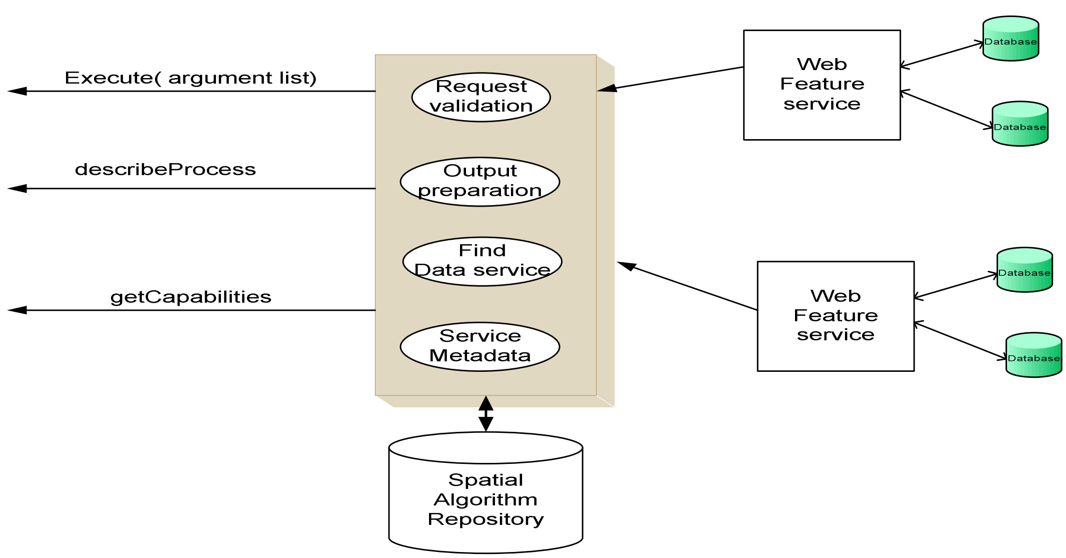

Figure 2. Framework of processing service module

The processing of geo spatial data is strictly based on defined geo processing algorithm. After getting the processing request, the processing server retrieves the data from the relevant data services and forwards in generated information to the user. The working principle of processing server is described in following steps.

Input: Spatial argument list in form of KVP(Key Value Pair) or XML request

Output : Generated geospatial information in XML format

STEP 1:	GetMessage()	//Get request Message from the user encapsulated with process name and corresponding arguments
STEP 2:	ValidateRequest()	
STEP 3:	IF Data Service not required THEN GOTO STEP 7	
STEP 4:	FindDataservice()	//Find Location of Data services from the Catalog services(CSW)
STEP 5:	Connect()	// Connect the Data services
STEP 6:	getFetures()	//Retrieve feature services to retrieve GML features
STEP 7:	ParseGML()	//Parse the GML Features to retrieve data corresponding to input arguments
STEP 8:	Process()	//Process the data with the stored algorithm according process name
STEP 9:	GenerateXMLoutput()	//Prepare the output in XML by generated information for mobile or other system
STEP 10:	DeleverResult()	

4.3. Catalog service

The catalog service offers other geospatial service to register their services along with service metadata. To manage large amount of data and processing service efficiently, the catalog service is needed. The web catalog service offers to register, search, and discover the relevant geospatial data and services to the other geospatial web services. According to this framework, the catalogue service contains metadata records of concerned processing service and data service. During processing of spatial data for generating information, this user will provide minimum amount of input data (such as road name to retrieve buffer region) to get the result. Most of the data are huge in amount and will be retrieved from different data services. To enhance the speed of delivering information, the Web Processing Service discovers the data description and the location of data services.

4.4. Orchestration of processing and data services

Orchestration is the mechanism of aggregation of web services in logical manner. It composes a set of web services and implements a logical sequence on those services. In this way it is possible to provide complex type information for critical analysis of geospatial data. Different complex problem can be solved by compositing and reusing of atomic services. According to user point view, the orchestration provides a single service by a abstracting underlying multiple spatial services. The orchestration of web services can be archived by chaining of the output of a web service as input into another web service and defining a logical rule of ordering of web service-interaction. Web services orchestration must be dynamic, flexible, and adaptable to modification of processing logic. The separation between the processing logic and the participating web services leads to promote the flexibility integration. An orchestration engine (OE) is required to be developed to achieve this separation. The OE handles the overall process flows, calling the appropriate Web services and executing the accessing logic to provide the exact information of the user. Finally, process designers must be able to compose higher-level services from existing orchestrated processes. Describing these processes through their Web service interfaces accomplishes the goal of geospatial web service composition.

