Urban Delivery Distribution Routing Optimizing Key Technology Based on Web GIS

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***Abstract*—Development of information technology, can provide efficient, safe, convenient support platform to logistics and distribution companies, improve logistics and distribution of economic benefits. The problem of the lack of geographic information and the actual line with the calculation of line, distribution routing optimizing, the introduction of Web GIS, and research key technologies. First, given a graphical Web GIS which based on distribution routing optimizing; secondly, study distribution routing optimizing algorithm, including model representation and reverse dynamic programming algorithm; again, study spatial data representation and data structure, including vector and raster data structure; then, study the structure of Web application framework, in the description based on the MVC framework, Spring MVC framework focuses on the component structure; finally, realize the Web GIS technologies, including Java Applet major technical analysis and implementation techniques. The results show that Web GIS technology will be combined with optimization algorithm on the city line distribution routing optimizing, is technically feasible, has some theoretical and practical prospects, an important future research direction.**

***Index Terms*—Web GIS, urban logistics, distribution routing optimizing, geographic information system, Optimizing Algorithm**

I. Introduction

Web GIS is also known as Web-based GIS, is the development of Internet technology product of GIS, is a special environment of geographic information system. The Web has a graphical user environment, user queries, real-time database access and data display functions, according to user requests made through the Web and display of interactive map data provides possibility, GIS extensions obtained through the Web, really become a tool for public use [1]. Any node of the Web, Internet users can browse the site in the Web GIS spatial data, producing thematic maps, as well as a variety of spatial search and spatial analysis, with the growing popularity of the Internet GIS, it will provide more services.

Urban logistics is usually the main motor transport, distribution managers adopt effective strategies to improve service levels, reduce distribution costs, including vehicle scheduling optimization is an important issue to be resolved. By Vehicle Scheduling can increase the loading capacity of vehicles, reduce empty vehicle miles, improve logistics and distribution of the economy. the traditional distribution routing optimizing lines exist the following deficiencies: the distance between the distribution of points is a straight-line distance calculated on the basis, from a distribution point between the actual road network; existing vehicle routing problem, not the quality of the road, the flux factors such as geographic information into account; the existing number of studies focused on relatively small network (usually no more than 20), but in the case of the large number of outlets, from the computational point of view, difficult to obtain the optimal method exact solution [2].

The above problems, lack of geographic information and the actual line from the problems with the calculation of line, basis on the traditional distribution routing optimizing, introduce GIS, through GIS-assisted route optimization.

II. Distribution Routing Optimizing Based on Web GIS

Vehicle routing problem based on GIS, mathematical model is essentially identical with the traditional VRP model, except that the model preconditions (constraints) of the building [2]. Specifically, the traditional VRP model search with a dry relatively simple traversal of the network diagram is based on the customer node to the path for the edge undirected graph, the data structure only

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by the path distance and number of the client node. The VRP-based GIS model used to search the network map is a path node, the client node and the path component of the undirected graph, the data structure includes not only the path from the node number and the customer, but also includes the path capacity, odd and even lines and other geographic attributes, greatly enriched the traditional VRP network diagram, but also to fit in the VRP model is more practical.

In each distribution, through the Web interface, input information to GIS, through the power of the map display these data so that dispatcher can easily and intuitively based on optimization objectives, using the optimized algorithm, the distribution centre and customer connections together to optimize the design of distribution lines [3]. Basic process shown in Figure 1.

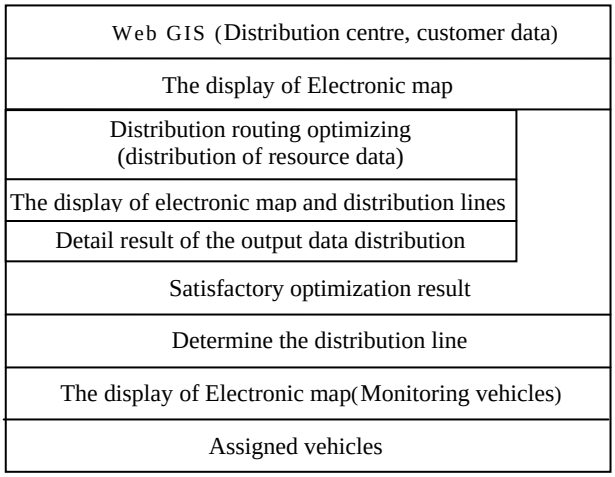

Figure 1. Distribution routing optimizing process based on Web GIS

Distribution process described as follows: In Figure 1, the distribution centre dispatcher data, customer data entry Web GIS, the power of these points on a map the location and relative distance; enter the number of customer delivery, pick-up time and distribution of vehicle data using distribution line design optimization method a viable distribution lines; determine the line is not satisfied, and if not, re-optimization, if satisfied, determine the distribution lines, and a map marker in the electric vehicle trajectory; driver in accordance with the power of the map marked lane, the manager in accordance with the power of the map the trajectory of vehicles to monitor the vehicle and traffic congestion in the network occurs when the vehicle scheduling.

