

Internet GIS

Transportation Applications

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Two technologies of the 1990s—the Internet and geographic information systems (GIS)—have changed the way transportation professionals access, share, disseminate, and analyze information.

The Internet has greatly improved the accessibility and transmission of all types of information, including that related to transportation. Providers of transportation information, including government agencies and private organizations, are discovering the convenience of publishing and disseminating the information on the World Wide Web, and many have set up their own Web sites. The Internet allows transportation professionals to request and download information from multiple sources on the Web almost instantly—a much more efficient approach than the use of disks. This ready access facilitates more informed decisions.

Because of the spatial nature of most transportation data, GIS has proven to be a powerful tool for constructing and analyzing transportation networks, conducting impact assessments of transportation facilities, and integrating transportation and land use planning (see National Cooperative Highway Research Program Report 359, *Adaptation of Geographic Information Systems (GIS) in Transportation*). Significant progress has been made during the last few years in implementing GIS technology within transportation organizations. Some agencies, such as the Wisconsin Department of Transportation, have been successful in pioneering the implementation of a networkwide, GIS-based pavement management system. But GIS is far from reaching its full potential as a transportation analysis tool in every department of a transportation agency. Part of the reason for this is that GIS software is mostly proprietary. The use of GIS for transportation (GIS-T) requires expensive GIS software and extensive

user training. Therefore, while the use of GIS in transportation has increased rapidly in the last decade, the technology is generally limited to a small number of transportation professionals within the transportation organization who have the resources and expertise to use it.

An emerging technology—Internet GIS—combines Internet and GIS so that transportation professionals without those resources and that expertise can access, share, and disseminate spatial data. Internet GIS is a network-centric GIS tool that uses the Internet as a primary means of providing access to the functionality (i.e., analysis tools, mapping capability) of GIS and to the spatial and other data needed for various transportation applications. Internet GIS has new features that allow transportation agencies to publish spatial data on the network for public access, and enable transportation professionals to share data more easily and conduct transportation analysis across a network, as well as at an individual site.

Features

Internet GIS has a number of features that make it highly promising for transportation applications. First, the fact that users do not have to buy expensive GIS software or have GIS expertise makes it easier for transportation agencies to disseminate transportation information to the public. The user-friendly interface of Internet GIS also facilitates data sharing within and between transportation agencies.

Another valuable feature of Internet GIS is the interaction between the user and the spatial data. Internet GIS offers interactive rather than static map images on the Web. Users can work with the maps interactively by performing conventional GIS functions such as zoom, pan, identify, and query.

In addition, Internet GIS can incorporate up-to-date, real-time information—an especially important feature for applications in intelligent transportation systems. Several applications have been developed to display real-time traffic information. Applications can also be developed for real-time traveler information, transit information, and trip planning through the linking of Internet GIS with automatic vehicle locators and automatic passenger counters.

The above features enable users in different parts of an agency or different jurisdictions to work directly with GIS data and tools that are maintained and shared by different departments. Thus Internet GIS becomes an efficient tool for implementing the concept of “top-down, bottom-

up" development of GIS-T applications endorsed by NCHRP Report 359: undertaking database design and data acquisition and maintenance as an organizationwide, top-down activity, while developing GIS-T applications on the basis of decentralized, bottom-up initiatives.

Two Kinds of Internet GIS

One of the key building blocks of the World Wide Web, HyperText Markup Language (HTML), does not directly support spatial data in the form of maps. Therefore, Internet GIS needs an "interpreter" on the Web to use GIS data that cannot be recognized by HTML itself. This interpreter is the core component of Internet GIS, and is used to translate user input from the Web site into a language the GIS software can understand. It can be located at either the server side or the client computer (user) side. Server-side Internet GIS relies on the host computer to perform all GIS analysis, while client-side Internet GIS performs GIS analysis and processing on the Web browser in the user's local machine.