The Orchestration Engine (OE) coordinates the interacting services involved, controlled by a configuration file containing chaining instructions in a certain description language. As an alternative to BPEL standards, a WPS framework is utilized to realize the geospatial Orchestration Engine. Although this approach may lead to contradict the actual utilization of OGC web processing service, but there is no restriction to provide the type functionality to define into the service interface. Since the main focus of the framework is to provide a logically integrated processing service, so that, it is possible to use a WPS for composing the OGC compliant geospatial web services. The composite processing service interface abstracts the participating atomic web services

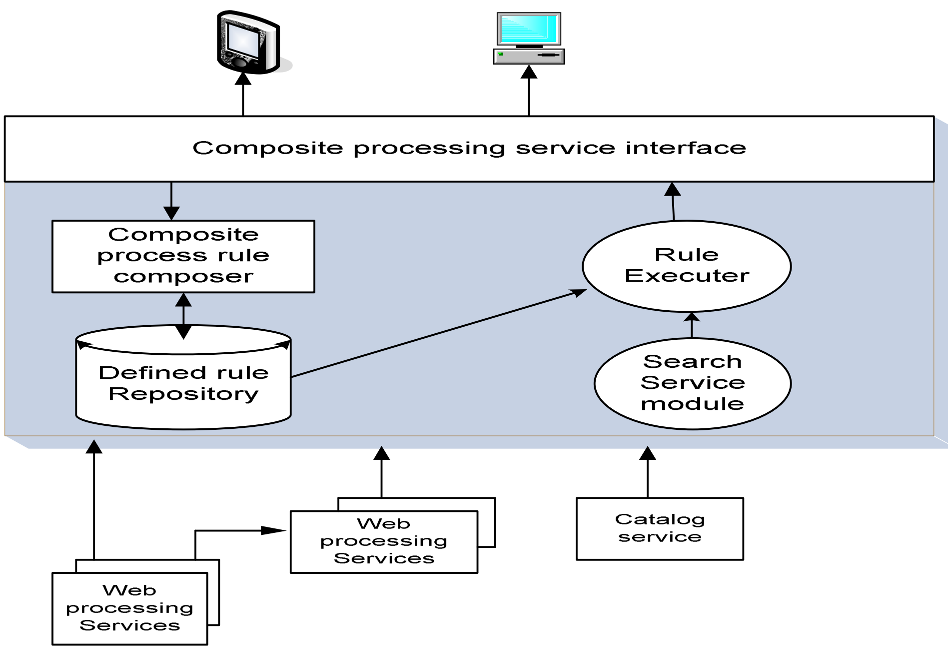

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Figure 3. Proposed Geospatial Service Orchestration Engine

To overcome the problem of service composition Figure 3 defines the framework of service composition. A user could access the composite geospatial information from the alternative service orchestration framework through a network. The composite service utility can be accessed any available processing service in order to process data.

To configure geospatial business logic a configuration has to be maintained within the orchestration engine. The sequence of business logic for a complex information generation the user could compose the logic sequence into the Composite process rule composer. Once the rule has been established, it can be reused in many situations. In this way, the processing potentiality of the Web Processing Service increased by utilizing flexible chaining of geospatial services. For example, the complex information can be derived from accessing Data from WFS1, process it through WPS1, and generates information by inserting input at WPS2 along with data of discoverable WFS. Then the rule this service composition will be defined according to figure 4.

Rule 1: ***Get data from WFS1***
Rule 2: ***Feed output of WFS1 to WPS1***
Rule 3: ***Find location of WFS with meta data from the Catalog service***
Rule 4: ***Feed the output of WPS1 and location of discovered WFS to the WPS2***
Rule 5: ***Deliver the result to the client***

Figure 4. Rules for generation of complex information

The XML format of figure 5 would generate after composing the above rules and stores it into the rule repository for further use. In the example, the composite process involves two feature services, two processing services and one catalog service. Each of these services provides their service independently. The sequence diagram of each transaction by the participating services is presented in the figure 6.

```
  <?xml version="1.0" encoding="UTF-8" ?>
<process>
 <sequence>
 <action name="WFS" Location="URL of WFS1" operation="getFeature with OGC
  filter">Feature Name</action>
<action name="WPS" Location="URL of WPS1" operation="Execute">
      <call>process4</call>
    </action>
   <action name="CSW" Location="URL of CSW" operation="Find">WFS2</action>
 <action name="WPS" Location="URL of WPS2" operation="Execute">
       <call>process8</call>
      </action>
  </sequence>
   </process>
```

Figure 5. Generated XML of defining rule for processes of transaction

The geospatial transaction activities may involve one or more types of input and some part of the input may be supplied from user and other part may be accessed from other services. According to predefined business logic, the processes are available through the network, thus allowing the reuse of the implementation. The user is enabled to define their own business processes by utilizing the rule composer for web services through the interface of Orchestration Engine. The rule engine is used as a central Business Process interpreting unit for generation of different complex information. The rule engine acts a mediator between client requests, geospatial data services, geospatial processing services and catalog services and co-ordinates the overall transaction logic to produce the user specific complex information.