III. Distribution Routing Optimizing Algorithm

A. Model Representation

The following assumptions: a city with a logistics distribution centre, a number of demand points; demand point and distribution centre point between the demand and needs, and the distance between points is known, the number of demand points of known demand for goods; all types vehicle load is known, but the number of uncertain demand; vehicle overloaded distribution centre to be from the starting point to finish unloading the cargo demand drove back after the load distribution centre; a demand point can only be visited once, that the needs of demand points does not exceed the vehicle load (if the demand is more than dead weight, alone sent a car, does not belong to optimize the scope, less than load some further optimization). With reference [3-5], the minimize total cost of the mathematical model:

$$\min \quad Z = \sum_{k\in V}\sum_{i\in N}\sum_{j\in N} c_{ij}\, x_{ijk} \tag{1}$$

Type(1), Z represents the total cost; V represents the number of vehicles; N is the number of nodes, N = 1 + demand points, 1 represents a distribution centre; i, j represent the specific node, $i = 1,2,\cdots,N$, when i= 0, it represents the distribution centre, $j = 1,2,\cdots,N$.

Type(1), c_{ij} represents the cost of node i to node j, it can be calculated:

$$c_{ij} = w_{ij} * d_{ij} \qquad (i \neq j) \tag{2}$$

Type(2), w_{ij} represents per unit distance costs of node i to node j; d_{ij} represents the shortest distance of node i to node j.

Type(1), the value of x_{ijk} satisfies the following formula:

$$x_{ijk} \in \{0,1\} \qquad \forall k \in V, \forall i \in N, \forall j \in N \tag{3}$$

Type(3), specific value of x_{ijk} as follows:

$$x_{ijk} = \begin{cases} 1 & \text{the k car from the node i to j} \\ 0 & \text{Other} \end{cases} \tag{4}$$

Each demand point can only be visited once, must meet the following formula:

$$\sum_{k\in V}\sum_{j\in N} x_{ijk} = 1 \qquad \forall i \in C \tag{5}$$

Type(5), C represent the demand point of N, the value is $1,2,\cdots,N$.

Demand points on each line and can not exceed the demand of the load the car, must meet the following formula:

$$\sum_{i\in C} q_i \sum_{j\in N} x_{ijk} \le Q \qquad \forall k \in V \tag{6}$$

Type(6), q_i demand for the demand point, Q is the vehicle load.

Ensure that each vehicle away from the distribution centre, the service needs of end points, go back to distribution centres, must meet the following three equations:

$$\sum_{j\in N} x_{0jk} = 1 \qquad \forall k \in V \tag{7}$$

$$\sum_{i\in N} x_{ihk} - \sum_{j\in N} x_{hjk} = 0 \qquad \forall k \in V, \forall h \in C \tag{8}$$

$$\sum_{i\in N} x_{i,n+1,k} = 1 \qquad \forall k \in V \tag{9}$$

B. Solution Algorithm

The method of distribution line for solving the optimization model can be divided into three types of exact algorithms, heuristics algorithms and intelligent algorithm [11][12], compare as shown in table 1.

TABLE I.
COMPARISON OF VEHICLE SCHEDULING OPTIMAL ALGORITHM

Category	Specific method	Characteristic
Exact algorithm	Branch and bound method, cutting plane method, network flow algorithms method, dynamic programming method.	It is very effective for smaller transportation scheduling problem. As the transportation system more complex and multi-objective requirements of schedule, computation increases with the size of the problem grow exponentially, more and more accurate method isn't applicable.
Heuristic algorithm	Construction algorithm include Saving method, nearest neighbor method, insertion method, two-stage method include grouping before arrange line method and arrange line method before grouping.	Solving problems can always get the optimal or satisfactory solution in polynomial time, therefore, the present vehicle fleet scheduling optimization method focus on the design of heuristics and improvement.
Intelligent algorithm	Genetic algorithm, taboo search\simulation annealing, ant colony algorithms, artificial neural network.	Advantage is that the problem for small and medium scale sub-optimal solution can be obtained, fault is computational complexity, large amount of computation, relate to complex neighborhood transformation and solving strategies, has strong theoretical and practical application has much difference.

