Explore: An Attraction Search Tool for Transit Trip Planning

*Kari Edison Watkins, PE
PhD Student, Dept. of Civil & Environmental Engineering
University of Washington
5702 35th Ave NE
Seattle, WA 98105
(206) 250-4415
kariwat@u.washington.edu

Brian Ferris
PhD Student, Dept. of Computer Science & Engineering
University of Washington
Box 352350
Seattle, WA 98195-2350
(206) 303-82220
bdferris@cs.washington.edu

Resubmission Date: November 12, 2009

Word Count: 5592 words + 6 tables/figures (1500 words) = 7092 words

*Corresponding Author

ABSTRACT

Publishing information about a transit agency's stops, routes, schedules, and status in a variety of formats and delivery methods is an essential part of improving the accessibility of a transit system and the satisfaction of a system's riders. One of the key staples of most transit traveler information systems is the trip planner, a tool that serves travelers well if the both origin and destination are known. However, sometimes the accessibility of a location via transit is more important than the actual destination. Given this premise, we developed an Attractions Search Tool to make use of an underlying trip planner to search online databases of local restaurants, shopping, parks and other amenities based on transit accessibility from the user's origin. The ability to perform such a search by attraction type rather than specific destination can be a powerful aid to a traveler with a need or desire to use public transportation.

BACKGROUND

Publishing information about a transit agency's stops, routes, schedules, and status in a variety of formats and delivery methods is an essential part of improving the accessibility of a transit system and the satisfaction of a system's riders. No longer the domain of just simple printed schedules, transit traveler information systems have grown to include route maps and timetables, trip planners, real-time trackers, service alerts, and others tools made available across cell phones, web browsers, and new internet devices as driven by rider demand (1). The numbers speak for themselves. As of June 2008, the US had almost 263 million wireless phone subscribers, the equivalent of 84% of the US population (2). As of 2007, there were 222 million internet users (3). With such usage rates, providing transit traveler information via cell phone and internet gives agencies the ability to reach most of their potential customers.

The primary reason for providing better traveler information as a service to customers is to increase ridership by making transit service easier to use and more convenient. This can be especially true for infrequent transit users and non-peak hour trips, two key markets for improving load factors for many agencies. Transit information appeals most to choice riders and can result in a mode-shift to public transportation (1). Providing automated user information through trip planners can also reduce the need for call-center representatives to address schedule questions over the phone (4).

One of the key staples of most transit traveler information systems is the trip planner. Trip planners use an origin address and destination address to search for a transit vehicle that travels between the two according to the desired time-frame of the traveler. Most trip planners begin with assumptions about walking distance, transfers and time-frame, requiring a user to enter only two addresses to perform a search. The next step can involve refinements to the initial information provided to narrow or enhance the search for a particular transit trip.

Trip planners have existed for decades, but were primarily used by agencies for in-house call center staff. The first internet-based transit journey planners were introduced by transit agencies in the 1990's. As of 2002, there were 30 web-based trip planners in the US (4). At the time, transit agencies had significant interest in developing online trip planners, with new ones being added at a rate of about 1 per month (4). Trip planners were seen as a way to save money, provide better service and increase ridership, but the agencies lacked the money to implement them and knowledge about GIS, ITS, trip planning vendor terminology and maintenance of websites (4).

Online transit trip planning took a leap forward with the release of Google's transit trip planning lab product in December 2005 and subsequent integration into their Google Maps site in June 2006 as Google Transit. Since the launch of this product, transit agencies of various sizes in 256 cities in 29 countries have provided their data to Google for integration into their system (5).

TRANSIT AGENCY TRIP PLANNERS TODAY

Today, the most useful source for pre-trip information is the internet (6), especially for younger riders (7). People typically consult information for a new trip unless their trip has no time constraints, service is frequent, or journey is local (7). Many different types of pre-trip information are sought by riders. Among other pre-trip queries asked by transit customers for occasional trips is the question, "What routes are near my home, work and other key locations, and what destinations can I reach by transit from these points?" (1) Table 1 shows the results of our investigation of the trip planners for the 50 transit agencies with the highest unlinked passenger trips in the United States. Trip planners are found on the websites of most of these agencies, either in their own version or through a link to Google. The few agencies without trip planners have provided schedule data to a larger agency in their area. In two cases however, those of the City of Los Angeles DOT and Ride-on Montgomery County, although their data can be searched on other agencies trip planners, their websites do not provide a link specifically to those trip planners.

TABLE 1 Trip Planner capabilities for the 50 largest transit agencies in the United States

