BIOGRAPHICAL INFORMATION

Dr. Charles O'Hara, PhD
Associate Professor
GeoResources Institute

Specific Responsibilities

Joined Mississippi State University in 2000 as faculty member. Serves as the Consortium Coordinator of the U.S. Department of Transportation-funded National Consortium on Remote Sensing in Transportation and Environmental Assessments.

Past Experience

I began my career with the U.S. Geological Survey (USGS), Jackson, MI, as a hydrologist and GIS specialist. At the USGS, I completed my dissertation, managed and conducted research and applied investigation, and served in the Office of Information as the Acting Systems Support Chief. I joined the faculty at Mississippi State University, in 2000, and serving as the Consortium Coordinator of the U.S. Department of Transportation-funded National Consortium on Remote Sensing in Transportation and Environmental Assessments.

Dr. O'Hara has received awards for research and technology development including the Department of Interior, Secretary's Distinguished Science Unit Award, in 2000, the U.S. Geological Survey's STAR Award in 1999, and the Environmental Protection Agency's Scientific Excellence Award in 1999. He also served on numerous technical committees as a member of the Future of Computing (FUTCOM) committee, as Chairman of the New Technologies Technical Advisory Committee (NT TAC), and as Chairman of the W2K Computing Committee. He currently serves on the IEEE Geosciences and Remote Sensing Society's Data Archiving and Distribution Technical Committee.

Educational Information

BS – Nautical Science, United State Merchant Marines Academy, Kings Point, NY
MS – Geological Engineering, University of Mississippi, MS
Ph.D. – Engineering Sciences, University of Mississippi, MS

Professional Memberships

FUTCOM – Future of Computing
NT TAC – New Technologies Technical Advisory Committee
IEEE – Institute of Electrical and Electronics Engineers

Venu Kanaparthy
Graduate Student/ Research Assistant
GeoResources Institute

Specific Responsibilities

Joined GeoResources Institute at Mississippi State University (MSU) as research assistant in 2003. Responsible for implementing Web services model for delivering spatial data services to desktop and mobile clients.

Past Experience

I began my career as Java programmer at Engineering Research Center at MSU in 2000. I was part of team responsible for implementing computational web portal funded by Office of Naval Research. I developed java server pages for file browsing, session tracking for front end of computing portal.

Later pursued internship at PixSell, a remote sensing and GIS applications firm. During one-year intern (2002), I developed broad range of GIS applications for desktop, web and mobile devices. I received student assistantship for attending the ESRI user conference 2003, San Diego, CA.

I joined GeoResources Institute as a graduate research assistant and worked on creating web services framework for providing spatial data services to diverse GIS applications.

Educational Information

BS – Electrical & Electronics Engineering, Nagarjuna University, India
MS – Computer Engineering, Mississippi State University, MS

Professional Memberships

GITA – Geospatial Information Technology Association
ACM – Association of Computing Machinery

FIELD MAPPING WORK MANAGEMENT MODEL USING OPEN STANDARDS AND WEB BASED SERVICES

Venu Kanaparthy, Graduate Student/Research Assistant
Geo Resources Institute
2 Research Blvd, Engineering Research Center, Box 9627, Starkville, MS 39759,
email: venu@erc.msstate.edu

Dr. Charles O'Hara, PhD, Associate Professor
Geo Resources Institute
2 Research Blvd, Engineering Research Center, Box 9627, Starkville, MS 39759
Tel: 662-325-2067, Fax: 662-325-7692, e-mail: cgohara@erc.msstate.edu

ABSTRACT

STARSS (Spatial Technologies Assessing Rural Septic Systems) is an effort to map and detect problems using mobile computing, field mapping, remote sensing and GIS technologies. Current methods are inadequate for mapping and managing wastewater resources as well as tracking problems and planning appropriate and effective solutions. New technologies must be identified and solutions implemented to provide information and work management solutions to address the existing problems. The vision of STARSS is to develop cost effective interoperable solutions for septic system information and work management by leveraging open standards and technologies. In this paper we propose a septic work management model (SWMM) for STARSS by implementing work management operations through standard interfaces, as a set of web services providing transparent data flow between mobile workforce, desktop application and GIS database.

