# Customized Geospatial Workflows for E-Government Services*

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## ABSTRACT

The past decade has experienced a phenomenal growth in the electronic delivery of business services. This has led to an elevation in the expectations of citizens for fast and efficient delivery of governmental services. Recently, workflow systems have gained importance as an effective infrastructure for automating the business processes within and across government agencies. Government services, such as permit processing for the development or preservation of land, can be modeled as workflow. They must consider geographic locations and the geodata that include location-specific data, documents and information. We call such workflows dependent upon locations and their geodata *Geospatial workflows*. We argue that geospatial workflows vary widely from one case to another, and therefore cannot be represented as a generic workflow. We demonstrate, with concrete examples, that there is a compelling need for customized geospatial workflows and propose a system that is capable of generating such customized workflows by capturing the user requirements and extracting the relevant governmental regulations. Our system also provides users with decision support functionalities comprising of various GIS layers, by which users can evaluate and identify a suitable workflow among various possible scenarios. Geospatial workflows can be used by government agencies to automate the delivery of their services. We present the features of a preliminary prototype.

## Keywords

Geospatial Workflow, E-government services, Customization, Decision support

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## 1. INTRODUCTION

With the Internet serving not only as a static information resource but also as a dynamic marketplace where buyers and sellers interact, the automation of various business processes in Electronic Commerce (EC) is a requisite for delivering goods and services. In EC, workflow management systems (WFMS) play a prominent role as an infrastructure solution for automating business processes. Business processes typically involve interactions of various *tasks* executed by *execution agents* (either humans or software programs) that are typically distributed, heterogeneous and autonomous, in a *coordinated sequence*. A *Workflow* is defined as a formal specification of the tasks and the coordination requirements, called *inter-task dependencies*, between them.

This trend of automation is also true for Electronic Government (EGov), where federal, state and local governments provide various services for citizens using information technologies. Government services often require cross-agency cooperation. For example social benefits services require a citizen to interact with unemployment and Social Security agencies while business registration services require citizens to interact with numerous agencies such as the Division of Taxation, Div. of Unemployment and Disability Insurance, Div. of Worker's Compensation, the Compensation Rating and Inspection Bureau, Div. of Commercial Recording, and the local County Clerk's office.

Because information collected and processed at each agency is in general not shared with other agencies, citizens are repeatedly required to provide redundant information. Also, due to the number of agencies, citizens often feel lost and frustrated when faced with having to decide which agencies to interact with and in what order the agencies should be "visited." WFMS for government services promises to support various tasks across different agencies, making the delivery of government services transparent to citizens [1].

Government services are constrained by citizens' personal choices and preferences, and by the rules and regulations mandated by the respective federal, state or local governments. Government services, therefore, can involve widely different tasks to be done in different sequences, depending on the individual's profile and the government mandates applicable to the situation.

One such government process that we will consider as an example in this paper is the process of developing or preserving land where personal choice of a location for development play a major role. As we will demonstrate shortly, a large number of variations also exist in this process depending on geographic locations. Specifically, the lots considered for development or preservation may be owned or may need to be acquired. A project may span across multiple lots or it may be confined to a single lot. Finally, depending on the zoning of the lot(s) and the intended use, a zoning variance may be required. A zoning variance is an exception to established zoning regulations that may or may not be granted to a developer based upon evidence presented to a zoning board at a public hearing.

There are many additional minor differences that collectively, with the major aspects just described, produce a large number of potential tasks and sequences of tasks. Existing technologies approach such a problem by attempting to enumerate and pre-define all the possible steps, sequences and exceptions in one workflow. However, capturing all these different service steps and sequences in one workflow for all the possible cases may result in a very complex workflow. Moreover, attempting to pre-define these workflows may be ineffective since any small change in the choice of location, zoning regulations or other rules would require major restructuring of the workflows. For this reason, we maintain that workflows must be generated on demand in a "customized" fashion taking into account the characteristics of the tasks, user requirements and government rules and regulations. Because the workflows are generated on-the-fly from a rule base, any changes to the rules are automatically reflected in the newly generated workflows. By employing customized workflows all variations of the development aspects are automatically taken into account.