With server-side Internet, a user at a Web browser client initiates a request that is sent across the Internet to the server. The server processes the request and sends the result to the client. The most frequently employed server-side application is the use of Common Gateway Interfaces (CGI) script as the interpreter to connect user input and the GIS server.

The advantage of server-side Internet GIS is that it can handle large databases at the server and answer specific questions for the user. But it offers the end user little flexibility and interactivity. The user cannot work directly with the data as one does with stand-alone GIS software. The limitations of the normal data transmission protocol prohibit the development of more advanced analysis tools. Thus server-side GIS can be used only for static spatial query and display.

Client-side Internet GIS allows GIS analysis and data processing to be done on the Web browser in the user's local machine. GIS data and analysis tools reside initially in a server. Users generally request them from the server, which sends them to the client for local processing. Client-side applications include three major technical approaches: GIS plug-ins and helper programs, ActiveX controls, and GIS Java applets. GIS plug-ins and helper programs and ActiveX controls extend the capability of HyperText Transfer Protocol (HTTP) to handle GIS data directly. The end user can view GIS data and perform simple analysis on the Web just as on local GIS software,

Efforts in Geographic Information Systems

National Cooperative Highway Research Program

The National Cooperative Highway Research Program has undertaken a number of research efforts to assist departments of transportation in understanding and implementing geographic information systems. NCHRP also continues to address common problems related to the implementation of GIS.

NCHRP Project 20-27, *Adaptation of Geographic Information Systems (GIS) in Transportation*, generated NCHRP Report 359 of the same title in 1994. The project led to the conclusion that GIS for transportation (GIS-T) is feasible for transportation agencies, and that its feasibility is dependent on the technology, data, and organization structures involved. The technology is available, and DOTs have a wealth of data, so they have a significant incentive to reshape their information resources. That incentive is reinforced by the capabilities of GIS to readily integrate data, offer the opportunity for new types of analyses, provide better information for decision making, and enhance the efficiency of data gathering and management.

NCHRP Project 20-27(2), *System and Application Architectures for Geographic Information Systems*, had two distinct phases. In the first phase, the contractor developed a generic location-referencing data model to provide a more sophisticated basis for the development of this most critical element of comprehensive, integrated transportation information systems. This model was derived from inputs of a diverse group of professionals at a 2-day workshop and then documented for further review. The resultant model is described in NCHRP Research Results Digest 218, *A Generic Model for Location Referencing*. In the second phase of the project, information system plans from eight DOTs were decomposed to establish a generic model of information systems for the various functions of transportation agencies. The template provided by the model was shown to facilitate the development of agency-specific information system plans. The generic model is described in NCHRP Research Results Digest 221, *System and Application Architectures for Geographic Information Systems*.

NCHRP Project 20-27(3), *Implementation of Location-Referencing Models for Multimodal Transportation*, was recently initiated. This project will assess efforts to implement location-referencing data models within comprehensive, integrated information systems in order to determine when enhanced models or improved procedures could help ensure the success of such implementations. Guidelines will be developed to assist agencies in updating their location-referencing schemes to provide the functionality needed to serve emerging applications such as GIS-T and intelligent transportation systems.

NCHRP Project 20-47, *Quality and Accuracy of Positional Data in Transportation*, will get under way soon to develop models for understanding positional data error in GIS applications. The project effort will include reviewing the positional data gathering tools and processes used by DOTs and assessing their impact on the information presented by GIS. The project will result in recommendations for defining accuracy levels and suggest means for displaying positional information to reflect the accuracy of the information.

although it should be noted that as of now, client-side Internet GIS has difficulty handling large databases.

Applications

Internet GIS provides a perfect tool for accessing, disseminating, and visualizing transportation information. Any data that can be displayed on a map, such as highway and transit traffic levels, construction conditions, and weather information, can be transferred using Internet GIS. Internet GIS also offers the potential for data sharing and transportation analysis over the Internet.