INTRODUCTION

Septic system failures are significant problem in fast growing rural areas. A majority of septic systems are greater than 30 years old, over 25 percent are in some sort of failure, and 10 percent overflow on an annual basis. Current methods are inadequate for mapping and managing resources as well as tracking problems and planning appropriate and effective solutions. New technologies must be identified and solutions implemented to provide information and work management solutions to address the existing problems.

Spatial data is critical to GIS applications that need to view, query, edit and update information from different locations to achieve business objective. It is more challenging to deliver data to applications developed in different programming languages and platforms. Traditionally, GIS applications were limited to the desktops, running proprietary GIS software for displaying, querying and editing the geographic data often stored in a spatial database. Data is stored and transported in proprietary formats. This enabled only certain GIS software packages and databases to read and store the spatial data respectively. Organizations developed different data models and structures to support their business cause, resulting in diverse software packages to interpret. Some data formats are proprietary and can only be read by certain software packages. To be usable with diverse GIS software products, data conversion tools are required at additional cost and time. This not only limits the integration of GIS applications but also places the constraint on software packages and geo-databases to be used for developing the application itself.

With the introduction of mobile devices, a desktop GIS system could be extended to any remote location by providing easy, accurate and efficient methods for field data collection. Interoperating mobile and desktop applications provide significant step towards field data availability and application integration. This paper presents web services framework providing GIS application integration.

WEB SERVICES

Web services (WS) are reusable software components that can be discovered and invoked for services over the Internet [Rosen, 02]. They are built around set of industry standard specifications and protocols such as WSDL, UDDI, SOAP and XML. WS extend the client/server architecture by enabling broader accessibility to diverse applications and reusability of the web components delivering the functionality. Services can range from weather data, sales tax and flight-timing providers to computational geo-processing operations.

Using WS framework, standalone applications can deliver their functionality to other applications located remotely through an open interface. All open interface definitions are described in a Web Services Description Language (WSDL) [Christensen, 01]. This interface describes the operations the application supports, input and output parameters for each operation, transport mechanism (HTTP, SMTP or JMS) and the web location (URL) to invoke the service. An example operation could be a GetMap function that takes bounding box coordinates, output image format (GIF/PNG/JPEG), and data layers names to be displayed as input parameters. The output of the operation is an image of the requested area, format and data layers. In a mobile workforce management scenario, work order creation, transport and updates operations can be implemented as web services.

Application interfaces enabled using WS are loosely coupled. This facilitates changes or upgrades to an application without disrupting services and requiring changes to other applications. WS provides standard specifications on structure and encoding of the messages exchanged between applications. Simple Object Access Protocol (SOAP) [Gudgin, 03] is the used to encode the messages exchanged between communicating applications. Data encoded in SOAP has XML structure. Since XML is platform, language and device neutral markup language, data transported in XML structure can be accessed by other applications transparently. This means applications are not limited by programming language or platform for interoperation.

However, a set of XML tags representing information can mean anything or nothing, if the applications do not have intelligence to interpret and extract the information. This problem is addressed by defining schemas. Schemas are XML documents that provide the applications with knowledge on the message structure and content. Applications communicating using XML need to have an agreement on the content and structure of messages. This will enable application integration through transparent data flow [Morgenthal, 01].