Heuristic algorithm can always be in the limited time, find a satisfactory suboptimal solution or a feasible solution, is one method of solving the problem of multi-stage decision process.

Distribution route optimization process is a multi-stage decision-making process, so the dynamic programming model can be solved.

A reverse dynamic programming solution method and the positive sequence of points, where the selection of reverse solution [5].

Set indicator function take form of indicators and the various stages, namely:

$$V_{k,n} = \sum_{j=k}^{n} v_j(s_j, u_j) \tag{10}$$

$v_j(s_j, u_j)$ represents the denotes of *j*'s segment index. The above equation can be written as:

$$V_{k,n} = v_k(s_k, u_k) + V_{k+1,n}[s_{k+1}, \cdots, s_{n+1}] \tag{11}$$

When the initial state given time, the process for determining the strategy, the index function also determined. Therefore, the indicator function is a function of the initial state and strategy. Can be written as $V_{k,n}[s_k, p_{k,n}(s_k)]$. Therefore, the above recurrence relation can be written as:

$$V_{k,n}[s_k, p_{k,n}] = v_k(s_k, u_k) + V_{k+1,n}[s_{k+1}, p_{k+1,n}] \tag{12}$$

The strategy of $p_{k,n}(s_k)$ can be regarded as the combination of $u_k(s_k)$ decision and $p_{k+1,n}(s_{k+1})$.Namely:

$$p_{k,n} = \{u_k(s_k) + p_{k+1,n}(s_{k+1})\} \tag{13}$$

If $p^*_{k,n}(s_k)$ represents the initial state of $p^*_{k,n}(s_k)$ that the rear sub-processes in all sub-optimal sub-policy strategy, the optimal value function as:

$$f_k(s_k) = V_{k,n}[s_k, p^*_{k,n}(s_k)] = \underbrace{opt}_{p_{k,n}} V_{k,n}[s_k, p_{k,n}(s_k)] \tag{14}$$

And:

$$\begin{aligned} \underbrace{opt}_{p_{k,n}} V_{k,n}(s_k, p_{k,n}) &= \underbrace{opt}_{\{u_k, p_{k+1,n}\}} \{v_k(s_k, u_k) + V_{k+1,n}(s_{k+1}, p_{k+1,n})\} \\ &= \underbrace{opt}_{u_k}\{u_k(s_k, u_k) + \underbrace{opt}_{p_{k+1,n}} V_{k+1,n}\} \end{aligned} \tag{15}$$

Since:

$$f_{k+1}(s_{k+1}) = \underbrace{opt}_{p_{k+1,n}} V_{k+1,n}(s_{k+1}, p_{k+1,n}) \tag{16}$$

Therefore:

$$f_k(s_k) = \underbrace{opt}_{u_k \in D_k(s_k)} [v_k(s_k, u_k) + f_{k+1}(s_{k+1})] \qquad k = n, n-1, \cdots, 1 \tag{17}$$

Boundary conditions $f_{n+1}(s_{n+1}) = 0$.

Type(17), $s_{k+1} = T_k(s_k, u_k)$, the solution process, the boundary conditions, from the beginning $k = n$, from back to front pushing, which gradually can obtain the optimal decision of each segment and the corresponding optimal value $f_1(s_1)$, and finally obtained to get the whole issue the optimal solution.

IV. SPATIAL DATA REPRESENTATION AND DATA STRUCTURE

Spatial data structure is the organizational form that is suitable for computer storage, manage and process of the data logical structure of spatial data is the spatial arrangement of geographical entities and the relationship of the abstract description.

Spatial data organization of a unified data is currently no structure can also store such as topography, maps, images, 4 types properties of data, but their data structure of each vector, raster data structure, two-dimensional data

table and other types of data structures stored. The most common is the vector data structure and the raster data structure.

Figure 2 shows that with the vector data structure composed of different soil structure and land. Soil structure is one with a starting point, end point coordinates of the line and constitute the necessary pointers. Because that entity segment has a direction, so called vector structure. Segment endpoint pointer that should be how to connect these segments together to form a correspondingly fast. This structure can be described as: Lot→Vector Group→connectivity.

