METROPOLITAN TRANSPORTATION COMMISSION

RTIS Architecture

Volume I: RTIS System Architecture

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List of Acronyms

CMS - Content Management System

COTS		Commercial Off-The-Shelf
DIVA	-	Software product from Dialogic Corporation
ESRI	-	Environmental Systems Research Institute
GDT	-	Geographic Data Technology company
GML	-	Geography Markup Language
MDV	-	Mentz software company
MPO	-	Metropolitan Planning Organization
MTC	-	Metropolitan Transportation Commission
RTD	-	Regional Transit Database
RTDNS	-	Regional Transit Database – Non-Spatial
RTDS	-	Regional Transit Database - Spatial
RTDWEB	-	Regional Transit Database – Web
RTIS	-	Regional Transit Information System
SDE	-	Spatial Database Engine
TAC	-	Technical Advisory Committee
XMI	-	XML Metadata Interchange
XML	-	Extensible Markup Language
IIS		Internet Information Server

Reference Documents

1 INTRODUCTION

1.1 DOCUMENT PURPOSE

This document introduces the reader to the Regional Transit Information System (RTIS) by explaining the RTIS (aka '511 Transit') purpose, function, history, and role within the San Francisco Bay Area's traveler information system, commonly known as "511."

The document then describes the physical and network architecture of the system. It describes the system environments, the components that make up the system, how the components are logically and physically connected together, where different information resides within the system, and which application sits on which servers.

1.2 DOCUMENT USE AND INTENDED AUDIENCE

This document will primarily be used by MTC and the RTIS contractor as a technical reference for the RTIS system architecture. It may also be used by Bay Area transportation partners and other external public agencies to learn about the RTIS system structure. Additionally, it may be used in "request for proposal" solicitation process to help potential bidders gain knowledge about the system in order to prepare their proposal.

1.3 RTIS TECHNICAL MANUAL ORGANIZATION

This document is part of a series of technical manuals, shown in Table 1 that documents MTC's 511 Regional Transit Information System.

Table 1 - RTIS Technical Manuals

RTIS Manual Titles	Purpose
RTIS Architecture:	
Volume 1: RTIS System Architecture – This document	Describe the system environments, the components that make up the system, and how the components are connected together, logically and physically. Documents how the components work together, how the system collects data and handles information requests, and how system's computing logic is structured.
Volume 2: RTIS Data Architecture	Describes how data flows into and through the system, how it is managed within the system and how it is disseminated to the users. Describes the tools used to facilitate this data flow.
RTIS Operations:	

RTIS Manual Titles	Purpose
Volume 1: RTIS Systems Operations	Defines how to operate the public side of the system (i.e., configure, run, and administer the system in terms of the public delivery of all information).
Volume 2: RTIS Data Operations	Defines how data moves through the RTIS - from the transit agencies to the Regional Transit Database to the trip planner. Document covers all aspects of maintaining up to date and accurate data.
RTIS Developers' Manual	This document provides technical guidelines for developers to understand the logical tier of the system. After reading this document a new development team member should feel comfortable to maintain and/or enhance a system component.
RTIS Users' Guides:	
Volume 1: RTIS Data Provider Guide	Describes the processes and tools of the RTIS that facilitate the provision of data from the transit agencies to the system. It also includes a list of requirements that a transit agency must fulfill in providing the data to the RTIS system and the roles and responsibilities both transit agencies and MTC have in sharing and maintaining data.
Volume 2: RTIS Customer Service Representative Guide including Trip Planner Call Center Interface User Guide	Instructions for transit agencies on how to use 511 Transit website including the trip planner call center interface to provide transit service information such as service announcements and transit itineraries to their customers.
Volume 3: Trip Planner User Guide	"How-to" instructions for public users using the transit trip planner
Volume 4: Traveler Information Center (TIC) Users' Guide	Instructions for TIC staff on how to use the RTIS online Content Management System (CMS) tool manage transit service announcements.

Readers looking for information not contained in this document should consult the Table of Contents of the other manuals.

1.4 DOCUMENT CONTENTS

Volume I: RTIS System Architecture includes the following contents:

1.4.1 Chapter 2: The RTIS Project History and Context

This chapter provides a background on the RTIS and how it relates to the broader San Francisco Bay Area 511 Traveler Information Services. It also describes RTIS stakeholder groups and agencies.

