A Trip Planner Interface with ArcGIS and HASTUS

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INTRODUCTION

This paper describes the integration of ArcGIS and the HASTUS transit scheduling and operations system to provide a powerful and cost effective on-line trip planner application. Our discussions focus on a tiered software architecture that is very accessible to other HASTUS sites.

The Orange County Transportation Authority (OCTA) has provided both bus routes and schedules information on its web site since early 2000. A trip planning module, calls YourTrip, http://www.octa.net/trip planner page1.asp, was added in early 2004, replacing the one provided by the Southern California Association of Governments (SCAG) for trips within the County. This web module is built using application interfaces to HASTINFO. The mapping interface further extends the trip planning functionality with a cartographic display that is consistent with other OCTA publications and map products.

BACKGROUND

The original YourTrip trip planning web application is designed to provide trip planning function to the general public from OCTA’s web site. It interacts with the HASTUS suite of applications from GIRO to deliver itinerary information to users. YourTrip is mostly textual; it has a wizard-type front-end to gather origin and destination, as well as travel time, information; and formats the recommended itinerary into a table layout. The mapping interface supplements the textual description of an itinerary with maps. These maps are optional outputs. The main benefits envisaged from this graphical display are: (a) better orientation for a rider regarding the trip, and (b) more concise directions to individual stops/transfers. Rider directions to egress points – the first, origin and the last, destination stops – are deemed especially useful.

HASTUS, the application that manages transit operations at OCTA, serves as the engine for the trip planning function. The sole purpose of the web application is to provide a customized user interface to the trip planning logic and schedule data residing entirely within HASTUS. We have considered using a slightly more sophisticated address lookup from GIS; however the function is not yet deployed.

Why did we go through all these troubles to customize the trip planning engine? HASTUS utilizes a skeletonized version of the transit system and streets network optimized for scheduling, crew assignments, and so on. The mapping interface gives a more aesthetically pleasing and more geographically realistic map image using spatial data maintained in the enterprise GIS at the Authority. While HASTUS does include a geographic database module in its suite of products, the GIS Section at OCTA has considerable data and programs to support both internal analyses and reports, and external publications. It is these investments that the project hopes to leverage.

Routes Planning and Alignment

GIS has traditionally been a significant contributor to transit planning and operations at OCTA. For more than 10 years, GIS has played the important role of data provider in transit planning and route alignments. Besides helping to manage the transit systems, GIS is also utilized in the highway side of the Authority, not to mention the large volumes of map products generated for various purposes.

There are a number of GIS-based tools within the Authority to manage bus stops and routes. Transit planners rely on a comprehensive GIS to conduct demographic studies, to identify and locate major employers and other concentration points, such as universities and community centers, to understand demands for transit service, to perform ridership analyses, and so on.

1 The author is a consultant to OCTA on the YourTrip mapping project. OCTA has not authorized or reviewed this paper. Opinions and discussions presented here are solely that of the author.
Route alignments are constructed using a suite of ArcView tools. Bus routes and bus stops are maintained in an integrated GIS, along with reference geography. Transit data elements are exported to the scheduling and operations application. Quite often scheduling data in HASTUS are accessed by GIS applications too. Nevertheless, the interface between these two systems had been limited to mostly data interchange. Details of these operations can be found in Hsiao and Chou.\(^2\)

This mapping interface extension to trip planning demonstrates a truly seamless, dynamic integration of ArcGIS and HASTUS at the Authority.

**Trip Planner Application**

On-line trip planners have become standard applications on transit agencies’ web sites. Figure 1 shows a sample output of the YourTrip trip planner at OCTA, with itinerary maps included. The report page shows itinerary summary at the top, containing information about the buses to be used for the trip. In the middle are the maps: an overview map showing the entire itinerary, and two inset maps for the starting and ending points of the trip. The bottom table displays textual, segment-by-segment instructions for the itinerary.

Given the familiarity and popularity of maps in today’s web sites, the page does not seem too exciting. In fact, after almost two-year in service, the page is very much dated. What this paper introduces is not web page design but an approach calls mashup\(^3\) – of combining multiple data sources and maps. And mashup is not just for Google map and Craigslist.

Maps are actually optional in our itinerary reports. Unlike driving instructions web pages, not all trip planner requests need accompanying maps. Transit passengers often simply want to confirm schedules for trips they make regularly. Figure 2 shows a version of the itinerary page where users can selectively decide the maps to display. If you visit the trip planner on the OCTA web site, the page shown in Figure 2 comes before the earlier figure in the wizard interface.

In our trip planning web application, the application, after having obtained itinerary reports from HASTUS, keeps the reports in the web page. When the user issues a mapping request, the itinerary report is submitted to a separate mapping web service where maps are produced and the itinerary overlaid on it. The decoupling of the trip planning function from that of mapping is especially suited to this usage scenario.