Interactive Road Maps

One of the most important characteristics of Internet GIS is the interaction between the user and the spatial data. The ability to perform GIS functions such as zoom, pan, query, and identify is especially useful for displaying road maps on the Internet. In addition to producing paper maps, state departments of transportation can publish interactive road maps on the Internet. Users can zoom into (or out of) an area, inquire about a specific address, and be provided with a map that is centered around the location of interest. Once this map has been obtained, the user can zoom in or

out and pan around to browse the neighboring areas. This electronic map is more convenient to use than the traditional paper maps. The distribution of Internet maps is also much broader than that of the paper maps generated by state DOTs. Anyone with a Web browser can get immediate access to a road map of any portion of a state.

MapQuest™ provides a good example of the interactive mapping services available on the Internet. The user can search for any address in the United States by entering the street address on the MapQuest Web site: <<http://www.mapquest.com>>. MapQuest will then present a map window such as that shown in Figure 1. The user can further zoom to a different scale, such as the street, city, or state level. The content of the map changes according to the scale requested.

Real-Time Information on Road Conditions

Internet GIS can be used to obtain real-time information on road conditions, such as road construction and weather-related road conditions. This capability reduces the burden on the 1-800 telephone road services. With Internet GIS, information on road conditions can easily be updated and maintained, and a weather-related road condition can be linked with weather information and changed in real time.

The Bureau of Automation Services at the Wisconsin DOT is implementing an Internet GIS site to disseminate road closure information using the MapObject Internet Map Server™ software, produced by Environmental Systems Research Institute, Inc. (see Figure 2). The road closure information can be updated by authorized transportation agencies and is instantly available on the Internet.

Information Sharing

Sharing of information is difficult even within agencies, and is virtually unknown across agencies. This is partly because there is no easy way to share spatial data, and partly because different data may not even be compatible. One must call around to find out who has what data, make a request, and wait for days or even weeks for the data diskettes to arrive.

This situation may soon change as Internet GIS enables agencies to publish information on the Web. Internet GIS offers an ideal tool for sharing information both within and across agencies. For example, a highway department can publish its real-time traffic information on the Web, and this information can readily be used by transit agencies for transit dispatch adjustment. Land use planning

FIGURE 1 Internet map service on MapQuest™ Web site.



agencies can publish their land use and zoning maps on the Internet, and environmental preservation agencies can publish their maps of environmentally sensitive areas. This information can be used by transportation planners in the development of transportation plans, and vice versa. This open sharing of information will greatly reduce the barriers within and among agencies. As an example, the Internet map in Figure 3 shows the availability and accessibility of transit service to a neighborhood in Milwaukee. Transit and social service agencies can share this information.

Public Involvement in Transportation Planning

Internet GIS offers an excellent channel for public involvement in the transportation planning process. Transportation planning agencies can use the Internet to publish information on planned road expansions or new transit routes. The public can interact with the road plan and offer input directly from the Web, without having to attend a town meeting.

Internet GIS and Intelligent Transportation Systems

Internet GIS can be an important tool in ITS development because of its capability to disseminate real-time travel information and assist in the formulation of trip plans.

Real-Time Traveler Information Systems. As noted earlier, Internet GIS is a perfect presentation tool for real-time travel information. For example, under the ITS model deployment initiative, Smart Trek in Seattle, Washington, in partnership with Microsoft, created TrafficView to present real-time traffic information on the Web (see Figure 4). Users can view the traffic flows throughout the city's freeway system and quickly find the travel speed along a specific link on a freeway; the road link is also connected with a real-time video snapshot so users can actually see the traffic flow. They can also zoom into a smaller area for a more detailed view.