1.4.2 Chapter 3: The RTIS Features

This chapter describes the features and functions provided by the RTIS to the traveling public.

1.4.3 Chapter 4: Network Architecture

This Chapter pictorially shows the network architecture. It shows and describes the different locations of the system equipment and how communication flows internally and externally. It describes the system environments, the hosting sites, the hardware and software used for the RTIS, and the flow of network traffic.

1.4.4 Chapter 5: Functional Architecture

This chapter includes a pictorial overview of the functional architecture, showing the interaction and communication within the system when various user features/functions are accessed through multiple interfaces. After describing the functional configuration of the RTIS system network, it explains the functional structure of the:

- Regional Transit Database (RTD)
- 511 Transit web pages (transit.511.org)
- Transit trip planner
- Content Management System (CMS)
- Monitoring System

2 RTIS BACKGROUND

2.1 HISTORY

In response to State legislation (Senate Bill 1474 [chapter 256, statutes 1996]), the Metropolitan Transportation Commission (MTC) adopted a Transit Coordination and Implementation Plan in February 1997 designed to improve the connections among over two dozen transit services in the San Francisco Bay Area. One of the projects in the Plan is to provide intra- and inter-agency trip planning information and maintain an accurate transit information database.

In July 1997, MTC signed a contract with GIS Trans, Ltd. (which later became bd Systems, then SAIC, and now Leidos) to design, develop, install, and provide maintenance for a database system to coordinate, collect, update, and disseminate transit data. MTC, in cooperation with the Bay Area's transit operators, developed the Regional Transit Information System (RTIS) to collect, organize, and disseminate transit schedule, route, and fare information and provide transit trip planning services across the Bay Area. Representatives from the transit agencies provide guidance to MTC on the RTIS project through the RTIS Technical Advisory Committee (TAC).

2.2 THE SAN FRANCISCO BAY AREA'S 511 TRAVELER INFORMATION PROGRAM

The RTIS is part of MTC's broader 511 Traveler Information Program, which provides transit, traffic, ridesharing, parking, and bicycling information to the public by telephone via the federally dedicated information phone number (5-1-1), the website at 511.org, through the mobile site at m.511.org, and through mobile applications for the iPhone and Android operating systems. The mission statement for the 511 Program is:

> "The 511 program must cost-effectively provide traveler information that customers both want and are prepared to act on, thereby enhancing the efficiency and maximizing the capacity of the Bay Area transportation system. This information should be accurate, reliable, multimodal, comprehensive and regional in scope. Responsibility for the gathering, processing and dissemination of 511 information should be regionally coordinated and rationally allocated to Bay Area transportation organizations — in both the public or private sectors — according to institutional interest, ability and wherewithal."

2.2.1 511 ORGANIZATION

Information provided through the 511 Program is organized by mode – transit, traffic, rideshare, bicycling, and parking. While the 511 program is presented to the customer as a single,

comprehensive service, multiple projects and contractors provide content and operations and maintenance support. The RTIS Contract provides services offered through the 511 Transit program in the form of a website (http://transit.511.org), but other MTC contracts provide some transit features. 511 contracts beside RTIS include:

Traffic: The 511 Traffic contract includes the collection and dissemination of traffic information as well as real-time transit information. It also includes dissemination of traveler information services for all modes through the 511 telephone system. The traffic information provided by the Traffic Contractor through 511 includes driving times, traffic conditions (congestion, roadway incidents), construction activity and special events. Detail about the transit information provided by the Traffic Contractor through 511 is described in Section 2.2.2.2.

Rideshare: MTC has a Regional Rideshare Program contract as well as Funding Agreements with several Congestion Management Agencies to provide rideshare services, such as ridematching and employer outreach. The Rideshare Program uses the 511 phone number and a website (http://rideshare.511.org) to provide phone and web-based information about carpooling, vanpooling, park-and-ride lots, employer resources, incentive programs, and includes an internet-based ridematching system.

Bicycling: Bicycling information on the phone is provided through the Regional Rideshare Program contract. The 511 Bicycling website (http://bicycling.511.org) provides information about using bikes on transit, bike safety, local bicycling organizations and more. It also includes an interactive bike mapping tool.