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\(^3\) For a good read on the original use of the term “mashup” in music, see S Frere-Jones, *The new math of mashups*, in The New Yorker, Issue 2005-1-10.
Figure 1. Sample Itinerary Report
Figure 2. Sample Itinerary Report, Without Maps

<table>
<thead>
<tr>
<th>Depart: 550 S MAIN ST in ORANGE at 6:16 a.m.</th>
<th>Arrive: 18 TECHNOLOGY DR in IRVINE at 7:01 a.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>This plan is for travel on Tuesday, August 03, 2004. Your trip will take approximately 45 min. You have one transfer. Estimated total walking distance is under 1/4 mile.</td>
<td></td>
</tr>
<tr>
<td>Walk to MAIN-LA VETA in ORANGE, stop #6526 [map this step]</td>
<td></td>
</tr>
<tr>
<td>At 6:17 a.m., take Route 53 South. Exit bus at 5TH-SYCAMORE in SANTA ANA, stop #6019 at 6:27 a.m. [map this step]</td>
<td></td>
</tr>
<tr>
<td>Transfer at 5TH-SYCAMEORE in SANTA ANA, stop #6019. At 6:32 a.m., take Route 206 South. Exit bus at ALTON-ADA in IRVINE, stop #8143 at 6:57 a.m. [map this step]</td>
<td></td>
</tr>
<tr>
<td>Walk to 18 TECHNOLOGY DR. [map this step]</td>
<td></td>
</tr>
</tbody>
</table>

For more information, call the Customer Information Center at 714.536.RIDE (7433), extension 1. From Riverside County and South Orange County, call 1.800.536.RIDE (7433), extension 1. We try to include all relevant detour and routing information. For a full list of current service changes, visit our Rider's Alert Page.
Solution Architecture

The mapping interface is architectured as an external service to the YourTrip web application; it uses the dynamically generated itinerary reports from HASTUS to highlight the routes and stops. This decision to use a service architecture rather than an integrated application stems from hardware and software constraints, and also industry best-practice. Services consist of their own applications with their own data sources, business logic and, infrequently, user interface. The trip planning and mapping functions have distinct business logic and quite different data sources. We believe this architecture gives us the most reliable, flexible, scaleable and maintainable solution. It also allows us to keep the HASTUS database components reasonably secured, behind firewalls.

The mapping interface was developed as a Java servlet. It utilizes the Java Connector of ArcIMS for map generation. The project has established early on that interactive map is secondary to “print and take-away“ itinerary similar to the popular MapQuest drive instruction maps, thus, map images from ArcIMS are embedded inside the YourTrip web pages and do not provide the conventional mapping zoom/pan user interface. Users can still zoom into details at transfer points.

The mapping interface accepts input from the YourTrip web application in the form of a well-formed XML document (described below.) This XML document is the same used in the generation of the formatted, text itinerary table. The document provides information about trip origin and destination, and also individual steps or trip segments. Figure 3 shows the architecture design of the web application.

In a typical use case of the mapping interface, users of the on-line trip planner answer a number of travel related questions through a wizard-style interface. The YourTrip web application then submits the information to the HASTUS application for the trip planning analysis. HASTUS, via a customized gateway, returns itinerary reports to the web application in XML documents, identifying the best transit alternatives available from its scheduling database. The YourTrip web application formats itinerary reports into a step-by-step table listing. At every transfer points, and for the start and end points of the trip, the step-by-step instructions include map request links. A link for the overview map covering the entire trip is included on every result page also.

Data Integration

The only information communicated between the YourTrip web application and its mapping interface is represented in a XML document. XML has become a standard, self-documenting data transfer mechanism. Figure 4 shows an excerpt of the XML document that fully describes an itinerary returned by the HASTUS trip planning application gateway. We do hope to switch to a standard-oriented format in the near future.

Figure 3. Architectural Diagram.
Briefly, the itinerary document has a top level "<trip>" element. There are four subelements within this root level element. These are (a) "<origin>", (b) "<destin>", (c) "<params>" and (d) "<steps>". Origin and Dest represent user specified trip origin and destination street addresses; these are normally not directly on or even adjacent to a bus route. Steps are a collection of bus rides, transfers, and waits. The Params contains travel information such as date and time of travel, estimated total travel time, and so on.