	Transit Agency	City	State	2007 UPT	Trip Planner on Website	Google Transit
1	MTA New York City Transit	New York	NY	3,256,977,960	Yes	Yes
2	Chicago Transit Authority	Chicago	IL	499,544,307	Link to Google	Yes
3	Los Angeles Co. MTA	Los Angeles	CA	495,362,403	Yes	Yes*
4	Washington MATA	Washington	DC	411,598,592	Yes	No
5	Massachusetts Bay TA	Boston	MA	357,578,991	Yes	Yes
6	Southeastern Pennsylvania TA	Philadelphia	PA	321,839,783	Yes	Yes*
7	New Jersey Transit Corp.	Newark	NJ	268,289,345	Yes	Yes
8	San Francisco Municipal Rail	San Francisco	CA	206,458,675	Yes	Yes
9	Metro. Atlanta Rapid TA	Atlanta	GA	147,523,544	Yes	Yes
10	King County Metro	Seattle	WA	113,928,156	Yes	Yes
11	Miami-Dade Transit	Miami	FL	111,263,859	Link to Google	Yes
12	MTA Bus Company	New York	NY	110,269,609	MTA NYC	Yes
13	San Francisco Bay Area RTD	Oakland	CA	109,219,470	Yes	Yes
14	Maryland Transit Admin.	Baltimore	MD	108,831,451	Link to Google	Yes
15	MTA Long Island Rail Road	Jamaica	NY	102,143,717	MTA NYC	Yes
16	MTA of Harris County	Houston	TX	100,868,417	Yes	Yes
17	Tri-County MTD	Portland	OR	100,638,004	Yes	Yes
18	Denver RTD	Denver	CO	94,196,136	Yes	Yes
19	Port Authority Trans-Hudson	Jersey City	NJ	82,406,648	NJ Transit	Yes
20	San Diego MTS	San Diego	CA	82,333,186	Yes	Yes
21	MTA Metro-North Railroad	New York	NY	80,324,201	MTA NYC	Yes
22	Metro Transit	Minneapolis	MN	76,966,724	Yes	Yes
23	METRA	Chicago	IL	74,550,584	Link to Google	Yes
24	Dallas Area Rapid Transit	Dallas	TX	73,949,618	Yes	Yes
25	City and Co. of Honolulu DOT	Honolulu	HI	72,557,307	Link to Google	Yes
26	Orange County TA	Orange	CA	70,266,572	Yes	Yes
27	Port Authority of Allegheny Co.	Pittsburgh	PA	68,525,198	Yes	Yes
28	Alameda-Contra Costa TD	Oakland	CA	67,414,737	511 SF Bay	Yes
29	RTC of Southern Nevada	Las Vegas	NV	63,733,694	Link to Google	Yes
30	The Greater Cleveland RTA	Cleveland	OH	60,187,823	Yes	Yes
31	Bi-State Development Agency	St. Louis	MO	53,990,802	Yes	Yes*
32	Valley Metro	Phoenix	AZ	50,590,609	Yes	No

33	Milwaukee County Transit	Milwaukee	WI	46,599,318	Link to Google	Yes
34	Santa Clara Valley TA	San Jose	CA	43,434,199	Link to Google	Yes
35	Broward County Office Trans	Pompano Beach	FL	42,442,268	Link to Google	Yes
36	VIA Metropolitan Transit	San Antonio	TX	41,717,688	Yes	Yes*
37	Utah Transit Authority	Salt Lake City	UT	41,349,702	Yes	Yes*
38	Pace - Suburban Bus Division	Arlington Hts	IL	36,590,058	Link to RTA	No
39	City of Detroit DOT	Detroit	MI	35,402,314	Link to Google	Yes
40	Capital MTA	Austin	TX	34,039,638	Yes	Yes
41	MTA Long Island Bus	Garden City	NY	32,440,169	MTA NYC	Yes
42	Sacramento RTD	Sacramento	CA	32,261,658	Yes	Yes
43	Westchester County Bee-Line	Mount Vernon	NY	31,079,433	Link Trips123	No
44	DOT and Public Works	San Juan	PR	30,491,313	No	No
45	City of Los Angeles DOT	Los Angeles	CA	30,205,735	On LA Metro	No
46	Ride-On Montgomery Co. Transit	Rockville	MD	28,302,019	On WMATA	Yes**
47	Long Beach Transit	Long Beach	CA	26,636,190	Link LA Metro	Yes**
48	Southwest Ohio RTA	Cincinnati	OH	26,146,916	Yes	No
49	Central Florida RTA	Orlando	FL	26,078,255	Yes	No
50	Niagara Frontier TA	Buffalo	NY	24,145,786	Yes	Yes

* = Added since research initially conducted in April 2009
** = Added since first version of TRB paper written in July 2009

Although online trip planning has come a long way in the past decade, the current information provided is still considered poor to average in many cases and there is a desire for higher quality information (8). Efficiency, the ease and speed of accessing and using the site, is the most critical contributor to users' perceptions of a website (6). In one rating of nine cities based on website performance, static information performance and journey planner performance, Melbourne and London performed the best, but US cities Portland and Washington DC performed well (9).

RECENT ENHANCEMENTS TO TRIP PLANNERS

The state-of-the-art in trip planning has changed rapidly over the past decade. Beyond the typical trip planner, several transit agencies and third-party developers have added more advanced tools to their trip planners. Recent enhancements include added input capabilities, output capabilities, mapping capabilities and multi-modal integration.

The minimal input into a trip planner includes the origin address, destination address, date and time of trip. In addition, many trip planners frequently add inputs such as maximum walk distance, maximum number of transfers, need of ADA accessible service, and preferred mode of travel. Such inputs can allow a user to minimize walking or transfers, rather than just journey time. Rather than just inputting origin and destination by address, some trip planners allow input by intersection, stop or station, or landmark. The trip planner for the Southeastern Pennsylvania Transportation Authority in Philadelphia even allows a user to click on a map to add an address (10). Utah Transit Authority in Salt Lake allows a rider to develop a history of addresses or categories searched (11). For most trip planners, the time of the trip can be specified by departure or arrival time, and sometimes the date of travel can be made variable.