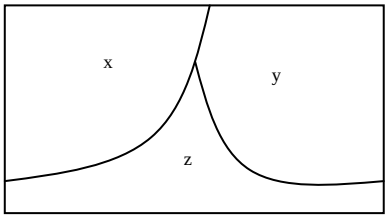

Figure 2. Vector data structure representation of spatial data

Table 2 shows the data structure with a grid of different soil structure that constitutes the land. Soil structure is a part of a grid composed of a collection of the grid, so called grid structure. Grid in the same collection has the same code "x" or "y" or "z" and so on. These values themselves are not necessarily the actual display, usually a symbol or they may represent a color or grayscale image. This structure can be expressed as: block→Symbol / Color→grid.

TABLE II.
RASTER DATA STRUCTURE REPRESENTATION OF SPATIAL DATA

x	x	x	x	x	x	x	x
x	x	x	x	x	x	y	y
x	x	x	x	x	y	y	y
x	x	x	x	y	y	y	y
x	x	x	x	y	y	y	y
x	x	z	z	y	y	z	z
y	y	y	y	y	z	z	z
y	y	y	y	z	z	z	z
y	y	y	z	z	z	z	z
Z	z	z	z	z	z	z	z

Two structures can be used to describe the geographic entities of point, line, area 3 basic types, their most fundamental difference is how to express the concept of space. Raster data using spatial enumeration of region or the spatial target audience directly; vector data used to represent the spatial boundaries or the surface of the target object's surface or body elements, the boundaries by recording the same time, the identifier used to describe the expression of its properties object entity.

V. WEB APPLICATION FRAMEWORK STRUCTURE

Web technology has been widely used in Internet. The usual GUI technology allows Web applications to interact with the client browser, to perform dynamic pages. But for Web GIS, GUI application there are many technical shortcomings, limitations in performance in areas such as the need for more secure and reliable data structures. MVC framework is a better choice.

A. MVC Framework

MVC Framework will be divided into three basic parts: model, view and controller, the coupling of these three parts rarely work together to improve application scalability and maintainability. MVC framework shown in Figure 3 [6].

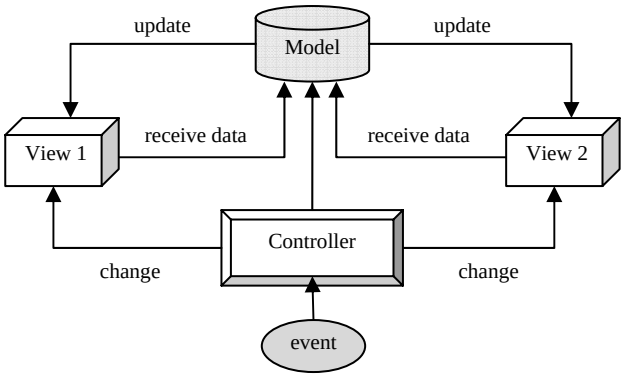

Figure 3. MVC framework structure

In the MVC model, event handling by the controller, the controller according to the type of event to change the model or view. Each model corresponds to a list view, this correspondence using the registry to complete. That is, the multiple views up to the same model, when the model changes, the model view to all registered send notifications, view the model from the corresponding access to information, and then complete the view update. MVC features as following:

- Multiple views correspond to a model. on MVC design pattern, a model corresponds to multiple views, you can copy the code and reduce code maintenance, once the model changes, but also easy to maintain.
- The data which model return and display mode separation. Model data can be applied to any display technology, for example, the use of JSP pages, Velocity templates, or directly from Excel documents.
- The application layer is divided into three layers, reducing the coupling between the layers, providing application scalability.
- Control layer includes the concept of user requests permission to different models and different views together to complete various requests.
- MVC more in line with the spirit of software engineering management. Perform their duties in

different layers, each layer has the same characteristics of the components is beneficial tool by engineering and production management of code.

B. Spring MVC Framework

Spring applications provides a lightweight solution for the Web GIS, it's an excellent Web MVC framework that provides the core mechanism based on dependency injection, AOP based declarative transaction management, persistence layer technology integration with a variety of other content. Spring is committed to J2EE application layers of the solution, not just focus on a particular layer of the solution. Spring is committed to enterprise application development, "one-stop" choice, Spring throughout the presentation layer, business layer and persistence layer. Spring MVC Framework component architecture shown in Figure 4 [7].

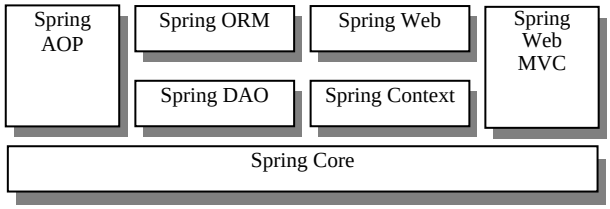

Figure 4. Spring MVC framework component structure

Spring MVC framework, you must use Spring Core, Spring MVC framework which represents the core mechanism, while other parts of the component, you can choose to use.