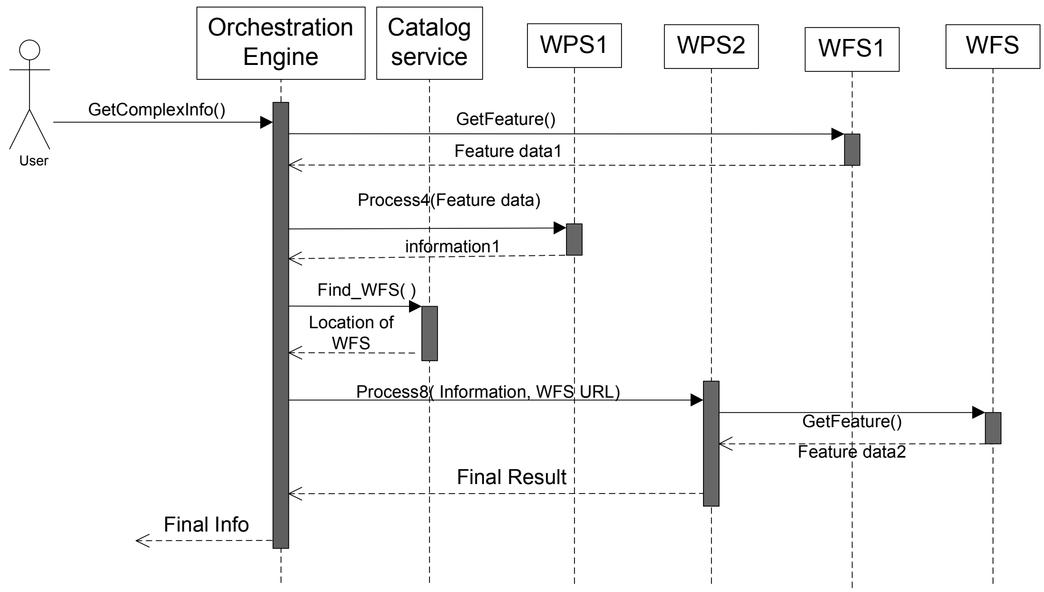

Figure 6. Sequential accessing of geo services for complex geo information

To standardized execution of Geo spatial Orchestration engine it is required to deploy a processing model through the standard service composition could be possible. To compose flexible service chaining it required to registrar all the participating service in the authorized catalog services which are recognized by processing service orchestration engine. For consistent operation of geo spatial service composition following procedure should be implemented.

STEP 1: *Initialize process of the Orchestration Engine.*
STEP 2: *Get the Input parameter of Composite process from client.*
STEP 3: *Check parameter and load the corresponding rule in form of XML.*
STEP 4: *Find the location of supporting data processing services and processing service from the catalog server.*
STEP 5 : *Access data server and processing server according to rule defined in the rule XML and continue the server accessing process until required information is generated.*
STEP 6: *Return result to the client.*

In the proposed framework, the huge amount of geospatial data transaction can be minimized by using sufficient amount of cascaded transaction. It is not always needed to transfer the data of a Web Feature Service to a Web Processing Service through the server of Orchestration Engine. Instead of providing data, the orchestration engine could provide location of WFS along with supporting parameters could be passed to the processing service. In this way a powerful, fastest and efficient services could be achieved.

5. DESIGN AND IMPLEMENTATION OF GEOSPATIAL SERVICE ORCHESTRATION FOR MOBILE DEVICE

In order to describe composition of OGC compliant geo spatial services a synthetic SDI environment is developed. The composition of different web services is tested by designing a distributed GIS environment including a WPS, WFS and WMS server and a client application for mobile device. To realize the system two case studies are carried out. The first case study is concerned with the calculation of effected area of road side water bodies when the road is expanded both sides to handle the road traffic problem. The second case study is carried to find out the shortest distance between two points on spatial map on mobile devices based on any parameter such as time, cost or road distance.

To realize the geo spatial service orchestration, the geo processing services are implemented in separate server as depicted in figure 7. Oracle 10g and Arch SDE are used as spatial data repositories. Two types of data repositories are used to realize the interoperability concept. All services interact with each other in interoperable manner. The sequence of service accessing is configured in a configuration file and access the chain of services from the composition server to provide the composite information.

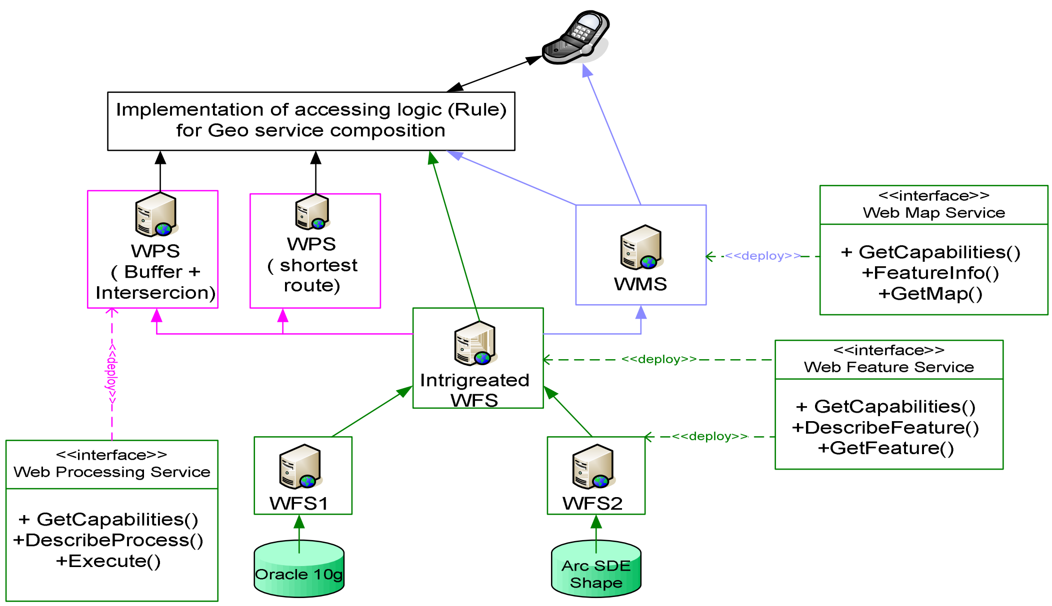

Figure 7 . Organization of composite services and realization of geo service orchestration