Government service delivery units are heavily dependent on Geographic Information System (GIS) technology as a decision support tool. However, GIS is only now starting to become used to support EC in applications such as mobile commerce. GIS tools and web-based interactive mapping capabilities have opened a new avenue to access integrated location dependent data. The integration of geodata reveals information that was not apparent by itself, thus it has been used for decision support and problem identification. In this paper, we maintain that a location is not only a bundle of *static* geodata as viewed in GIS community, but the location is also associated with service processes (i.e. workflows) that include tasks and dependencies. This location dependent process is determined by location and its geodata, such as zoning and cadestral data, as well as government regulations, such as zoning rules. We call this service workflow based on geographic location and its associated geo-information *geospatial workflow*.

In this paper, we present an approach to automatically generate customized geospatial workflows based on the specific requirements of each individual. The objective of our system is to provide the following functionalities:

**1. Generation of customized geospatial workflows:** The generation of customized workflows based on the geographic information associated with a parcel will benefit individuals in making decisions on whether a location is suitable for their needs and, once a location is selected, will guide them in the permitting process. Variations among individuals' goals and locations may yield different workflows that vary in their complexity. The graphic presentation of workflows generated for different potential locations will allow a user to compare how they differ in terms of permit requirements in conformance with regulatory restrictions, thus aiding in the development or preservation decision.

**2. Streamlining of business processes:** Government agencies delivering services also benefit from geospatial workflows. The geospatial workflow can guide the execution agent in the specific tasks, the sequence of the tasks, and the conditions under which each task is to be carried out. Thus the geospatial workflow will streamline the business process of government.

The remainder of this paper is organized as follows. In section 2 we formalize our discussion of geospatial workflows and provide a motivating example that will be used throughout the remainder of the paper. In section 3 we present the customized workflow generation, and its motivation, followed by workflow selection phase for decision support. In section 4 we present overall architecture and its prototype implementation. Finally we discuss related work in section 5, and conclusion and future research in section 6.

## 2. GEOSPATIAL WORKFLOWS

A geospatial workflow we propose has the following characteristics:

- **Location dependent component-based composition model:** Business processes and services are location dependent. Tasks and dependencies in a geospatial workflow are associated with a particular geographic location. For example, while an order processing workflow does not change when an order is placed in New Jersey or New York, a land development permit process, which is a geospatial workflow, can vary when it is requested in New Jersey or in New York. Thus, a geospatial workflow is composed of location dependent tasks.

- **Geodata and geographic rule driven customization model:** Geodata used in a geospatial workflow may come from heterogeneous (multimedia) format and from different data sources, but they are all pertinent to a particular location. The contents of geodata for a particular location, such as zoning data or geo-characteristics (near water front), influence the geospatial workflow. In order to determine whether a parcel is within 100 meters from water front, the geodata might need to be processed by conventional GIS tools, such as distance measurement from the water front to the parcel. Thus, changes in geodata for a particular location can yield a different geospatial workflow. In dynamic business and government environments, geospatial workflows are able to generate customized workflows based on current business or government rules and regulations. Because workflows are not statically defined, changes to any rules are immediately reflected in geospatial workflows.

Geospatial workflows with these characteristics which combine existing GIS and workflow system approaches are ideally suited for supporting location dependent e-government services. The remainder of this section will provide a detailed discussion concerning the need for customization in geospatial workflows. To provide a more meaningful example, we limit our discussion to a land development scenario. Individuals intent on land development or preservation face a number of tasks such as identifying suitable parcels, and obtaining relevant permits and certificates. For example, a developer must consider the characteristics of the land parcels such as geographic location, co-location with other resources and zoning and permit requirements in order to select a parcel suitable for his requirements. Traditional GIS with various layers have been used to support such siting applications, however, they do not consider the relative complexity of the tasks the individual faces in terms of regulatory agencies. In this paper, we argue that the decision making process should also consider the complexity involved in obtaining various permits from local and state level governments. Below, we will give an example of a geospatial workflow demonstrating the need for customization.