Parking: MTC's 511 Parking program (http://parking.511.org) provides parking facility and pricing information as well as real-time information (select availability) throughout the Bay Area. Details on available parking, facility locations, pricing, hours, and near-by transit station hubs are made available for nearly 100 cities and communities. The 511 Parking program is provided under the 511 Traffic contract.

Marketing: Marketing services for MTC's regional operations programs, including 511, are provided through the Regional Ridesharing and Bicycling RRBP contract. It provides support for marketing, promotional activities, market research, and public relations/information assistance for the 511 Program.

Web Communication Services: This contract supports the web coordination and communications services for MTC's regional operations programs that include 511. It provides support for web design and maintenance guidelines for the 511 Program.

2.2.2 THE 511 TRANSIT PROGRAM

Transit is one of the critical components of the 511 system. Different aspects of the 511 Transit program are supported through a number of contracts.

2.2.2.1 RTIS CONTRACTOR

With coordination support from MTC, the RTIS Contractor provides the majority of services for the 511 Transit Program including:

- In cooperation with transit agencies, collection and processing of transit services data including routes, schedules, stops, fares, and other information for all Bay Area transit operators.
- Development, operation, and maintenance of the 511 Transit Website, http://transit.511.org.
- Development, operation, and maintenance of the mobile 511 Website, http://m.511.org. The mobile website allows for convenient, mobile device access to 511.org's most popular features including: Real-Time Transit Departures, the 511 Transit Trip Planner, the 511 Traffic Map, and Popular 511 Driving Times.
- Development, operation, and maintenance of the 511 Transit App. The Transit App is available for the iPhone and Android smartphones. The app provides door-to-door transit trip planning the more than 30 transit agencies in the region. It also provides scheduled departure times for transit stops and an interactive map where users can view and locate routes and stops.
- With technical support from the software vendor, management and operation of the online 511 Transit Trip Planner, which combines data from all transit agencies and allows the public to generate transit trip itineraries throughout the entire region.
- Management and operation of an online interface to the 511 Transit Trip Planner customized for the use of transit agency customer call centers.
- Management and operation of an online content management system that facilitates processing of user feedback, management of transit service alerts and announcements, and certain augmentation of transit data.
- Operation and upkeep of the system hardware and software.

2.2.2.2 511 TRAFFIC CONTRACTOR

The 511 Traffic Contractor is responsible for the development and operation of the regional Real-Time Transit system including real-time data collection and real-time information dissemination.

The 511 Traffic Contractor also operates the automated 511 Phone Service, which requires the 511 Traffic Contractor to:

- Make beat calls to transit agencies and monitor information outlets to find out about transit system delays.
- Record floodgates on the 511 phone system about transit system delays as appropriate.
- Manage critical transit service disruption information through the online 511 Transit content management system and online ticker messages.
- Provide personalized transit trip information through MY 511. Users can save favorite transit trips based on departure stops and then receive real-time departure predictions for all routes serving those stops.
- Maintain the 511 phone system that automatically routes 511 callers to transit agency customer service centers.

- Collect transit agency information about cash fares, transfers, pre-paid passes and hours of operation on a quarterly basis and make them available on the phone.

2.2.2.3 MARKETING CONTRACTOR

The 511 Marketing Contractor is responsible for the following activities related to the provision of transit service on 511:

- Overall 511 program marketing efforts including promotion of 511 Transit services.
- Assistance for 511 branding.
- Market research support for the 511 Transit program.

2.2.2.4 WEB & COMMUNICATION SERVICES CONTRACTOR

The 511 Web & Communications Services Contractor is responsible for the following activities related to the provision of transit service on 511:

- Management of the 511.org website that provides link to the 511 Transit website.
- Assistance for 511 branding and consistent website design support for all 511 websites that includes 511 Transit website.

2.3 PROJECT STAKEHOLDERS

2.3.1 MTC

The Metropolitan Transportation Commission (MTC) manages the San Francisco Bay Area's 511 Program including the Regional Transit Information System. MTC is the regional transportation planning agency and the Metropolitan Planning Organization (MPO) for the nine-county San Francisco Bay Area, with statutory responsibilities for coordinating transportation services in the region.