5.1. Case study1 - *Calculation of wastage area of water bodies due to expansion of road on the spatial map*

To demonstrate the generation complex information according to predefined business logic two diverse data source are considered. The water body feature is stored in the first data source in Arc SDE spatial format and the road feature is maintained in the oracle10g database. Both the databases are connected with their local web feature server to provide the GML response of Pond feature and Road feature.A Web processing server is developed in which two processing services are implemented. The first processing service generates the buffer geometry of any type of spatial features. If the GML of a spatial feature along with buffer distance is supplied as input to the processing service, then the GML of buffered area will be returned by the server. Another processing service is implemented in same server to for the intersection of two spatial themes. After the service receives an execute request with a reference to two GML datasets it generates the GML of intersect area. The processing service describes an interoperable processing service interface to hide the implementation of processing algorithm. To calculate the area of a polygon feature a process is implemented in the same processing service. It returns a GML file which contains area of all polygon geometry within a GML file as input.

A part of the service chain, namely the calculating the area of wastage of water body due to expansion of road is defined within the rule repository. The composite processing service activates all the related service defined in the rule of configured for calculation of area of wastage of water body and accesses according to defined logic to derive sensitive information. The sequence diagram is presented in the figure 8.

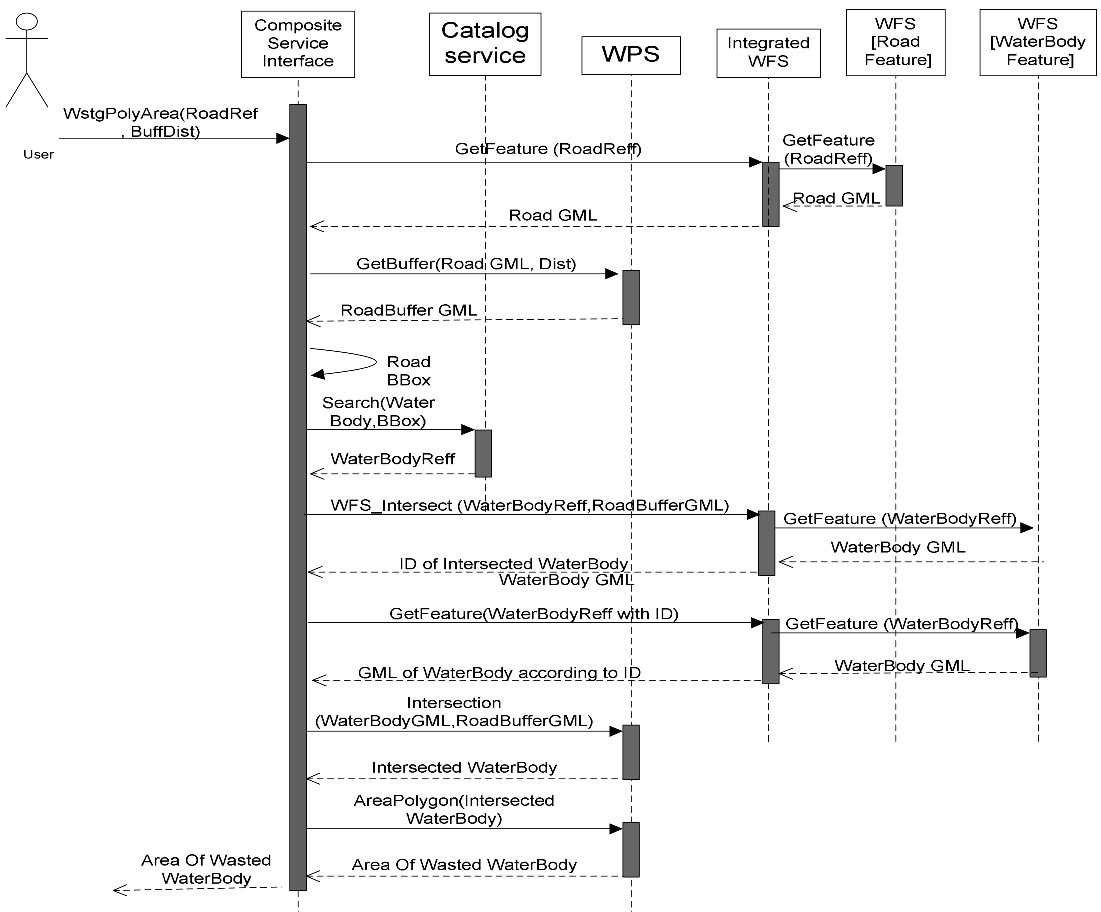

Figure 8. Sequence of calculation of wastage area of water bodies due to expansion of road on the spatial map

In the implementation, all the services are invoked from a single centralized processing service to realize the working principle of web service orchestration. This technique involves in redundant data transferring over the network. This can be improved by providing the requested data to the all recipient who are involved in the particular service chaining. The required data should be sent directly from the actual source, not through the composite service. The experiment results of each step for calculation of wastage area of water bodies. Each step is captured in form of geospatial map with a mobile device. In figure 9 shows the road network along with Water Body map accessing from the diverse data sources. To generate the buffer of the specified roads the GML of the road network has to be retrieved and passed to buffer generation process of the WPS. Therefore, a GML of buffer region of road will be returned. The figure 10 shows the buffer map which overlapped some part of adjacent water bodies of the road.