**Focus Area of our study:** The specific focus area for our study is the Hackensack Meadowlands District (District), a 32 square mile area located in Bergen and Hudson Counties in New Jersey, less than five miles from New York city. The District includes portions of 14 municipalities, ten in Bergen county and four in Hudson county. The District contains approximately 11,500 acres of upland, and 8,500 acres of wetland and open water. Most of the upland areas are developed, and the principal land uses in the uplands are industrial, landfill, institutional and commercial. Undeveloped areas within the district are largely wetlands, and these areas are under intensive development pressure [2].

The District is a governmental jurisdiction, within which the New Jersey Meadowlands Commission is the agency responsible for land use planning, implementation of zoning controls, subdivision and site plan review and approval, regional solid waste management, and protection of the environment. In the course of a year the NJ Meadowlands Commission handles about 800 permit requests with about 1,000 cases open at a given time.

**Geospatial Workflow Example:** For the purposes of demonstration, we will refer to the following scenario through the remainder of the paper. A developer is interested in building an automobile service station close to or within a residential neighborhood. The lack of existing service stations in the surrounding area make for a compelling business case. However, establishing a service station requires the developer to comply with numerous zoning regulations and to obtain a number of permits to begin construction and eventually take occupancy of the new structure. Some of the regulations involved include [5]:

- The service station can only be established on an appropriately zoned parcel. Appropriate zones include “Service-highway commercial” and “Light industrial and distribution zone.” It is also possible to develop in a “Neighborhood commercial zone,” if a variance can be obtained.
- The lot size must be at least 10,000 sq. ft. with a minimum width of 100 ft. Each Side yard must be at least 10 ft. in width or at least 25 ft., if a side yard is adjacent to a residence.
- A minimum of 15% of the lot must be maintained as open space.
- Off-street parking requirements include one space for each employee plus three parking spaces for each garage repair bay.
- Buffers should be 10 ft. in front, 5 ft. for side and rear (20 ft. if neighboring a residence).

Based on these constraints, the developer would like to evaluate different lots to see what would be involved in terms of permits, variances and other considerations. Clearly, depending on the lot selected, variances may or may not be required. Given the above constraints on the land parcels, the developer may wish to investigate several alternate lots to see what regulatory steps would be involved in the development process. For example, assume a location chosen by a developer is identified as a contaminant site, has lot size less than 1000 sq ft, and the developer specified his venture would require an underground tank storage installation. The geospatial workflow for this particular developer would be as shown in figure 1.

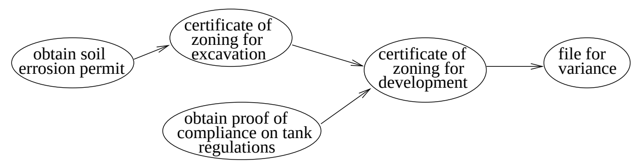


**Figure 1: An Example of a Geospatial workflow for the Auto Service Station**

Once a lot is selected, a development plan must be written and submitted to the NJ Meadowlands Commission for approval. The NJ Meadowlands Commission will follow a procedure for verifying compliance with zoning regulations before issuing construction permits. After construction permits have been issued and construction completed, a final stage of verification of the zoning regulations must take place before a certificate of continued occupancy is issued.

## 3. CUSTOMIZATION OF GEOSPATIAL WORKFLOWS

Typical standard workflow design tools allow a user to define a business process using a graphical user interface. The workflow designer models complex and varied tasks, the dependencies among them, and data flows among tasks. The target business processes are supposed to be completely specified. The complete specification of business processes is often very complex and error prone. Such an intricate workflow would also be extremely difficult to model in advance and would be overly complex for users to comprehend. One solution for this problem would be for the designer to provide incomplete or underspecified workflow (or generic workflow), and provide greater flexibility for task agents. We take a different approach that minimizes run time modifications by providing customized workflows tailored to the specific set of location-based contingencies the user is presently facing. Thus geospatial workflows are dynamically generated from location dependent geographic information, such as zoning rules, permit regulations, with a customer’s specific goals and preferences.