Advanced Trip-Planning Systems. The graphical presentation of Internet GIS makes it an ideal tool for use by travelers in planning their trips. Through the link between Internet GIS and real-time traffic information, a traveler can plan a trip on the Internet based on his/her origin and destination as well as real-time traffic. For example, travelers in Seattle can plan their travel itinerary according to real-time traffic conditions

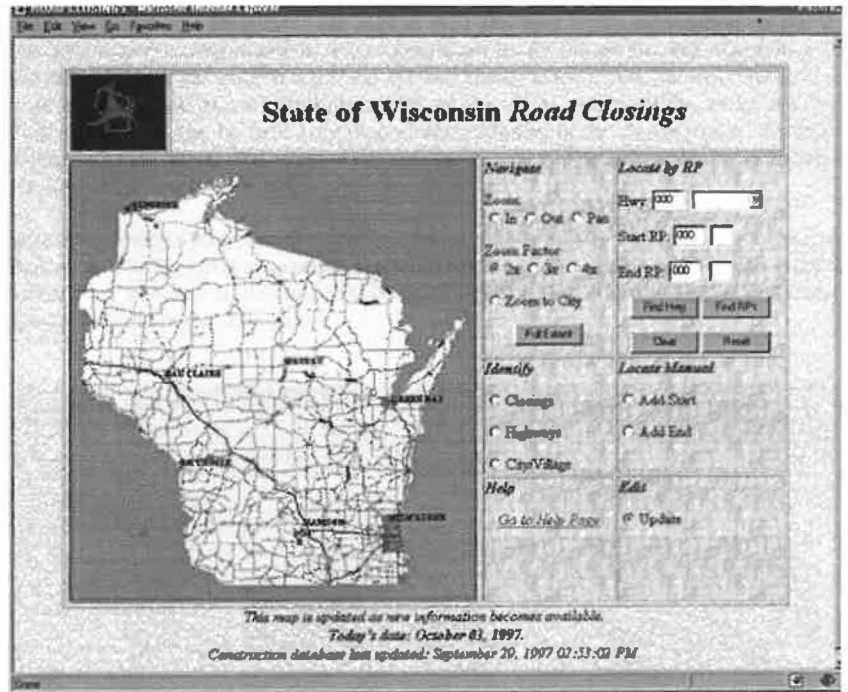
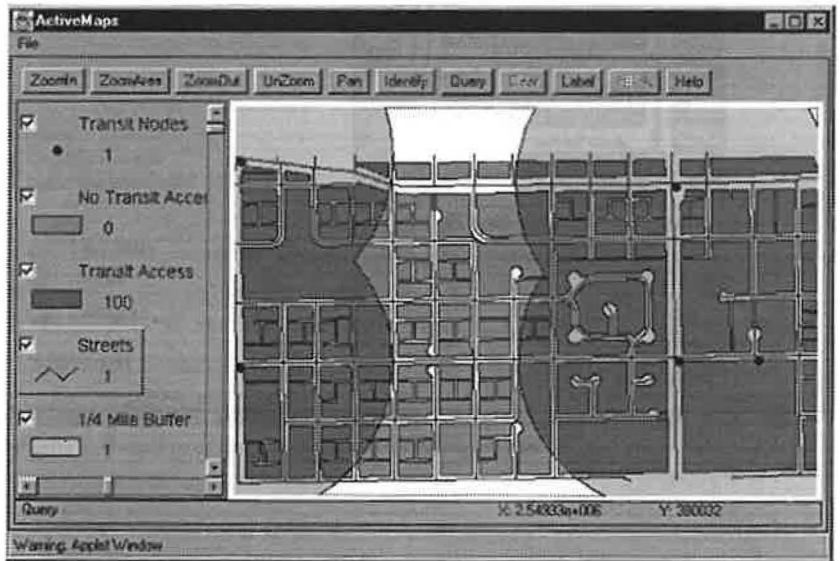


FIGURE 2 Road closure information on Internet, Wisconsin DOT.



NOTE: Map created by Kelley Raleigh-Otobed using ActiveMap™.

FIGURE 3 Internet map showing accessibility to transit service at midtown Milwaukee.