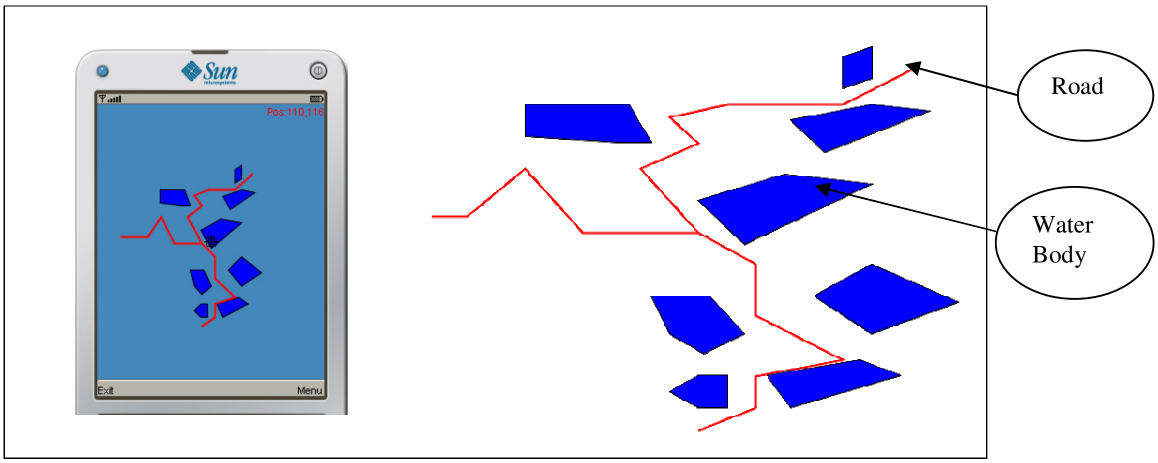

Figure 9. Visualization of Road and Water Body Map on mobile device

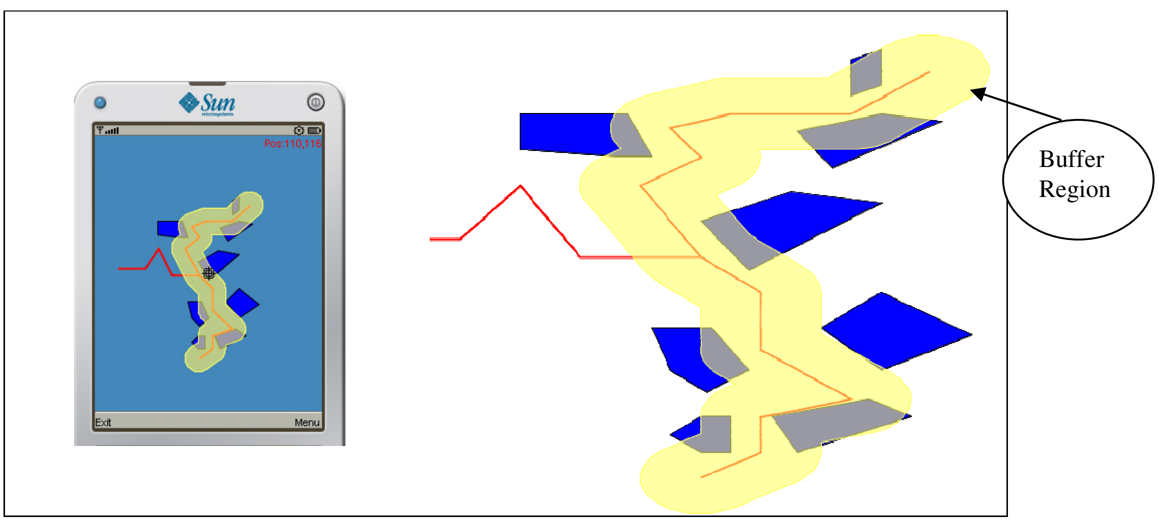

Figure 10. Generation of Buffer along with Road Map which overlap the adjacent Water Bodies

OGC Intersects operation is applied to find the ID of intersected water body with the buffer region. After getting the ID of overlapped water body, the GML of buffer region and the GML of overlapped water body are passed to the Intersection Processing service to find the GML of wastage water body. In figure 11 the intersected water bodies have been shown. The processing service generates a GML response which contains only the intersected polygons. Then the total area of the polygons is calculated to get total wastage of water body. Figure 12 shows the rest of water bodies after the expansion of the specified road.