Using this input, trip planners output at least one potential route in response to the input constraints. These output routes typically include detailed walk, transit and transfer directions with times of trips, as well the potential to investigate earlier or later trips, fare information, links to schedules, and route maps. This information appears on the screen, but more recent enhancements allow results to be printed, e-mailed or downloaded to a PDA. Many agencies now include a button to quickly plan the return trip as well. The Dadnab text-message based trip planner is available in ten metropolitan areas and Metropolitan Transit Authority in New York has a mobile trip planner available from their website (12, 13). Bay Area Rapid Transit in San Francisco has several mobile tools available for riders. BART also has one of the best website trip planners in terms of output, with maps of walk and transit components and information such as detailed station information, carbon saved by using public transportation, fare information, and station advisories all on one output screen (14).

One area of potential online trip planner enhancement is the use of maps not only for displaying outputs, but also for locating origin and destination addresses. Cherry, Hickman, et al have implemented an ArcIMS GIS-based itinerary planner for Sun Tran in Tucson that allows users to select origin and destination on a map in addition to traditional manual address entry or pull down landmark menus. As they point out, the difficulty in implementing such a feature is in the slow speed of calculation due to the necessity of redrawing the map (15). The Melbourne journey planner has successfully been enhanced to include the ability to input origin and destination by clicking on a map (16).

A critical component of the future of transit trip planning is the ability to integrate trip planners across agencies and across modes. Regional trip planners such as Goroo, the trip planner found on the Chicago area Regional Transportation Authority website, typically work through obtaining a feed from all agencies involved in the trip planner (17). Regularity of feed data through standards such as the Google Transit Feed Specification and the JourneyWeb protocol allow integration of multiple trip planners (18). Others have attempted the integration of two completely independent trip planners using a broker that divides the trip between the two systems and assembles the answer for the user. One system was developed and tested for the trip planners in greater Waukesha and Milwaukee, Wisconsin (19).

In addition to integration across agencies, integration across modes is a critical future direction for trip planning. The Google transit trip planner began as an enhancement to their online roadway directions. Multi-modal trip planners have been developed by others prior to Google's work (20). More recently, several regions, including greater Chicago, Atlanta, London, and Athens have developed multimodal trip planners. The Regional Transportation Authority's Goroo trip planner includes the option to obtain directions for train, bus, driving and drive to bus, comparing the distance, time, cost and carbon output of the trip for the modes queried (17). The goal of the site is to eventually include biking as a mode and parking availability features. The A-Train in Atlanta and Transport for London already include cycling and walking routes in their transit trip planners, however driving is not an option (21, 22). In Athens, an urban trip planner has been combined with country-wide coach, air and ferry service (23).

BEYOND THE SINGLE TRIP ORIGIN / DESTINATION PLANNER

To aid commuters in their individual transit planning, several agencies have added trip planner tools that go beyond a single origin to destination trip. MTA in New York, MUNI in San Francisco, Seattle's King County Metro and Minneapolis all have added Point to Point schedules to their websites to allow users to obtain personalized schedules over a range of times between any two locations on the same route. In addition, King County Metro recently added a Commuter Trip Plan feature that gives a series of trip plan options between any two points, such as a home and work location.

Many agencies have added "service in area" searches to allow a user to search for routes in the area of a landmark or address. Examples of this can be found on the NJTransit and WMATA websites. This type of search appeals to someone who is new to a location or new to transit and trying to investigate routes accessible to one location. However, without consulting maps for each of the routes, these "service in area" tools cannot provide information about potential destinations along the reachable routes.

In addition to these agency trip planners, Google Maps has implemented a Search Nearby tool that allows users to enter an address and then search for attractions nearby by entering a category (doctor, park, etc). Although users could then click on any of the resulting nearby attractions to find transit directions, it may require several tries before an easily accessible destination is found.

ONE BUS AWAY EXPLORE TOOL

Typical online trip planners work well if the destination is known. However, sometimes the accessibility of a location via transit is more important than the actual destination. Here are a few examples:

1. A transit-dependent elderly woman needs to find a new doctor's office for regular visits. Although the quality of the care is important, several doctors would be acceptable for her situation. The ability to search for a doctor that is easily accessible via transit can help make her routine trip to the doctor easier on her.
2. A group of college roommates wants to go out drinking and are concerned about getting home without needing to drive. Although some bars are more popular, many would be welcome choices. By having the ability to search a website for easily accessible bars, the group finds using transit preferable to driving intoxicated.
3. A new mom with a desire to limit her carbon output is looking for activities to entertain her toddler. She is willing to go to any number of local parks or community centers, but would enjoy traveling without her car. Using an accessible attractions search tool allows her to pick a location for their daytrip and travel car-free.

For first-time and infrequent riders who are not familiar with what is accessible using their local routes, these can be difficult questions to answer. Such a search would require looking up and typing in multiple destinations into a trip planner (or worse yet – consulting a paper schedule) and would not be worth the effort. Given this premise, we developed the Explore Attractions Search Tool to make use of an underlying trip planner to search online databases of local restaurants, shopping, and other amenities.