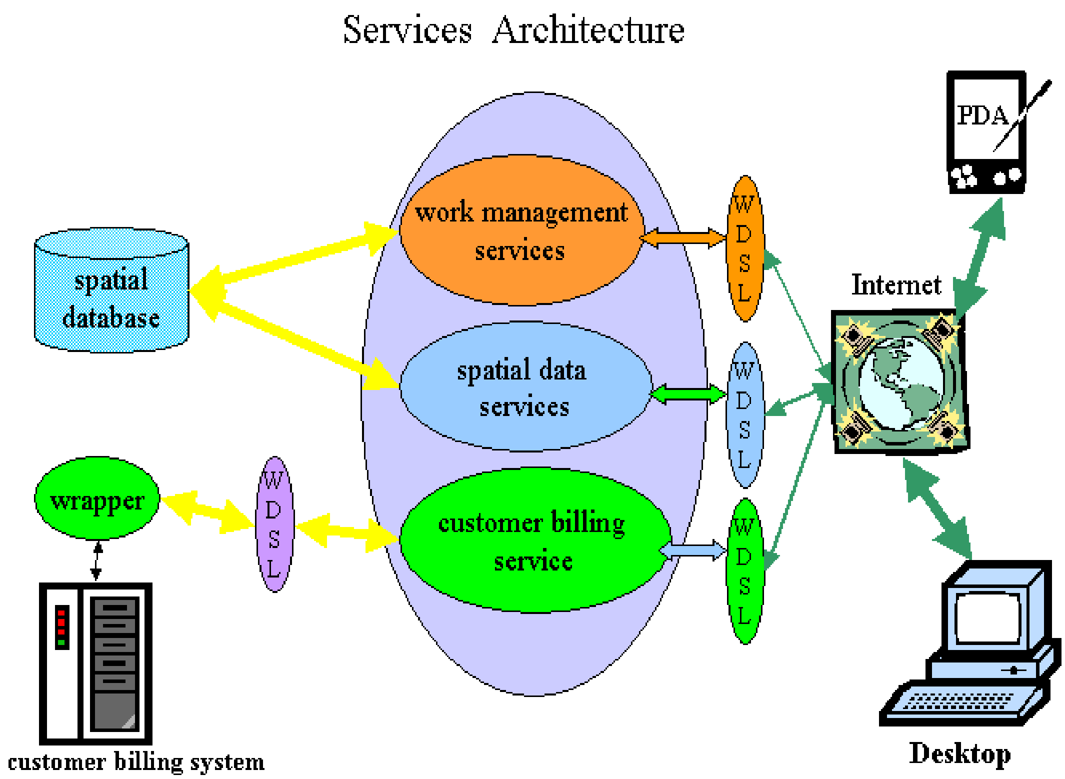

Figure 1 – Service Oriented Architecture

Web services model in Figure 1 provides service-oriented architecture providing work management, customer information and billing and spatial data services. Each service interface provides operations through WSDL interface. Work management component provides operations for work order creation, updates and transport. Spatial data services component provides operations for delivering spatial data layers. Customer billing service component provides operations for billing the customers for wastewater services. The billing service communicates with customer billing system through WSDL interface.

Through web services architecture applications can access services provided by different applications located remotely and perform operations to enable consistent workflow. The key to choosing service-oriented architecture for GIS application integration is by evaluating the current system productivity [Juric, 01]. Does the existing system provide data and workflow requirements and reusability of software components? Existing legacy systems need to be wrapped into reusable components and interfaced to other applications through web services interface. WS provides entry points to legacy systems for interoperation with other applications. Wrapper in Figure 1 is software adapter encapsulating the legacy system functionality for reusability.

WS can be categorized into synchronous and asynchronous services. With synchronous web services, application requesting a service will be blocked until the service provider has processed the request and returned the response. With asynchronous web services, application can send a service request and can get back to complete others tasks, while the service provider processes the request. The client does not wait for the server to return a response immediately. Delays in the service response may block the user applications from performing other useful work. Hence, Asynchronous services provide decoupling of applications.

Geographic Markup Language (GML)

GML is an XML encoded format for representing and storing the content and structure of geographic features. GML is an OGC (Open GIS Consortium) standard [Cox, 03], primarily targeted at addressing geographic data interoperability among GIS applications. Since GML uses XML encoding, it inherits all the features such as extensibility, interoperability and human readability. XML provides extensibility by enabling user defined custom data types. XML is not dependent on specific platform, programming language or a device. Diverse software tools are available for reading and writing XML data in different

GML can capture and transport geographic features over the Internet to remote GIS applications including mobile devices. It can be used to represent spatial and non-spatial aspects of geographic features. Feature characteristics such as topology, routing and orientation can be captured. GML provides schemas documents for modeling feature attributes and geometries. For example, waste water features such as manholes, sewer lines and pumps can be modeled in GML. Figure 2 shows the GML schema representing feature collection of manhole attributes and geometry. Likewise, application objects for work management operations can be modeled, extending GML schemas.