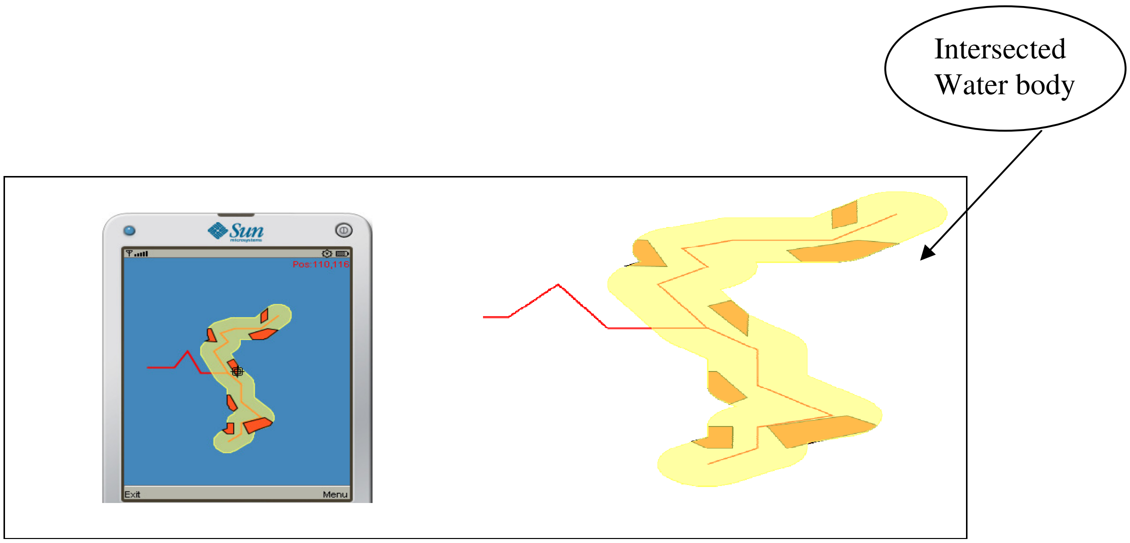

Figure 11. Intersected Water body overlapped by Buffer region

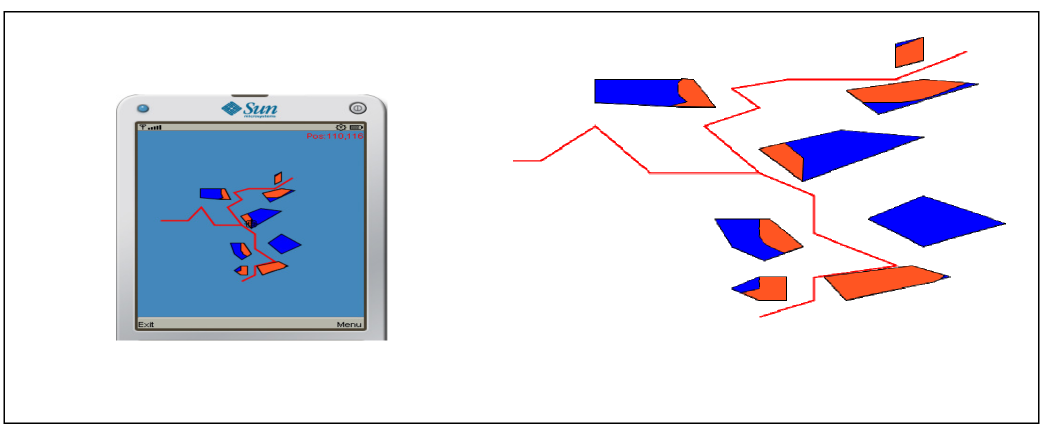

Figure 12. Geospatial map of wastage of Water Bodies due to road expansion

The web processing service interface provides a processing service which calculates the area of polygons in form of GML file as input. By using this processing service, the areas of intersected polygons are calculated and returns to the client. In table1, the results of the calculated area of each water body are shown. In this way the application serves a proof of concept which could produce complex information by accessing chain of data and processing services.

Table 1. Geospatial map of wastage of Water Bodies due to road expansion

Water Body ID	**Initial Area of Water Body**	**Area under Buffered region**	**Final Area of Water Body**
1	75.0	58.1999975	16.8000025
2	172.5	172.41706	0.08294
3	177.0	63.957591	113.042409
4	275.0	0.0	275.0
5	312.5	61.733094	250.766906
6	224.0	54.3829734	169.6170266
7	168.0	131.62443	36.37557
8	50.0	46.25	3.75
Total	1454.0	588.565146	865.434854

5.2. Case study2 - *Finding of shortest distance between two points on spatial map by considering any parameter*

By utilizing the concept of composition geospatial services it is possible to display the shortest route between any two points on the displayed map on the mobile device environment. The finding shortest route may be calculated by considering any parameter such as length, cost, time. It is one of the most widely used function provided by many geo map portal. Popular examples are the routing services offered by Google maps, Yahoo maps and Live maps. But these geo portals access the road data from their own data source. If the road map provided by the diverse data sources it required to compose that data sources. Moreover, these portals provide their services in proprietary way and do not provide map of less important roads especially internal roads of villages. To display the shortest route on the mobile device following geospatial web services are required to access.

- To retrieve the GML of road network corresponding to the source and destination point related Web feature servers are to be accessed.
- To generalize the all GML files to a build topology graph all road networks a processing service is needed.
- To calculate the shortest path and retrieve to co-ordinates of intermediate nodes of that path another process has to define on the processing service interface.
- To display the shortest path on the mobile map Web Map Service is required.

To access services in single click the accessing rule should be defined in the rule repository. The implementation detail of accessing different geospatial services according to the logic of the rule is described in the following sequence diagram in figure 13.