Initial Version

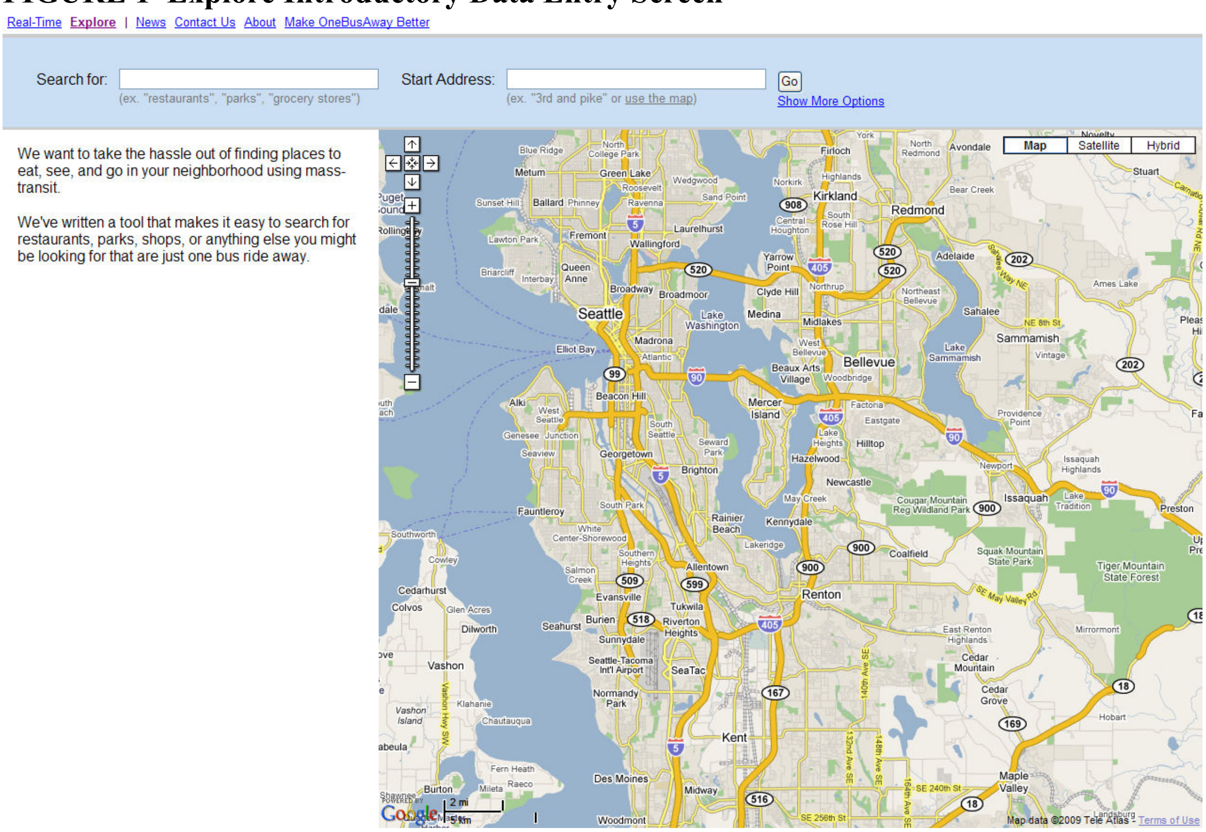
In the first iteration of the Explore tool, a website was created that searched a four table Microsoft SQL Server database. The user would input a route number and an attraction type (doctor, bar, park, etc). The program would then search an ordered pattern stop table to translate the route to a list of stops along the route. Using the longitude and latitude of the stops, the program would search a destinations table for the particular category and output a list of possible destinations. The functionality of this version was limited because the user had to input a route rather than an address. In addition, only a list of destinations and their addresses was output, rather than typical trip planner directions. However, the main problem with this approach was that all the data was static GIS data stored locally on a computer and would have had to be maintained by the authors. Therefore, it was decided that the next iteration should rely entirely on data updated by other parties, such as King County Metro, Google or Yahoo.

As the process of redoing the Explore tool began, the authors brainstormed features they would use in such a tool. In addition, they interviewed several users from different demographic categories to gain input for format and features.

Current Version

In the current version of Explore, the user specifies their starting point along with what they are interested in searching for. Optionally, they may specify a start time and date, a maximum trip length, a maximum number of transfers, and a maximum walking distance. A screen shot of the introductory data entry screen is shown in Figure 1.

FIGURE 1 Explore Introductory Data Entry Screen



When the search is submitted, the program executes the search in two steps. The first step involves computing the total area reachable by transit given a starting point and any constraints supplied by the user. The second step involves doing a local search within the reachable transit area for the amenities specified by the user. We describe these two steps in further detail below.

Finding the Area Reachable by Transit

To find the total area reachable by transit, we specifically search for the set of all transit stops reachable from the user-specified starting location in the specified amount of time along with any additional constraints, such as the number of transfers or max walking distance. This search problem is fundamentally different than the search task undertaken by a typical trip planner. In the typical case, the search is between a known source and destination, so directed search algorithms such as A-Star search can be leveraged to efficiently find paths between the two points. In our case, we have no fixed destination. Instead, we are looking for efficient paths to ALL potential stops and destinations reachable within the constraints specified by the user.

To compute this set of stops, we employ what is essentially Dijkstra's graph search algorithm on a memory-resident street/sidewalk and transit network graph, with a number of optimizations to limit the search space. Effectively, we simulate all potential trips taken by a rider from the starting location, advancing each trip in parallel through time. As each trip reaches a new stop, we note if it was the first trip to reach the stop. If so, we continue modeling the trip. If not, we prune the trip from further consideration, since any travel from this stop going forward would be made using the first trip that had already reached the stop. We stop searching when the length of the longest trips in the current search reach the time window specified by the user.

As an optimization, we pre-compute offline the full set of potential transit transfer points in the transit network graph. Since we are computing the fastest times to reachable stops, as opposed to the set of all points on the street/sidewalk network, our graph search can avoid having to search the street/sidewalk network for potential destinations and transfers and can instead only consider transfer points between stops in the pre-computed set. This optimization dramatically reduces the search space of potential trip itineraries.

Through the careful optimization and pruning in the graph search described above, combined with keeping the entire transit network graph in-memory for fast access, we can usually compute in under 200 ms the set of all reachable stops for a typical time window (20 minutes). This response time is good enough for use in a web application where quick responses to webpage requests are essential for user satisfaction.