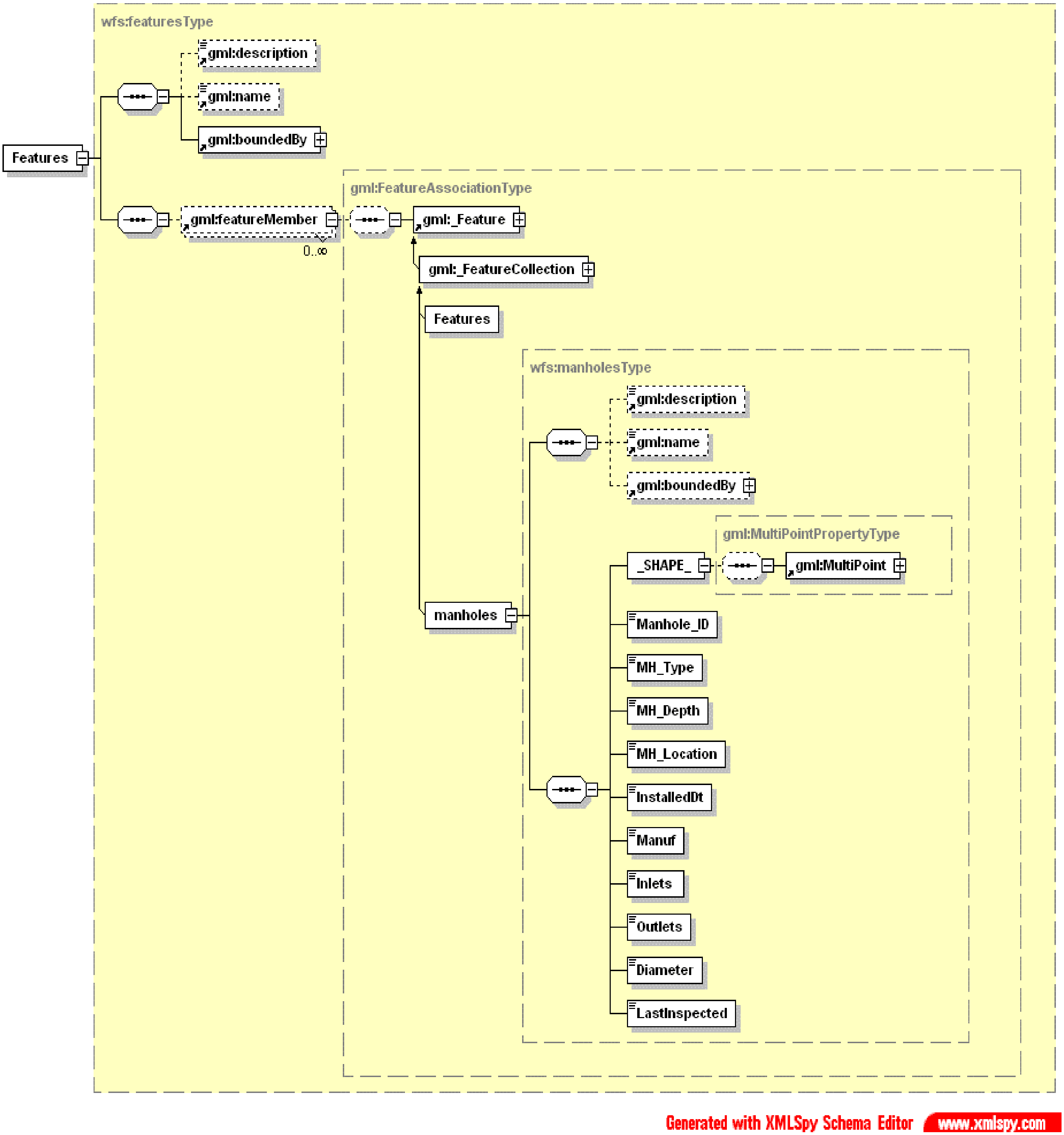

Figure 2 - Manholes schema document

A GML document typically is a collection of features of certain type such as point, line or polygon. In other words, this feature collection represents a single data layer or theme. Complex GML documents can contain multiple feature collections, where each feature collection can represent a data layer or theme. Features in a features collection may originate from multiple data sources located geographically. Feature from remote data sources can be linked to GML document using XLink [DeRose, 01] mechanism supported by GML schemas. Figure 3 represent XML data packet for job description and data layer information required to perform field inspection.

```
<?xml version="1.0" encoding="UTF-8" ?>
<Job xmlns="http://example.org/mytypes" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:gml="http://www.opengis.net/gml" xmlns:xlink="http://www.w3.org/1999/xlink" jobid="1202">
  <description>Perform Pipleline Inspection</description>
  <date>2003-06-06</date>
  <duration>60minutes</duration>
  <dueDate>2003-06-16</dueDate>
  <jobStatus>Not Started</jobStatus>
- <owner>
    <Name>Charles O'Hara</Name>
    <Street>2 Reseach Blvd</Street>
    <city>Starkville</city>
    <state>MS</state>
    <zipcode>39759</zipcode>
  </owner>
- <Redline>
  - <linearGeometry>
    - <gml:LineString>
        <gml:coordinates>129.71401977539062,63.420372009277344 129.66734313964844,63.428123474121094
          129.62132263183594,63.439395904541016</gml:coordinates>
      </gml:LineString>
    </linearGeometry>
    <classification>Pipleline</classification>
    <number>11</number>
  </Redline>
- <Map>
  - <layers>
    - <gml:boundedBy>
      - <gml:Box>
          <gml:coordinates>104.17711639404297, 1.2297935485839844</gml:coordinates>
          <gml:coordinates>144.184886391449744,1.746393839876993</gml:coordinates>
        </gml:Box>
      </gml:boundedBy>
    - <manholes>
      - <featureMember>
        - <manhole>
          - <_SHAPE_>
            - <gml:MultiPoint srsName="">
              - <gml:pointMember>
                - <gml:Point>
                    <gml:coordinates>33.04900404,68.3963545</gml:coordinates>
                  </gml:Point>