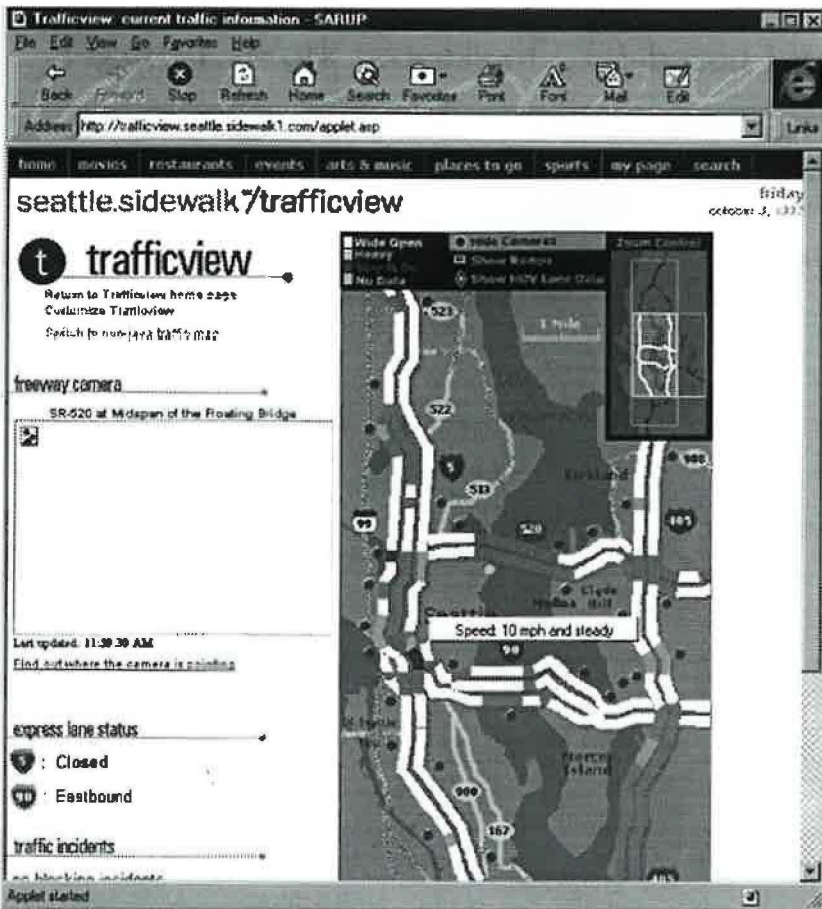


FIGURE 4 Real-time traffic information in Seattle.

displayed at the Seattle Sidewalk™ Web site: <<http://trafficview.seattle.sidewalk1.com/>>. Similarly, a transit user can use the Internet to plan his/her trip based on the real-time transit schedule and bus locations by linking with an automatic vehicle locator.

Implications

New technology usually has unintended consequences. Internet GIS allows transportation agen-

cies to share information with other agencies and the general public in ways never before possible. This capability raises issues related to the way these agencies deal with others and the extent to which they are willing to share information that was not so readily available in the past. The new capability also can disrupt existing relationships and the internal control of the organization. To the extent that knowledge is power, procedures that make information available to more people may be seen as a threat. The transition from an organization with tight controls on the release of information to one that has open access will be difficult and involve issues that extend far beyond the technology.

In the long run, the results of the transition to Internet GIS and wide access to information will likely be positive. The technology offers users many significant immediate benefits that can help improve transportation services. Greater scrutiny of information by others will result in more effort being made to provide valid and useful information, and this in turn will improve procedures and techniques over time.

GIS implementation in transportation is dependent upon technology, data, and organizational structure (NCHRP Report 359). Internet GIS technology has opened new possibilities for sharing and displaying information. However, it is important to stress that Internet GIS, like all tools for transportation analysis, relies on good data. The implementation of Internet GIS cannot solve the accuracy and consistency issues associated with differing transportation data. Transportation agencies have a great wealth of important data, but the accurate integration of these data is not as simple as adopting Internet GIS technology because the data are organized in fundamentally different ways. The adoption of Internet GIS will, however, promote more open and more systematic ways of organizing, acquiring, maintaining, and sharing transportation information.