By providing such facilities, service consumers as well as service providers benefit. A land owner can make decisions on which parcel is most suitable for his intended project, while regulating organizations in turn use this geospatial workflow to automate its process of issuing relevant permits and enforcing the zoning rules.

The customized workflow generation is based on a set of interview questions posed to an individual. Answers to these questions specify development objectives and other preferences. One input would be location information (if known) or a potential location that is picked from GIS mapping tools. This personal and location information gathered through interview and GIS map layers together with a rule base for zoning regulations are used to generate customized geospatial workflows.

The zoning rules are implemented as IF-THEN production rules. When the conditional clause in a rule is matched with a characteristic of a parcel or interview answer, the rule fires (i.e. the then-clause applies), and adds relevant tasks and dependencies in the workflow. The following are some examples of rules that are relevant to the developer of a gas station. We show the condition part of the rule in parenthesis:

1. IF (area $<$ 10,000 sq ft ) OR (lot width $<$ 100 ft) THEN add variance;
2. IF (fuel tanks and container involved) THEN obtain Proof of Compliance with NJDEP[1] tank regulations;
3. IF (another gas station located closer than 1000 ft) THEN deny permit or ask to pick another location;
4. IF (solid waste site) THEN require soil erosion plan permit and zoning certificate for excavation;
5. IF (property affects county road or drainage structure) THEN apply for County site plan approval;
6. IF ( expected land disturbance $>$ 5,000 sq ft.) THEN obtain Soil Conservation District Approval;

To contrast this set of rules, consider another example in which a new hotel could be sited on one of several different areas including one location that spans commercial and residential zones and a second that is adjacent to wetlands and would be partially constructed on a reclaimed landfill. Finally, assuming the parcel is adjacent to Hackensack River with no public sewage facilities available, the following rules become relevant:

1. IF (development borders the Hackensack River or any of its tributaries) THEN include buffer strip in the plan
2. IF (no public sewage facilities available) THEN get permit for construction and operation of temporary sewerage facility
3. IF (temporary sewage facility needed) THEN obtain proof of compliance with regulations of NJDEP

Figures 1 and 2 show the customized geospatial workflows generated by the rule base for our two development examples.

A final set of characteristics concerns the preferences of the individual performing the decision support. These differences coupled with the varying geographic characteristics make developing a single static workflow for all contingencies a practical impossibility. As will be demonstrated in the next section, our approach of automatically generating customized workflows based on user preferences, location based data and zoning and permitting rules and regulations provides an effective solution to this problem. Finally, the resulting workflow can be used to both provide decision support to the individual as well as guide the permit review process from the agency's perspective.

[1]New Jersey Department of Environmental Protection

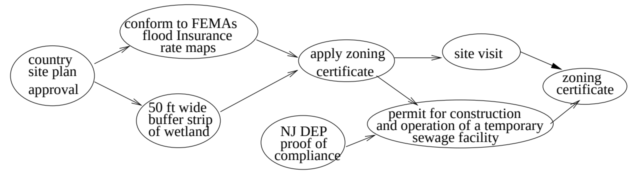


**Figure 2: An Example of a customized geospatial workflow for the Hotel example**

# 4. SYSTEM ARCHITECTURE AND FUNCTIONALITY

An outline of the system architecture is shown in Figure 3. The major components are categorized as User Interface, processing Subsystems and Data sources. The user interface components are assembled on one web page for easy navigation.