                </gml:pointMember>
              </gml:MultiPoint>
            </_SHAPE_>
            <Manhole_ID>MH_105</Manhole_ID>
            <MH_Elevation>78.3</MH_Elevation>
            <InstallationDt>1999-12-11</InstallationDt>
            <LastInspected>2003-09-14</LastInspected>
          </manhole>
        </featureMember>
      + <featureMember>
      </manholes>
    - <sewerlines>
      - <featureMember>
        - <sewerline>
          - <_SHAPE_>
            - <gml:MultiLineString srsName="">
              - <gml:lineStringMember>
                - <gml:LineString>
                    <gml:coordinates>123.79524230957031,56.40748596191406
                      123.7499771118164,56.46192932128906</gml:coordinates>
                  </gml:LineString>
                </gml:lineStringMember>
              </gml:MultiLineString>
            </_SHAPE_>
            <SEW_ID>SW_1345</SEW_ID>
            <TYPE>GRAVITY</TYPE>
            <LENGTH>82.4477</LENGTH>
            <DIAMETER>12</DIAMETER>
            <MATERIAL>VIT</MATERIAL>
          </sewerline>
        </featureMember>
      + <featureMember>
      </sewerlines>
    + <parcels>
    </layers>
```

Figure 3 - Job description in XML.

Implementation

The proposed test-bed is a client/server architecture extended with web services framework for delivering spatial data services over the Internet to desktop and mobile applications. The components of the architecture are, desktop manager, server framework, geo-database and mobile GIS applications. This prototype is built to address the work management needs of sewer utilities for a rural areas consisting of 1000 parcels, 400 sewer features (sewer lines, manholes and meters).

a. desktop manager:

   Desktop manager (DM) assists managers or supervisors to receive and register incoming complaint calls for wastewater services. The manager can view and query data layers of the complaint area. DM provides tools viewing history of complaints associated with a parcel, select features (redline) for field inspection and create task description for work order. Additionally, support data for executing the tasks is packaged with the work order. Figure 3 shows the desktop manager.