Finding Amenities Within in the Area Reachable By Transit

Once the set of reachable stops is computed, the second step of the search begins as we discretize the reachable area into a half-mile grid, including a grid cell if it contains one of the reachable stops. We then start searching for local businesses and amenities as specified by the user within the activated grid cells of the reachable area. The beta version of One Bus Away Explore utilizes the Yelp (http://yelp.com) online database of reviews, but we could just as easily integrate another local search database such as Google Local or Yahoo Local. Once results have been returned, we check them against out street/sidewalk network to ensure that there is a path from a nearby stop to the search result and that the total travel time is still under the specified limit. We wish to avoid search results that are close to a reachable stop, but that are separated by non-walkable barrier such as a major highway or a body of water.

FIGURE 2 Parks that are less than 30 minutes away by bus from a Seattle residence

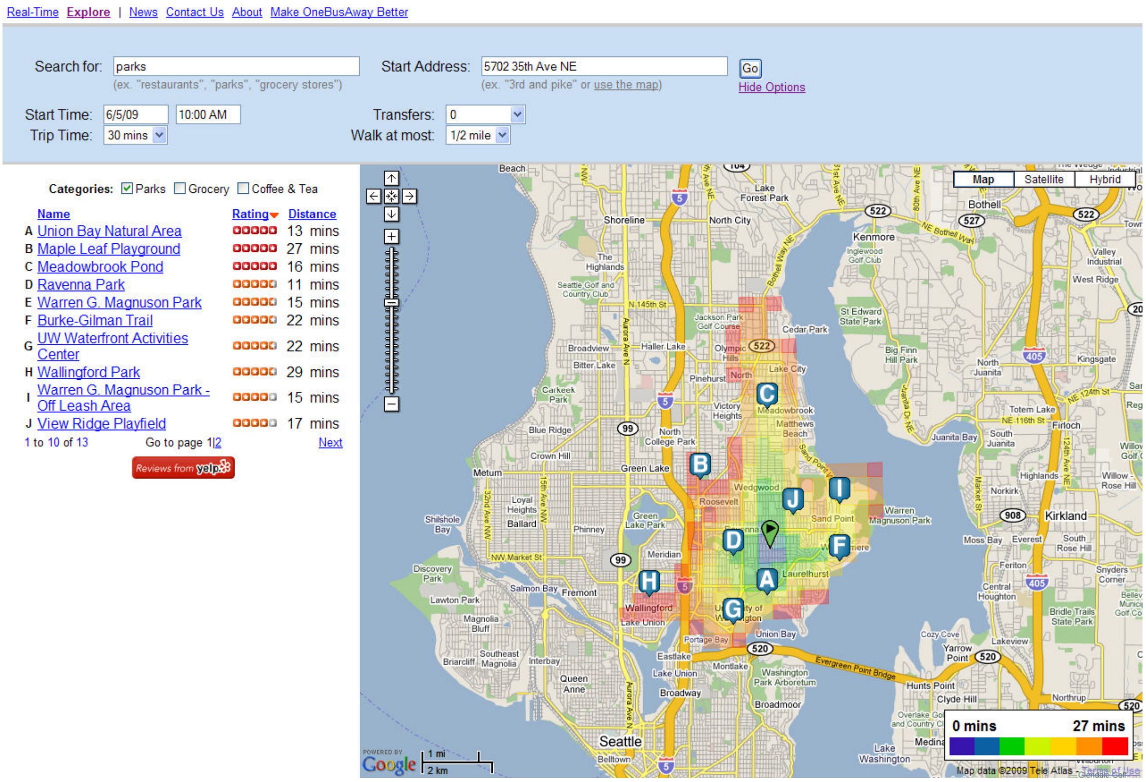


FIGURE 3 Trip plan results for a specific park using Explore

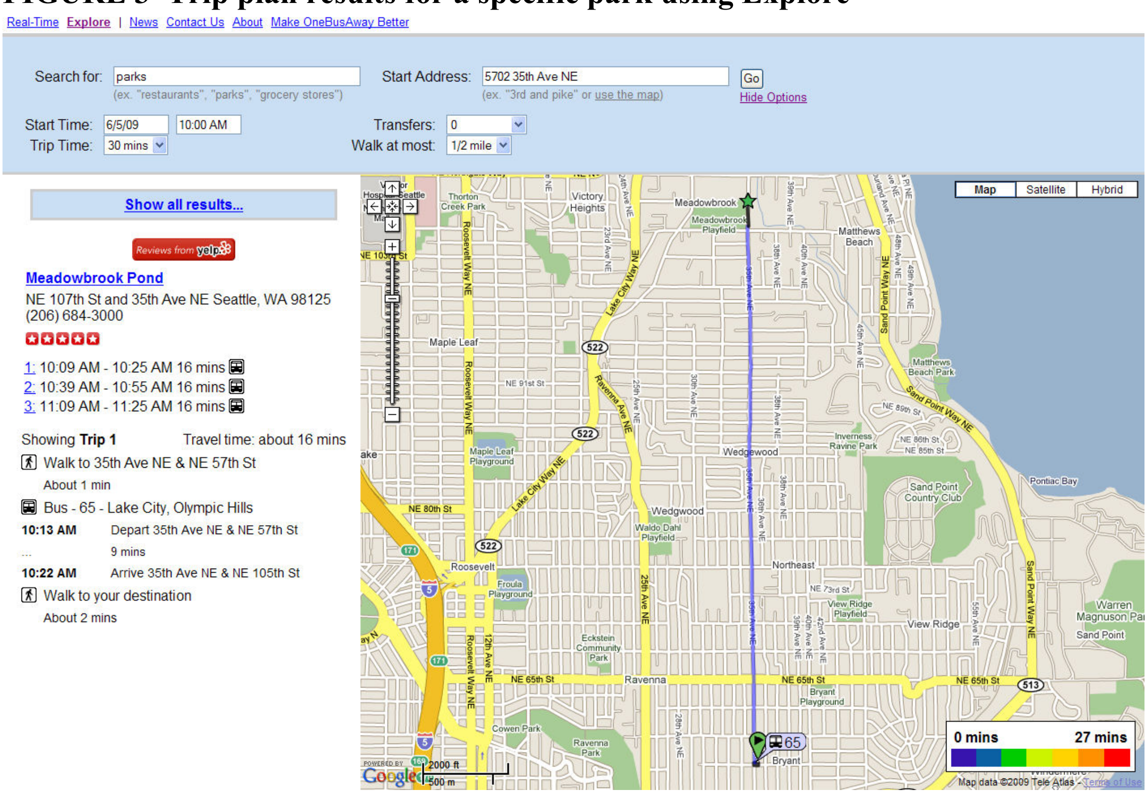
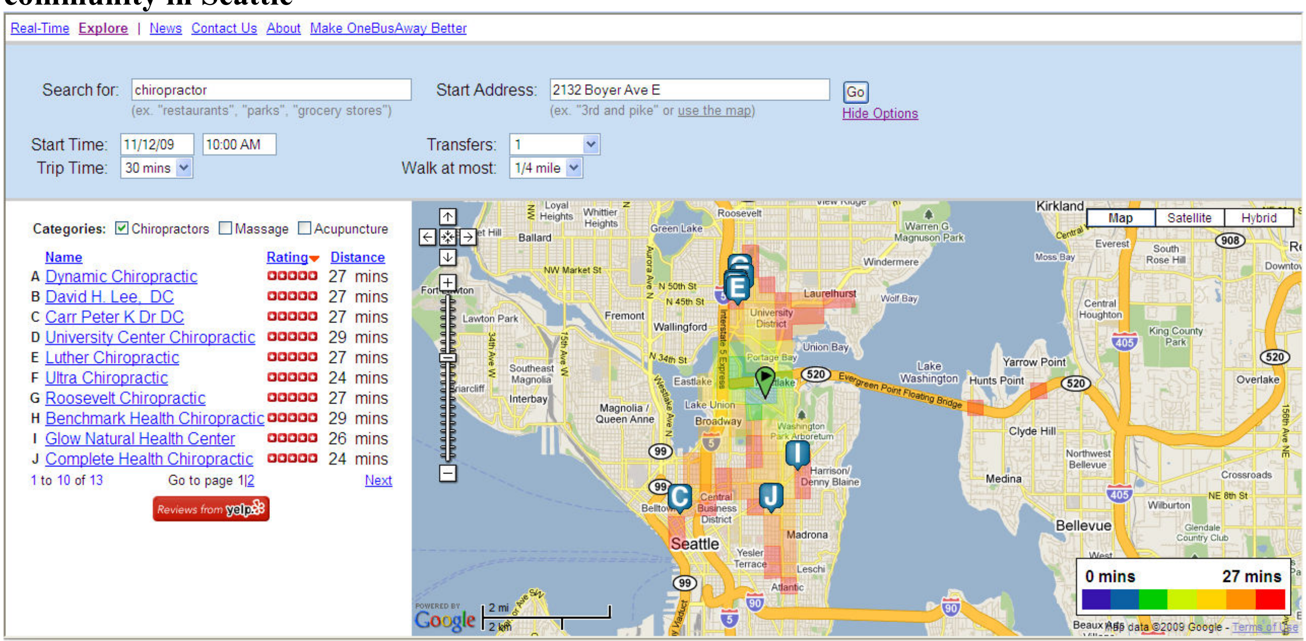


Figure 2 shows the resulting screen from the initial search. In this example, the user has searched for nearby parks within 30 minutes by transit from their home with no transfers. The display of results includes the name of the park, the average rating for that park, and the minimum travel time to that park, along with a display of all the results on a map.

Once a user has settled on a particular park, they can select it for more information, including location and up to three transit trip plans that will get them to their destination at the selected time frame, as shown in Figure 3. By clicking on the individual trip number, the walk and transit paths are explained and shown on the map.