Spring MVC framework has the following advantages:

- Low-intrusive design, the code of the pollution is very low;
- Independent of the various application servers, based on the Spring Framework applications that can truly "Write Once, Run Anywhere"
- Spring of the DI mechanism reduces the complexity of the business object replacement;
- Spring in the highly open nature does not force applications that are dependent on the Spring, developers are free to use some or all of the Spring framework.

VI. WEB GIS IMPLEMENTATION TECHNOLOGY

With the increasing popularity of Internet application, online construction GIS, Web GIS will be created more and more in work, the establishment of Web GIS involves in all aspects of the technology.

A. Main Technical Analysi

Current, Web GIS technology implement method typically including: common gateway interface method CGI, server application programming interface Server API, plugins Plug-in method, dynamic server pages Active Server Page, ActiveX Control client controls and Java and so on.

(1) Common Gateway Interface CGI

CGI Web GIS Technology is the first method used.CGI is a Web server interface for calling external programs, through the CGI, web server can't be done to complete some of their work.CGI is the common gateway interface (Common Gateway Interface), it establish the Internet between the server and the application interface. CGI-based Web GIS is to be achieved WWW interactive as follows: the user sends a request to the server, the server forwards this request through the CGI to run to the back-end GIS applications, the results generated by the application returns to the server, then result is passed to the client display. Work process show in figure 5.

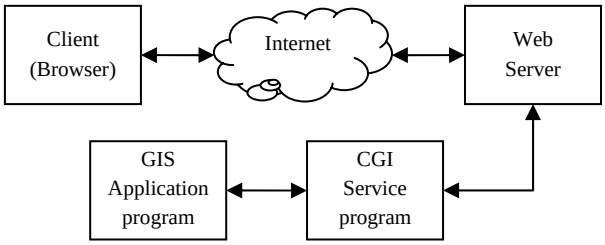

Figure 5. Web GIS Work Process Based on CGI

(2) Server Application Programming Interface Server API

Server application programming interface Server API is more efficient than CGI Web Server extension method. Generally only loaded once shared object, a possession of Sever address space, once again request the cost that is the cost of a function call, so Server API as an extension of the method within the process, create process and interprocess communication greatly reduces the load and run faster than CGI program much faster. Web GIS work mode based on Web Server API as shown in figure 6.

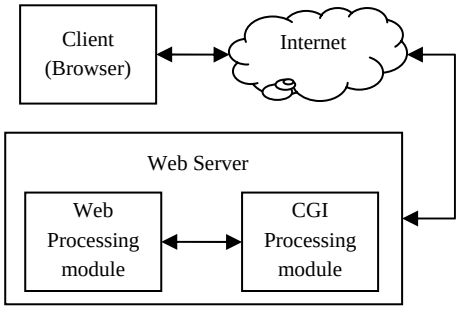

Figure 6. Web GIS Implementation Based Web Server API

(3) ASP and ActiveX Components

ASP and ActiveX technology use the Web GIS Component Object Model COM (Component Object Model) and network-related technology, GIS software systems can be decomposed into relatively independent components.ASP is a server-side scripting language, its purpose is to efficiently and easily dynamically generated HTML content, can call up the Web server ActiveX components to perform the task, in order to achieve a powerful Web applications. Because ASP scripts run on the Web server, use ASP to create cross-platform applications can be run in a variety of Web browser.

ASP technology can solve the problem of CGI interface object, it can automatically parse the data which collected from the page.ASP can use the Windows environment which contain other ActiveX objects.

(4) Browser Plugins Plug-in

In order to facilitate a variety of browser extension, provide a plugins Plug-in environment, can plug-in runs as part of the browser.GIS functionality with Plug-in is downloaded from the web server to the client, install on the user's local computer GIS operation which used to provide small application embedded in HTML that can handle the GIS data.

Plug-in for GIS based on the work process: the client browser to the Web server sends the request from the GIS data manipulation, Web server based on user request, the necessary GIS data the user back to the client. Coming from the client receives the GIS Web server data, identify the type of GIS data in the local system with the GIS data to find the corresponding Plug-in. If found, use it to manipulate GIS data; Otherwise, you need to install the GIS plug-ins to manipulate GIS data. GIS data manipulation, such as graphics zoom in, zoom, roaming and other plug-ins to be completed by the GIS.