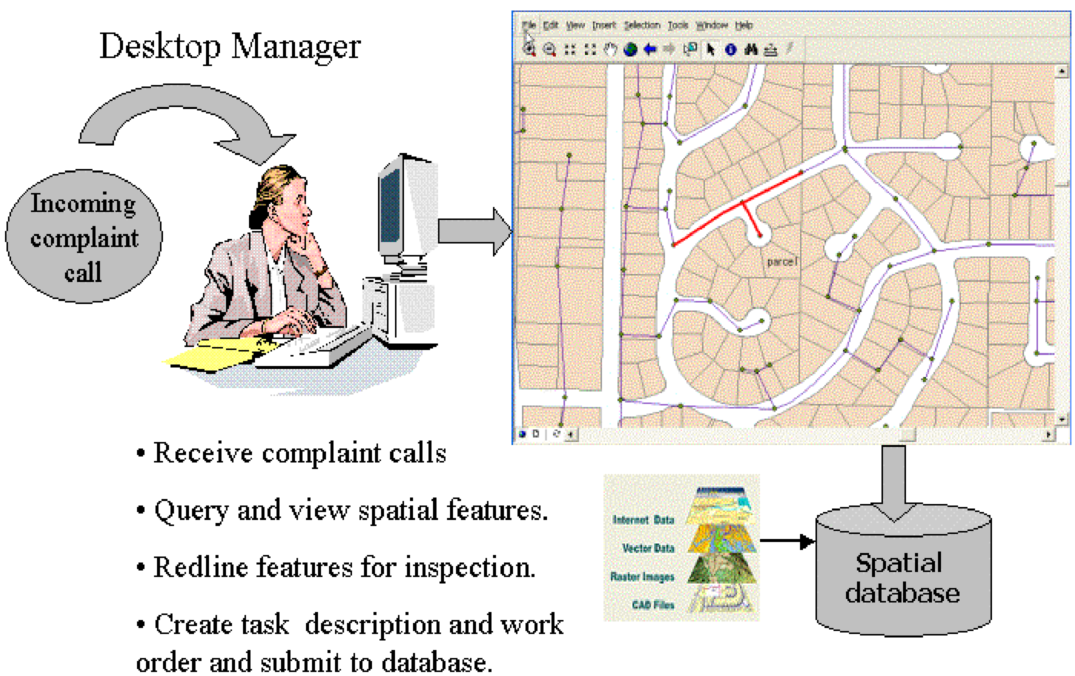

Figure 4 – Desktop Manager

b. service provider

The service provider (SP) acts as a mediator between GIS applications (both desktop and mobile) and spatial database. The SP responds to user applications request for data layers by retrieving features attributes and geometries from the database and delivering spatial data in GML. User applications (desktop and mobile) convert GML data from SP to data layers on the fly. Feature geometries are retrieved in Well Known Binary format from the database. Changed to the feature geometry and attribute information on the client side are updated into the database through SP. Operations such as work order creation, spatial data delivery and updates from mobile and desktop applications is supported by SP framework.

c. spatial database:

Spatial database is a repository for data types such as vector and raster layers. The spatial data stored in some databases is in proprietary format and can only be read by certain GIS software packages. STARSS chose to use PostgreSQL, an open source database. This database can store spatial data when configured with spatial extension package, PostGIS. This database supports storing, retrieving and editing spatial features apart from support for spatial queries such as intersect and buffer. PostgreSQL stores spatial data layers as tables in a database. Each table corresponds to a single theme or layer. Spatial and non-spatial information of a data layer is stored in table columns. SQL is used to perform insert, delete and update operations on tables. The performance of the database for retrieving or updating spatial and non-spatial data features is significant. PostgreSQL is accessible to java clients and visual basic clients over JDBC and ODBC protocols respectively. The data model for supporting the work management tasks of STARSS is developed by extending ESRI wastewater data model with work management objects.

d. mobile application:

The mobile application communicates with the spatial database through SP. Field personnel can query and download work orders over the Internet or through desktop synchronization at the office. Each work order will contain tasks description, data layers of parcels and sewer features. Field inspector can locate his position on the map with the GPS device integrated with mobile device. He can edit or add new feature geometry or attribute information in the field. This information is locally saved on the mobile device. On completion of the tasks, the field inspector can update the work order through Internet or through desktop in the office.