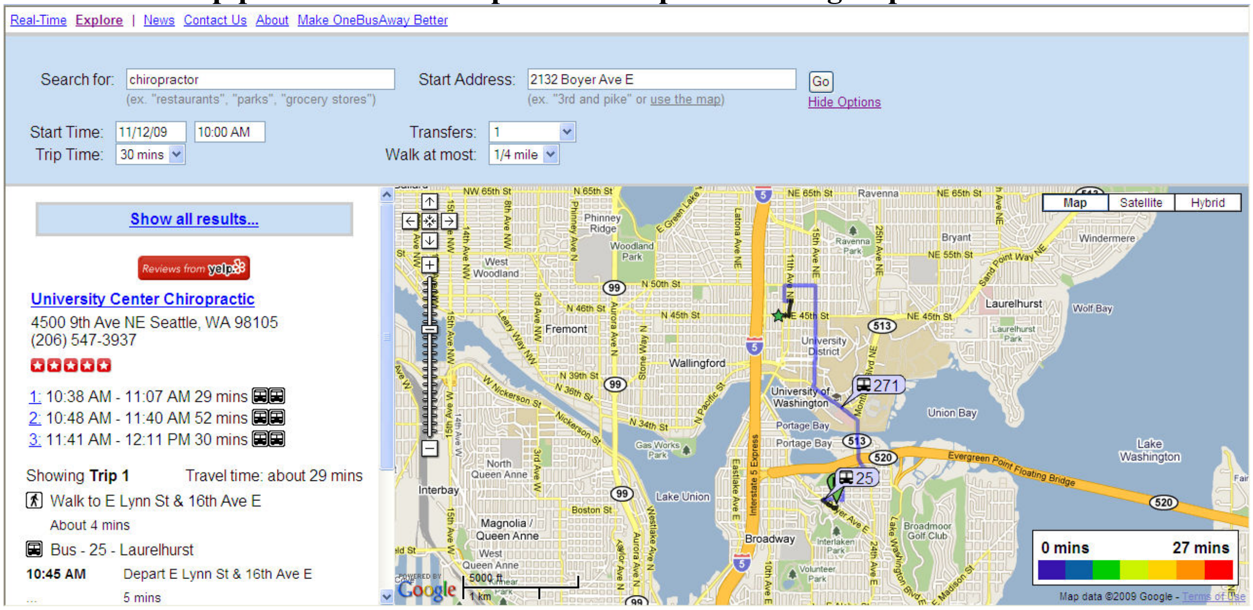
A second example search is shown in Figure 4 and Figure 5. In this example, the user has searched for a chiropractor from a local retirement community. The user does not wish to walk very far, so they have opted for a maximum of ¼ mile walk, but are allowing one transfer during the trip. Several choices are available and they choose a chiropractor close to the university.

FIGURE 4 Chiropractors that are less than 30 minutes away by bus from a retirement community in Seattle



This beta version of Explore has been implemented on the OneBusAway website at http://onebusaway.org/explore/onebusaway/ using data from King County Metro and the Yelp online database of reviews (www.yelp.com) for a comprehensive list of attractions. Although Yelp is fairly thorough and offers user ratings for their listing, the site is predominantly used by a younger demographic. Future versions may explore the use of another local search database such as Google Local or Yahoo Local to overcome this barrier.

FIGURE 5 Trip plan results for a specific chiropractor using Explore



NEXT STEPS FOR EXPLORE

The Explore tool is still under development by the OneBusAway project team. In addition to smaller bugs that have to be addressed, we have a list of enhancements to the tool that we would like to add. One enhancement would add details about the bus frequency and return trip frequency and exceptions (weekdays only or only until 10 pm), so that a user does not get stuck at their destination. Another enhancement would give more details that a new bus rider might need such as the side of the street to get on the bus and the fare information. As mentioned previously, there are some drawbacks to the use of Yelp, especially with the searching of categories in which the word must only appear somewhere in the write-up. Therefore a restaurant near a park may get listed with a "park" category search. We would therefore like to add support for Yahoo and Google Search as well. We would like to add features such as a print button to make it easier to print and take all the needed information with the user. In addition, the user should have the ability to store a search to repeat it or alter it slightly from the last time the site was used. Finally, we think the user should be able to have an option to connect a trip to the original one searched. With this ability to add a second destination, a user could plan an evening including dinner and then a movie, all with the stipulation that the locations would be easily accessible via transit.

In addition to these Explore enhancements, another missing element of the Explore tool is a link to the real-time information that is the cornerstone of OneBusAway (24, 25). One goal of OneBusAway is to develop many rider information tools, including more tools that build on underlying trip planners and to add more transit agencies to the system so that the tools can be used outside the metro Seattle area. Our hope is to integrate an open-source trip planner with real-time arrival information and real-time service alerts to create a network of linked transit rider tools. To this nature, we are currently undergoing a value sensitive design process to identify the most needed rider tools and enhancements to our existing tools.

IMPLICATIONS AND FUTURE RESEARCH

The ability to perform such a search by attraction type rather than specific destination can be a powerful aid to a traveler with a need or desire to use public transportation. Explore allows riders to choose their destinations based on transit accessibility, which can encourage transit use. The only other existing attraction search tool has been implemented by Google Maps. Although their Search Nearby tool allows users to enter an address and then search for attractions nearby by entering a category (doctor, park, etc), users interested in determining the transit accessibility of the destinations may have to try clicking several results before an easily accessible destination is found.

The Explore tool is one of many possible online search tools to make transit more easily accessible to current and potential riders. In addition to our work at OneBusAway, the WalkScore developers are currently implementing a TransitScore algorithm to inform potential homebuyers and renters about which locations are the most transit-friendly. Their initial efforts are found at http://www.walkscore.com/transit-map.php.

The goal of the One Bus Away project is to implement tools that will make transit easier to use and better able to compete with non-public modes. One Bus Away is being developed as an open-source transit traveler information system to allow transit agencies to access the code and use it themselves. In addition, the open-source model allows other developers to make use of the code or the data to create further transit traveler information tools such as those described. The source code for the deployment is available at http://code.google.com/p/onebusaway/ under an open-source license.

The development of this type of program is only possible with the aid of transit agencies that are willing to make their data available for free. The leader in this type of data exchange between a transit agency and transit software developers for the past two years has been the Bay Area Rapid Transit agency. BART has partnered with the developer community and makes their schedule data, real time data and service alert data all easily available for other websites and tools. Tri-met and MBTA have more recently implemented similar programs and other agencies are following suit. King County Metro in greater Seattle has graciously partnered with One Bus Away to provide the data for this project.