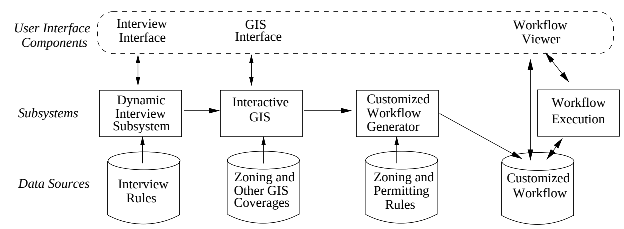


**Figure 3: System Architecture**

The major components of the system include:
**1** An on-line interview system that dynamically changes the sequence and content of questions depending upon answers to prior questions. The interview system relies on a database of IF-THEN rules that dictate the presentation of questions based on answers given to prior questions.
**2** The interactive web-based GIS consists of data coverages that include zoning, parcels, land-use and infrastructure (roads, railways, etc.). The traditional GIS operations such as panning, zooming and selection are all supported. Specific functions to assist in the decision support stage include the ability to highlight a specific block and lot, measure the dimensions (width and depth), and query the underlying layers to determine zoning, land use and other characteristics. Regions within the coverages are automatically highlighted or obscured according to the parameters specified during the interview process. The user interface allows the user to incrementally remove from consideration those parcels that do not meet the development or preservation criteria. Upon selecting a land parcel for development or preservation, the location and other parameters are passed to the customized workflow generator where a workflow is created.
**3** The customized workflow generator receives location and user parameter inputs from the interactive GIS and the interview subsystems. Based on these parameters and the applicable zoning and permit rules, a customized workflow is automatically generated and stored in a database under the user's account.
**4** The workflow viewer provides the user with the tools to interact with the customized workflow. The user can view and compare several different workflows (based on the dif-

ferent regions selected via the GIS) and choose one to be executed. When a workflow is executed, each task is presented to the user and highlighted according to whether the task is pending, active or completed.

## 4.1 Prototype System

A screen capture from our prototype system implementation can be seen in Figure 4. Our prototype makes use of the NJ Meadowlands Commissions' permit and zoning regulations to assist individuals in choosing appropriate parcels to preserve or develop. The same system may also be employed by the NJ Meadowlands Commission to track the progress (represented as a workflow) of specific projects.

The three main user interface components are shown in the frames of a standard web browser. In the first scenario introduced in section 2, we described the issues facing an individual wanting to construct a service station in a light residential neighborhood. In the prototype application, the left frame shows the results of the interview phase wherein the individual has specified that this will be an alteration of an existing structure and that the lots are already owned by the individual. Specific blocks and lots are then specified in the fields and the type of business activity is selected from the list (Auto Service/Repair). There is an indication that the project will span 2 existing lots and the last question asks if lots requiring a variance should be highlighted.

With these inputs from the interview, the specified lots are highlighted in the interactive GIS in the upper right hand frame. The user has selected a measuring tool and has used it to gain a rough measurement of the dimensions of the lots under consideration.

Finally, with the highlighted lots and the interview questions answered, clicking on the "Generate Workflow" button causes the system to generate the workflow shown in the bottom right hand frame. The user preferences specified in the interview are combined with the relevant zoning and other data about the specific parcels from the GIS and set to the workflow generator. The workflow generator uses these inputs to match against rules in the zoning and permitting rule database to generate the customized workflow. Note that the first task to be completed (obtain soil erosion permit) is highlighted as it is the first task to be completed.

# 5. RELATED WORK

A prototype system (RRAIT) [7] supports the land use permit process. It is a networked document management and workflow system capable of supporting a fully electronic record of the minor project review process, and it is also capable of accessing, analyzing, and capturing information from the GIS system, and archiving the project record. It facilitates the permit review processes allowing parallel access to a project record. Its primary goal was to digitize all the relevant maps and plans and other data for a project and put these into a project record file. By having all relevant documents available electronically, the review process boils down to document routing process: i.e. which documents are relevant for which review steps. This prototype also focuses on the internal review process by an agency, while our study is focussed on primarily for developers. The workflow execution part in our system can be modeled as this system, but our geospatial workflow system facilitates customized generation workflows and allows preliminary decision support for developers.

[3], [9] and [11] describe the use of workflow techniques to coordinate geoprocessing activities such as data collection, data integration and processing, and output generation (e.g., maps) and analysis.