2.3.2 BAY AREA TRANSIT AGENCIES

Numerous agencies offer bus, rail, ferry, and shuttle services in the region. The systems' combined service area covers the nine Bay Area counties - San Francisco, Alameda, Contra Costa, Santa Clara, San Mateo, Marin, Sonoma, Napa, and Solano. Together, the Bay Area's transit services carry an average weekday ridership of more than 1.1 million; they provide 9,000 miles of bus routes, including 470 miles of rail transit.

2.3.3 THE RTIS CONTRACTOR

MTC contracts out the operation, maintenance, and development of the RTIS system. With guidance from MTC, the RTIS contractor is responsible for delivering 511 Transit services satisfying set performance standards.

2.3.4 OUTSIDE DEVELOPERS AND DATA USERS

The 511 Transit data feed is valued by individuals, agencies and organizations that want to develop applications or conduct research related to transit services in the San Francisco Bay

Area. RTIS provides the only comprehensive and integrated transit data repository and information services for all of Bay Area transit agencies. Those receiving the RTIS data feed range from individual students conducting research to private application developers to Google for inclusion in Google Transit.

The RTIS also offers a transit trip planner widget that can be easily plugged in to other websites allowing users of those websites plan transit trips. See Section 3.14 for more information about the Transit Trip Planner widget feature of the RTIS.

2.3.5 THE PUBLIC

The RTIS exists to serve the traveling public. Its function is to provide comprehensive transit information to regular and occasional transit riders. Much of that transit information is available to the public via telephone services and through the web. In the month of December 2013, the system processed over 446,000 phone requests for departure times, Clipper information, All Nighter information, paratransit information, and information on specific transit agencies. The transit web services processed just shy of 1.4 million web requests in December 2013 for departure times, rail information, nearby routes and services, fares, popular destinations, transit schedules, and trip planner itineraries. Requests for trip planner itineraries accounted for 48% of all web requests in December 2013.

3 RTIS FEATURES AND FUNCTIONS

The Regional Transit Information System provides transit schedule, route, fare, and other information for Bay Area public transit agencies. It also provides the Transit Trip Planner, which offers complete transit trip itineraries across the region with fares and inter-agency transfers. RTIS is the only source for most accurate, complete, and comprehensive public transit information in the region.

The primary dissemination channel for the RTIS is the transit web pages through the main 511 website at http://www.511.org or directly through the 511 Transit website at http://transit.511.org. In addition, transit trip planner is also available on handheld devices through the 511 Mobile website at http://m.511.org as well as the 511 mobile application available for both iOS and Android platforms. In 2013, the 511 Transit website experienced an average of 1.8 million user sessions per month.

511 also provides transit information on the phone (by calling 5-1-1). Callers can listen to recorded transit information or be transferred to transit agencies where a live operator can provide further information. As mentioned in Section 2.3.5, the 511 system processed over 446,000 phone requests relating to Transit information in December 2013. Transit phone requests have more than doubled since the end of 2009, in large part to departure time requests. Departure time phone requests alone normally constitute 75%-80% of all monthly transit phone requests. Requests for departure time information and information on specific transit agencies accounted for 99% of all transit phone requests in the month of December 2013.

3.1 THE TRANSIT TRIP PLANNER AND ASSOCIATED FEATURES

MTC uses customized transit trip planning software from mdv. Trip planning services are provided through the 511 Transit website, 511 Mobile website, and the 511 Mobile application. The transit trip planner was first launched on the Internet in July 2001. Over 30,000 trip itineraries are currently viewed on a daily basis and this number has grown by nearly 20% since 2008.

The trip planner also provides interfaces that can be embedded on external websites allowing those website users an easy way to plan transit trips.

The trip planner allows users to obtain inter-agency transit itineraries by entering their origin and destination addresses, intersections, landmarks, or finding the locations on the map. Users are provided multiple trip options optimized for least travel time, fewest transfers, least walking, or least cost. Figure 1 shows a sample generated trip plan.