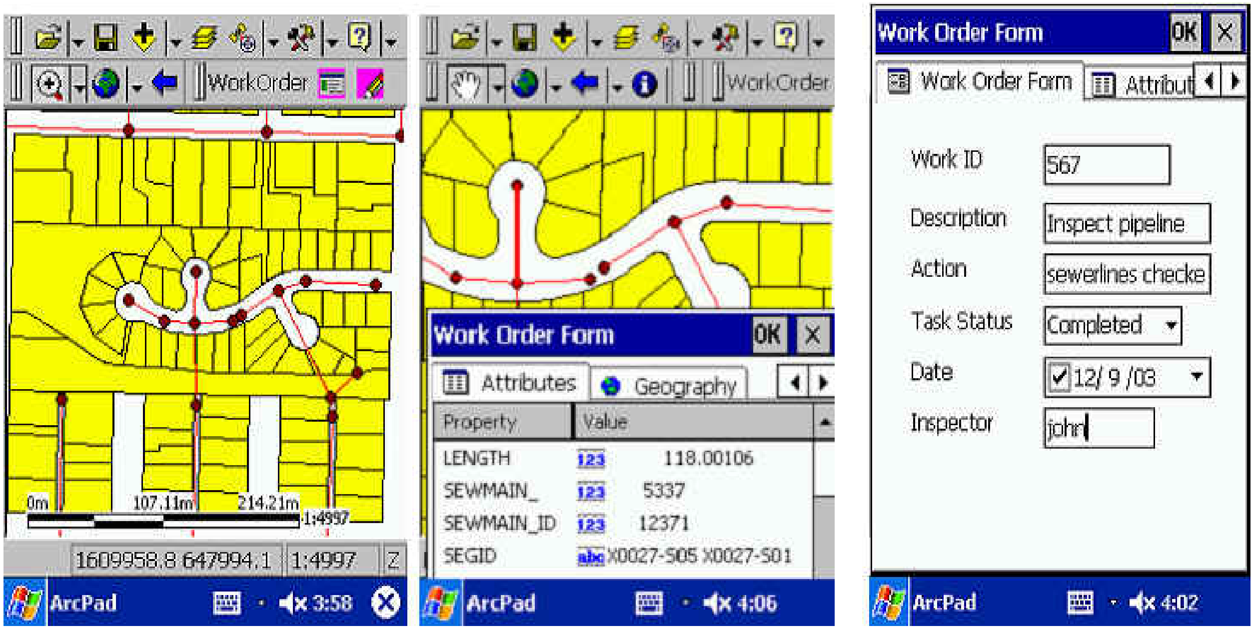

Figure 5 – Mobile GIS

Conclusions

Through web services, applications are decoupled and have a standard communication mechanism for transparent data exchange resulting in easy application integration. Since the data exchanged between applications is XML encoded, it is portable across multiple applications operating on different platforms. Hence, spatial data services delivered through web services are portable across diverse applications. Data and business operations can be modeled through GML schema documents, providing intelligence (semantics) to user applications for interpretation, validation of data exchanged and reusability. Limitations such as cost of data conversion from XML to others formats usable by applications still exists. With the increasing number of applications accessing spatial data services, interfaces to service providers and users need to agree on standard message structures and content for interoperation.

References

a. Rosen. M, Boak .J, 2002, eAI journal, January, p. 39-43, Developing a Web Services Strategy.

b. Christensen .E, Curbera .F, Meredith .G, Weerawarna, 2001, W3C Web Services Description Language.

c. Gudgin .M, Hadley .M, Mendelsohn .N, Moreau .J, Nielsen .H, 2003, W3C SOAP Version 1.2.

d. Morgenthal .JP, 2001, eAI journal, October, p.12-16, XML for Data Integration.

e. Cox .S, Daisey. P, Lake .R, Portele .C, Whiteside A, 2003, Open GIS Consortium, Geography Markup Language Implementation Specification.

f. DeRose .S, Maler .E, Orchard .D, 2001, W3C, XLink, XML Linking Language.

g. Juric .M, 2002, eAI journal, July, p. 31-35, EAI and Web Services.