A number of studies report GIS tools as decision support tools (e.g. [10, 8]), but we find they are not directly related to our study. [6] addresses the problem of GIS user interface complexity and describe an active customization approach in which user interface elements are generated automatically depending on the context of the application (what the user is doing) and the user's preferences. A system of Event-Condition-Action (ECA) rules is used. Even though it is interface customization, we find it relevant to our work, since it considers user preferences and rule bases for customization.

[4, 1] reports a prototype system for rule-based generation of a customized workflow for business registration process for a State government. The customization is based on user preferences gathered from an interview session, rules and regulations on business entities, and business services (tasks) provided from different agencies. The workflow system guides citizens through the tasks and also acts as an agent to provide a coherent business process. Our paper expands this work in the GIS domain for decision support and for streamlining the review process for local governments.

# 6. CONCLUSIONS AND FUTURE WORK

In this paper, we have developed a methodology supporting the customized generation of geospatial workflows. Our approach takes into consideration GIS information associated with a location (e.g. zoning data, property data, contaminant data, etc.) and rules and regulations (e.g. zoning regulations, or business development regulations, building regulations) to generate a customized geospatial workflow. We have presented a prototype system for a specific e-government process that allows users to easily explore multiple sites and produce the appropriate geospatial workflows to support decision making. The graphic presentation of workflows at different potential locations allows users to compare how they differ in terms of permit requirements and in conforming to regulatory restrictions, thus aiding in the development decisions. The government permit process for land development, alteration, and preservations has two sides: one internal for the government as permit issuing entity, the other for the developers and preservationists as its consumer. We have shown both sides can benefit by the GIS-based workflow automatically generated by integrating rule bases, GIS data, and user input.

One future avenue of research concerns the execution aspects of the workflow such as handling exceptions, monitoring, and incorporating changes to the workflow in a dynamic fashion. In terms of development, we will work to enhance the prototype with additional GIS layers such as traffic patterns, demographic data and other data to assist in the decision support phase. Finally, the rule base implemented in the prototype is not comprehensive, and we plan to implement a more robust set of rules that more accurately reflect a broader range of existing rules and regulations of the NJ Meadowlands Commission.

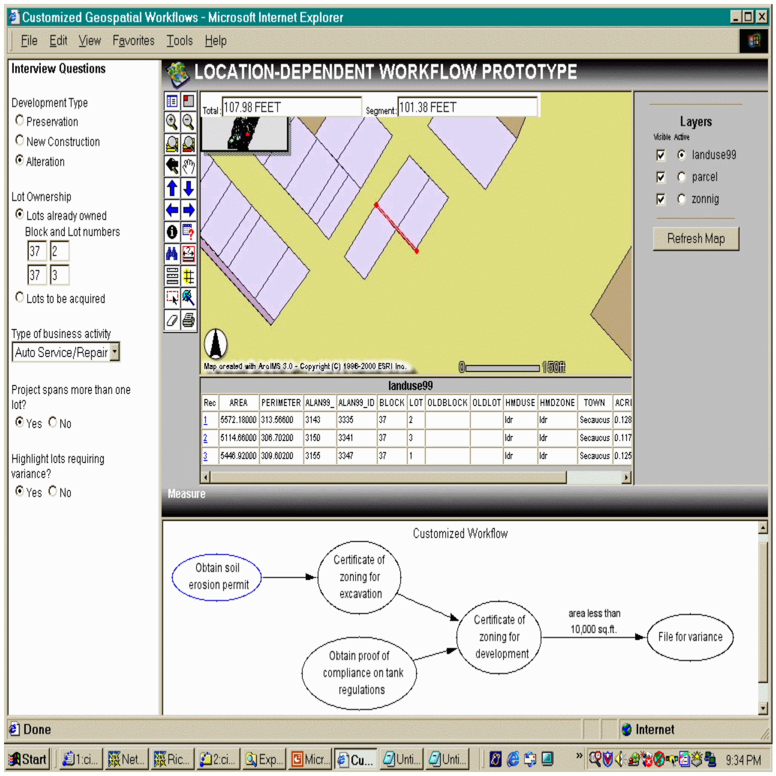


**Figure 4: Prototype System**

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