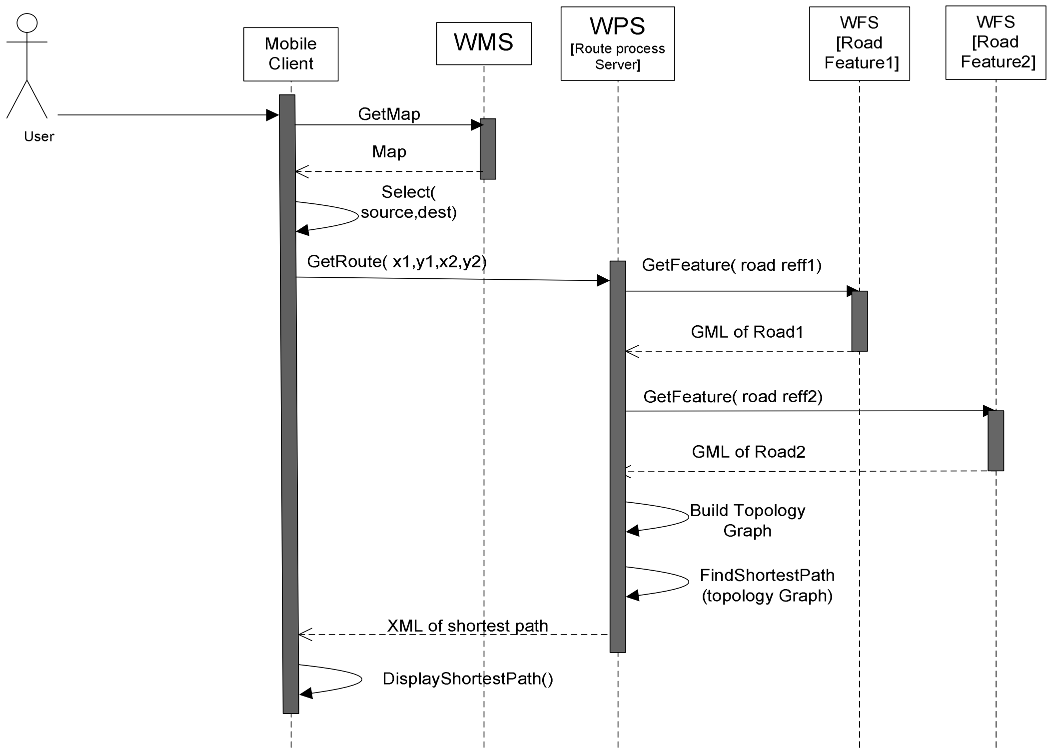

Figure13. Sequence of displaying shortest route on the mobile device

For searching of shortest distance, it is required to build the topology of the road map To generate topology of road map from the diverse data sources some processing is required. Since more than one data source may provide data of same road, then it is required to simplify before applying the shortest distance algorithm. Moreover, there would be multiple nodes for a single point on the road. Thus the data has to be simplified to finding the shortest distance.

The graph is constructed from the GML of the road networks received from GetFeature request to WFS. Each road string is read from the file and a node is created for each coordinate. To find the shortest path a separate processing service has been developed for the purpose of map generalization and calculates the shortest distance. Dijkstra's algorithm is used to find the shortest path between the source node and destination node and as mentioned earlier Graphics class is used to draw lines to show the path to the user. The processing service retrieves the data of road network from the relevant diverse data source between two selected points. When a road map is shown on the screen, to select the source the user can tap at any point on the map which may or may not lie on the road. Therefore, it is required to find a node on the road which is at minimum distance. Same method is applied for the destination point. In general the road map is layered with map of area of interest such as buildings, office etc. The user selects two buildings to be visited as source and destination and shortest path will be displayed with just few clicks.

The WPS for shortest path calculation provide an interface to access the processing service. The client generates KVP (Key-Value Pair) encoded execute request to access the co-ordinates of shortest path to route processing service. The request format is shown in below.

http://10.14.89.240:7777/routing/route?x1=86.829&y1=23.302&x2=86.834&y2=23.304

In above url (x1,y1) is the source co-ordinate and (x2,y2) is the destination co-ordinate and the processing server will find the coordinates between them in response. After getting the request, the processing server generates the GetFeture request to the related Web Feature Servers to retrieve the GML of corresponding road networks according source and destination point. Then all the GML files are simplified to build the topology graph. Then by applying Dijkstra's algorithm, the shortest path will be calculated and co-ordinates of the nodes between the path are collected to generate the following XML response as shown in figure 14.


```xml
<?xml version="1.0" encoding="ISO-8859-1" ?>
<paths>
 <path param="length">
        <start x="86.834000" y="23.304000" name="start" />
            <point x="86.834274" y="23.304268" />
            <point x="86.834969" y="23.304302" />
            <point x="86.834742" y="23.304165" />
            <point x="86.834128" y="23.303925" />
            <point x="86.833925" y="23.303851" />
            <point x="86.833129" y="23.303587" />
            <point x="86.829682" y="23.302216" />
            <point x="86.828674" y="23.301838" />
            <dest x="86.829000" y="23.302000" />
  </path>
  <path param="cost">
        <start x="86.834000" y="23.304000" name="start" />
            <point x="86.831859" y="23.306854" />
            <point x="86.831723" y="23.305714" />
            <point x="86.831605" y="23.304927" />
            <point x="86.831275" y="23.304173" />
            <point x="86.831008" y="23.304026" />
            <point x="86.829815" y="23.303328" />
            <point x="86.829674" y="23.303253" />
        <dest x="86.829000" y="23.302000" name="dest" />
   </path>
   </paths>
```


Figure14. XML response of WPS containing the co-ordinates shortest path

The service is implemented using the Java Servlet technology. Java Servlet technology provides Web developers with a simple, consistent mechanism for extending the functionality of a Web server and for accessing existing business systems. Java servlets make many Web applications possible. The servlet can be run in any servlet container. Currently, we are running the servlet in Apache-Tomcat. The routing servlet contacts the WFS server and then retrieves the routing features by making the GetFeature query to the WFS server. Once, the features are retrieved they have to be parsed and the corresponding topology has to be built for routing purposes. This is the most computationally intensive part of the whole routing service. Once the graph is built, the initialization ends, and then the routing service is ready to service its clients.