(5) Java

Java language is cross-platform, very suitable for Internet and distributed data environment, by downloading the Java Applet to the client, it can calculate all the other operations run on the server or in part, or part of the server to run on the client. Therefore, Java as a distributed Web GIS application system to achieve optimal development of language structure. The current development of Web GIS systems using Java in two ways: first, only the client part of the technology using Java Web GIS systems, server-side code based on the existing system, with the development of GIS and spatial data transfer protocol, and Java programs to interact Function module implementation, which is the vast majority of Web GIS systems approach. Second, both client and server-side Java-based Web GIS, which is pure Java System Web GIS, can maximize the advantage of Java technology, in particular can take advantage of Java on the server side and client to build a distributed network Support for technology applications.

B. Java Applet Implementation Technology

Web GIS implement based on Java Applet Mode, GIS Java Applet is embedded in the HTML file, the Web browser downloads the HTML documents, Java programs execute code are also downloaded to the client machine, by the browser interprete it [15].

Map of all the needs of the user operating with the mouse events handle by the Applet. Applet requires user to select the tool bar, capture the different mouse events and mouse screen coordinates, correspond canvas Applet treatment. Depending on the type of map, operations need to be processed Applet and capture mouse events and coordinates. When the user operate complete a map, Applet should make to the Web server that operate such as data query request. Structure as shown in figure 7.

Applet response for enlarging local implementation of the map, reduce, roaming and other functions, through the CGI,RMI,IDL communicate to application server. Web server is responsible for WWW services, process and distribute requests. Application server response for handling requests, an instance of the state, transaction processing, security management, database connection pool management. Application components are used to complete different user applications. This works to some extent reduce the server load and network data, it has applicability, reliability and security features.

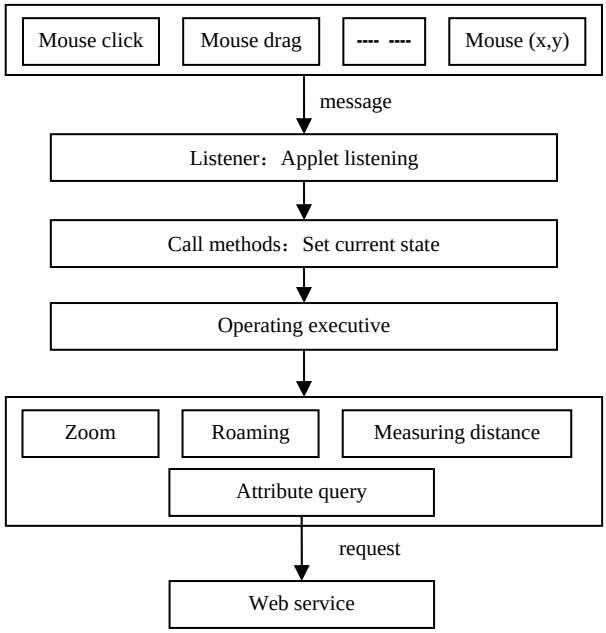

Figure 7. Implementation process of Applet

Servlet can be considered a server-side Applet. Servlet Web server is loaded and executed by the browser like Applet load and execute the same. Servlet receives the request from the client (from the Web server),performs an operation, then returns the result. Servlet basic process show as follows [1]:

(1) client(Web browser) through HTTP to request,

(2) Web server receives the request and sends it to the Servlet. If this hasn't been loaded, Web server will load it into Java virtual machine and implementation,

(3) Servlet receives HTTP request and implements treatment,

(4) Servlet will return a response to Web server,

(5) Web server sends the response to client which receives from the Servlet.

VII. CONCLUSIONS

Select urban logistics lines transport scheduling and optimization is an important part of business logistics costs, modern computer and communication technology rapid development of optimization of distribution lines put forward new requirements. This paper uses Web, GIS, route optimization and other technology, information technology and the combination of optimization, spatial geographic data automatically associated with the optimization model. By B / S mode, reducing maintenance and training costs. Best routes on

the Web GIS analysis is one of the key distribution optimization, subject to various factors, the current implementation as the desktop GIS flexible, there are many factors to consider. With the further development of information technology, this paper will also be further improved in order to provide efficient logistics and distribution, safe, convenient support platform, to provide scientific decision-making program delivery, and maximize the effectiveness of logistics and distribution companies have better secondary support role. Web GIS-based Route Optimization of urban logistics distribution has some theoretical significance and potential applications is an important research field of GIS.

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