Figure 4. Itinerary Document Sample.

```
<origin>
  <name>LAGUNA WOODS CITY HALL</name>
  <id>01[834|445504|1]-2147483648|291|6112920|2168477|LAGUNA WOODS CITY HALL</id>
  <time>11:01 AM</time>
  <param type="0">Ident LWCTYH</param>
  <params id="ident LWCTYH"/>
  <type>0</type>
  <destin>
    <name>WESTMINSTER CENTER</name>
    <id>01[788|519302|0]-2147483648|401|6026554|2224987|WESTCNTR|WESTMINSTER CENTER</id>
    <time>1:01 PM</time>
    <param type="0">Ident WESTCNTR</param>
    <params id="ident WESTCNTR"/>
    <type>0</type>
    <steps>
      <step>
        <instruction>Walk to EL TORO-MOULTON in ORANGE COUNTY, step #4640</instruction>
        <detail>Walk to EL TORO-MOULTON in ORANGE COUNTY, step #4640</detail>
      </step>
      <detail>Walk to EL TORO-MOULTON in ORANGE COUNTY, step #4640</detail>
      <mode>WALK</mode>
      <sequence>1</sequence>
      <segment>60873942</segment>
      <params id="ident WESTCNTR"/>
      <type>0</type>
    </steps>
    <traveldate>12/06/2004</traveldate>
    <stepcount>0</stepcount>
    <duration>143280</duration>
    <distance>120</distance>
  </destin>
  <params id="ident LWCTYH"/>
  <type>0</type>
</params>
```

"Your trip will take approximately 2h00 min.\nYou have 2 transfer(s)"

```
<steps>
  1
  <step>
    <instruction>Walk to EL TORO-MOULTON in ORANGE COUNTY, step #4640</instruction>
    <detail>Walk to EL TORO-MOULTON in ORANGE COUNTY, step #4640</detail>
    <mode>WALK</mode>
    <sequence>1</sequence>
    <segment>60873942</segment>
    <params id="ident LWCTYH"/>
    <type>0</type>
    <traveldate>12/06/2004</traveldate>
    <stepcount>0</stepcount>
    <duration>143280</duration>
    <distance>120</distance>
  </step>
  2
  <step>
    <instruction>At 1105am, take Route 089 North.\nExit bus at EL TORO-PASEO DE VALENCIA in LAGUNA HILLS, step #3910 at 1117am.</instruction>
    <detail>At 1105am, take Route 089 North.\nExit bus at EL TORO-PASEO DE VALENCIA in LAGUNA HILLS, step #3910 at 1117am.</detail>
    <mode>WALK</mode>
    <sequence>1</sequence>
    <segment>60873942</segment>
    <params id="ident LWCTYH"/>
    <type>0</type>
    <traveldate>12/06/2004</traveldate>
    <stepcount>0</stepcount>
    <duration>143280</duration>
    <distance>120</distance>
    <depart>11:01 AM</depart>
    <arrive>11:05 AM</arrive>
  </step>
</steps>
```
Remarks

For this trip planning application, OCTA maintains all the servers: HASTUS, ArcIMS, and the Web application; however the solution allows other configurations. For example, should the Authority decide not to maintain the map server any longer, the solution could be easily migrated to, say, map.Google.com, or to a pay-service such as ArcWeb from ESRI or MapPoint Web Services from Microsoft. To another agency which does not intend to deploy an internet map server, this could be additionally attractive.

Last year, the Federal Transit Administration initiated a project to demonstrate integration of existing single mode trip planning through the use of eXtensible Markup Language (XML) schemas based on the Society of Automotive Engineers (SAE) Advanced Traveler Information Systems (ATIS) Standard (J2354) and the Transit Communications Interface Profiles (TCIP) standards. The trip planning application presented here did not take advantages of these standards, although we hope to in the future. Granted the integration of multiple, independent, trip generators is significantly more complex than the mashup of images. The use of standard itinerary description is extremely powerful.

There are other data integration issues besides the content and format addressed by the like of ATIS and TCIP that are critical in our integration exercise. Figures 5 and 6 illustrate the different geometric – spatial – representations of bus routes and stops in GIS and HASTUS at OCTA.

As mentioned earlier, HASTUS maintained a network representation optimized for scheduling and run-cutting. There is simply no justification to maintain the double-side curb lines or highly detailed curves of streets in a scheduling application. These are, however, often desirable in mapping applications.

Another, more insidious, representation difference is that bus stops are logical nodes in the transit network; they are not free floating points as shown in the GIS maps here.

It is as easy, or as hard, to implement both representations in the two systems. But we are of the opinion that a service architecture provides more effective and flexible integration.
As map examples in this paper show, being able to clearly identify bus stops, in their relative geographic locations rather than on street centerlines, could be helpful for a passenger to locate the appropriate stop, especially at intersections. In a customer information application such as the trip planner, helping customers get to the system is more important than highlighting the particular streets transit vehicles travel from the origin to the desired destination. Much of the information required to direct transit clients to egress points resides outside of the transit database. Fortunately, usually they can be found in other geospatial databases. Given the relative dense network of bus stops in an urban situation such as the examples here, the “best” stops to use might require considerations of pedestrian crossings, not to mention ADA accesses, and other criteria not strictly within the transit system.

This paper documents a solution where a web application successfully integrated ArcIMS and HASTUS to improve the delivery of information to transit users. Furthermore, this project demonstrates but one example of how improved technologies and better developed standards allow us to integrate seemingly disparate and specialized systems together.
Figure 7. Sample Itinerary Report.