A menu based application is developed for mobile client to display shortest route after getting the XML file through the logical accessing of geospatial processing and data services. The user has to select the source the source and destination the menu as shown in figure 15.

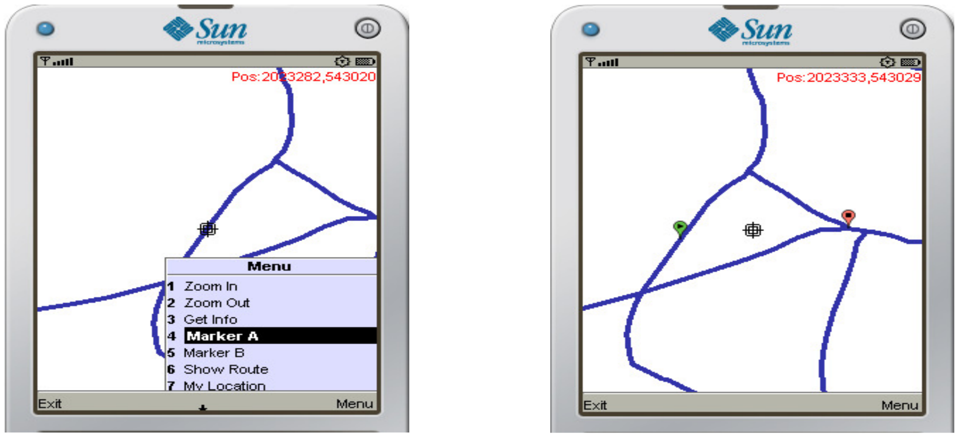

Figure15. Use selects the Source and destination on the mobile device

After getting the client input, the mobile application generates a KVP request to the web processing server to access the shortest route process and a XML file received in response. After parsing the XML the shortest route will be displayed on the map as shown in figure 16.

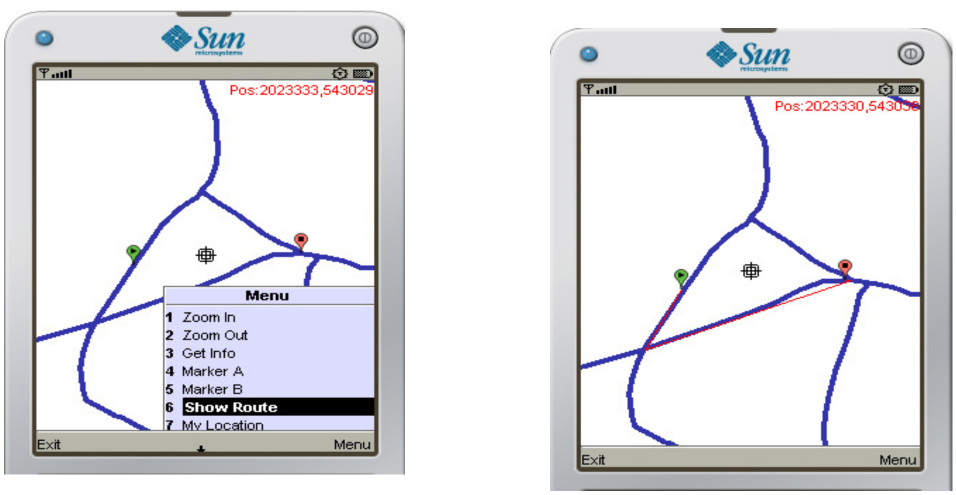

Figure16. Shortest route between the selected source and destination

6. CONCLUSIONS

Integrated accessing of geospatial information with the geospatial map enhanced decision making capability. Moreover, with the use of mobile device it is possible to get user specific information timely and accurately especially when the user is moving. Only straight way accessing the geospatial data from the distributed database is not sufficient to provide user specific information. The proposed framework utilizes different geo processing and data services to the chain of services to generate complex geospatial information. To implement business logic for chaining of different web services W3C introduces BPEL for service orchestration. However, there is no such type of standards for orchestration of geospatial web services. The proposed framework utilizes a web processing server as an orchestration engine. The orchestration engine contains a service accessing rule repository, according to which different type of complex geospatial information could be generated.

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Authors

Short Biography

Arindam Dasgupta has received Post Graduate Diploma in Information Technology form Indian Institute of Technology, Kharagpur, India. He is currently pursuing MS in Information Technology from the same institute. He is working in the area of geo spatial web services and interoperability for the last three years. His research interests include web service in mobile device and geo spatial web service chaining.

S. K. Ghosh is presently working as Associate Professor in the School of Information Technology, Indian Institute of Technology (IIT) , Kharagpur, India. He received his PhD from IIT Kharagpur in 2002. Prior to IIT Kharagpur, he worked for Indian Space Research Organization (ISRO) in the field of Satellite Remote Sensing and GIS. His research interest includes Geospatial database, Spatial web services and network security.