ACKNOWLEDGEMENTS

Thanks to King County Metro for the continued use of their data and for their recent efforts to establish a Seattle-area transit developer community. Thanks to Nokia Research and the National Science Foundation under Grant IIS-0705898 for financially helping to support this project. Thanks also go to our advisors at UW for being supportive of OneBusAway: Alan Borning, Dieter Fox, Scott Rutherford, Mark Hallenbeck and Paul Waddell. Thanks to Evan Siroky and Carl Langford for helping with the original Explore OBA vision and to several anonymous reviewers for their comments. Finally, thanks to all our friends at UW and beyond who have used OneBusAway and given us feedback.

REFERENCES

1. Multisystems. *Strategies for Improved Traveler Information*. Transit Cooperative Research Program Report 92, Transportation Research Board, 2003.
2. CTIA. *Wireless Quick Facts*. www.ctia.org/advocacy/research/index.cfm/AID/10323. Accessed February 15, 2009.

3. International Telecommunication Union. *Internet Indicators*. www.itu.int/ITU-/icteye/Reporting/ShowReportFrame.aspx?ReportName=/WTI/InformationTechnologyPublic&RP_intYear=2007&RP_intLanguageID=1. Accessed February 15, 2009.
4. Radin, S., D. Jackson, D. Rosner, and S. Peirce. *Trip Planning State of the Practice*. Volpe National Transportation Systems Center; Federal Transit Administration; Federal Highway Administration, 2002**.**
5. Google. "*Google Transit Partner Program*." maps.google.com/help/maps/transit/partners/faq.html. Accessed July 29, 2009.
6. Eriksson, L., M. Friman, and A. Norman. Electronic Service Quality: Public Transport Information on the Internet. *Journal of Public Transportation*, Vol. 10, No. 3, 2007, pp 35-46.
7. Farag, S. and G. Lyons. What Affects Use of Pretrip Public Transport Information? Empirical Results of a Qualitative Study. In *Transportation Research Record: Journal of the Transportation Research Board* , No. 2069, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp 85-92.
8. Caulfield, B. and M. Mahony. An Examination of the Public Transport Information Requirements of Users. *IEEE Transactions on Intelligent Transportation Systems,* Vol. 8, No. 1, 2007, pp 21-30.
9. Currie, G. and M. Gook. Measuring the Performance of Transit Passenger Information Web Sites. In *Transportation Research Board Annual Meeting*. CD-ROM. Transportation Research Board of the National Academies, Washington, D.C., 2009, Paper No. 09-1363.
10. SEPTA. *Trip Planner*. airs1.septa.org/bin/query.exe/en? Accessed May 18, 2009.
11. UTA. *Trip Planner / Advanced*. www.rideuta.com/ridingUTA/tripPlanner/default.aspx. Accessed May 18, 2009.
12. Dadnab. www.dadnab.com/. Accessed May 18, 2009.
13. MTA. *Mobile Trip Planner*. tripplanner.mta.info/tripPlannerPDA.aspx. Accessed May 18, 2009.
14. BART. *Quick Planner*. www.bart.gov/. Accessed May 18, 2009.
15. Cherry, C. R., M. D. Hickman, and A. Garg. Design of a Map-Based Transit Itinerary Planner. *Journal of Public Transportation,* Vol. 9, No. 2, 2006, pp 45-68.
16. Metlink. *Viclink Journey Planner*. jp.metlinkmelbourne.com.au/metlink/XSLT_TRIP_REQUEST2. Accessed May 17, 2009
17. RTA. *GoRoo, Learn More*. www.goroo.com/goroo/showLearnMore.htm. Accessed May 16, 2009.
18. Fingerle, G. P. and A. C. Lock. Practical Issues in Prototyping National Public Transport Journey Planning System Using Journeyweb Protocol. In *Transportation Research Record: Journal of the Transportation Research Board* , No. 1669, Transportation Research Board of the National Academies, Washington, D.C., 1999, p. 46-52.
19. Peng, Z.-R. and E. Kim. A Standard-Based Integration Framework for Distributed Transit Trip Planning Systems. *Journal of Intelligent Transportation Systems,* Vol. 12, No. 1, 2008, pp 13-28.
20. Chen, C., R. Kitamura, and J. Chen. Multimodal Daily Itinerary Planner: Interactive Programming Approach. In *Transportation Research Record: Journal of the Transportation Research Board* , No. 1676, Transportation Research Board of the National Academies, Washington, D.C., 1999, p. 37-43.

21. Citizens for Progressive Transit. *A-Train Atlanta Transit / Bike / Walk Trip Planner*. trip.atltransit.com/. Accessed May 19, 2009.

22. Transport for London. *Journey Planner*. journeyplanner.tfl.gov.uk/user/XSLT_TRIP_REQUEST2?language=en. Accessed May 18, 2009.

23. Zografos, K. G., V. Spitadakis, and K. N. Androutsopoulos. Integrated Passenger Information System for Multimodal Trip Planning. In *Transportation Research Record: Journal of the Transportation Research Board* , No. 2072, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp 20-29.

24. Ferris, B., K. Watkins, and A. Borning. OneBusAway: Location-Aware Tools for Improving the Usability of Public Transit. To appear in *IEEE Pervasive Computing Special Issue on Location-Based Services,* 2009.

25. Ferris, B., K. Watkins, and A. Borning. OneBusAway: A Transit Traveller Information System. *International Conference on Mobile Computing, Applications and Services (MobiCase),* 2009.