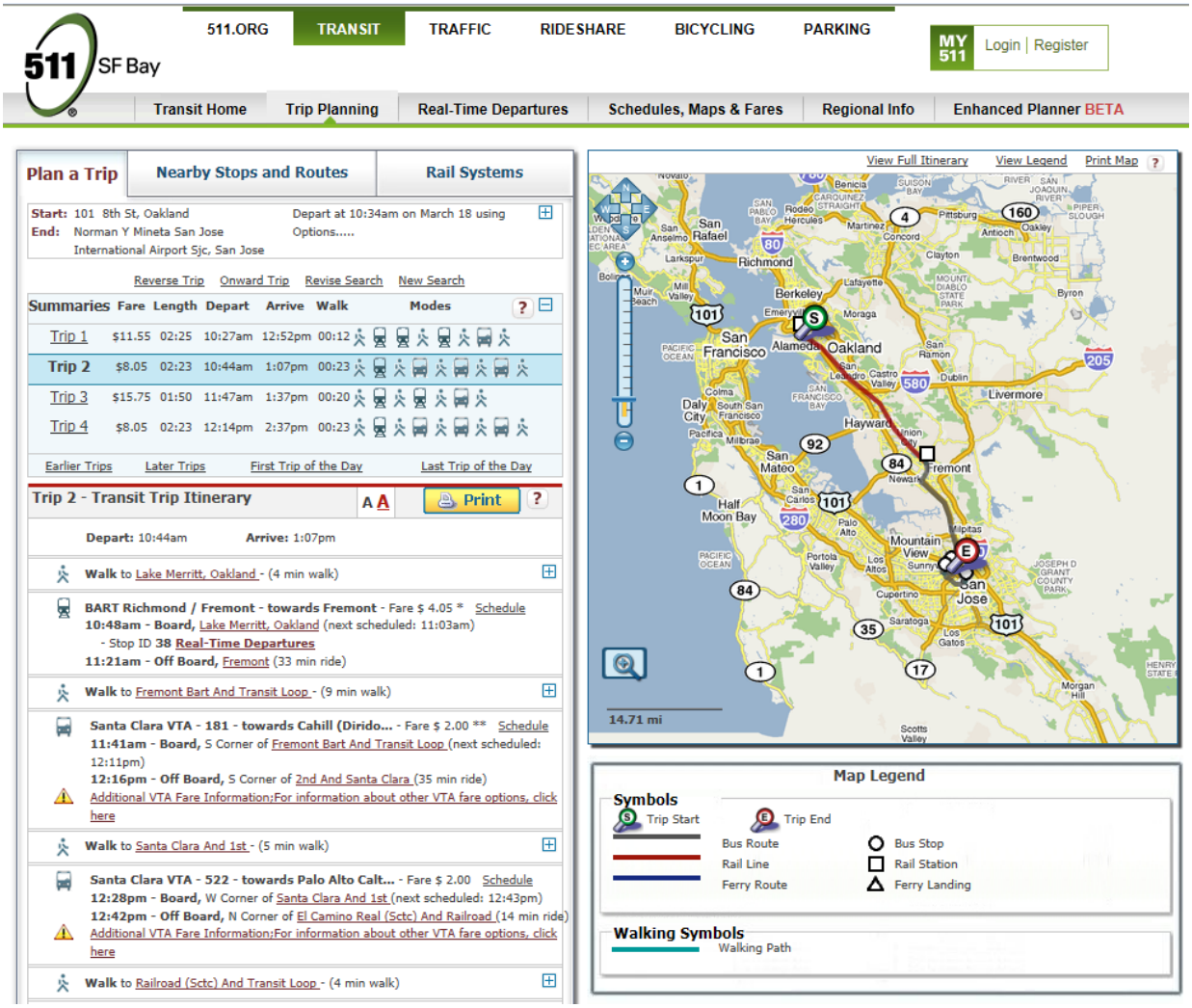

Figure 1 – Sample Transit Trip Itinerary Generated by 511 Transit

3.2 NEARBY STOPS AND ROUTES

This feature allows users to view transit routes and stops near a user specified location. Routes and stops are filtered by user selected radius distance, time, and date. Users can then display on the map up to three of the nearby route patterns at a time from the list of routes, and view relevant and available information near these stops. Figure 2 shows a sample generated Nearby Stops and Routes map.

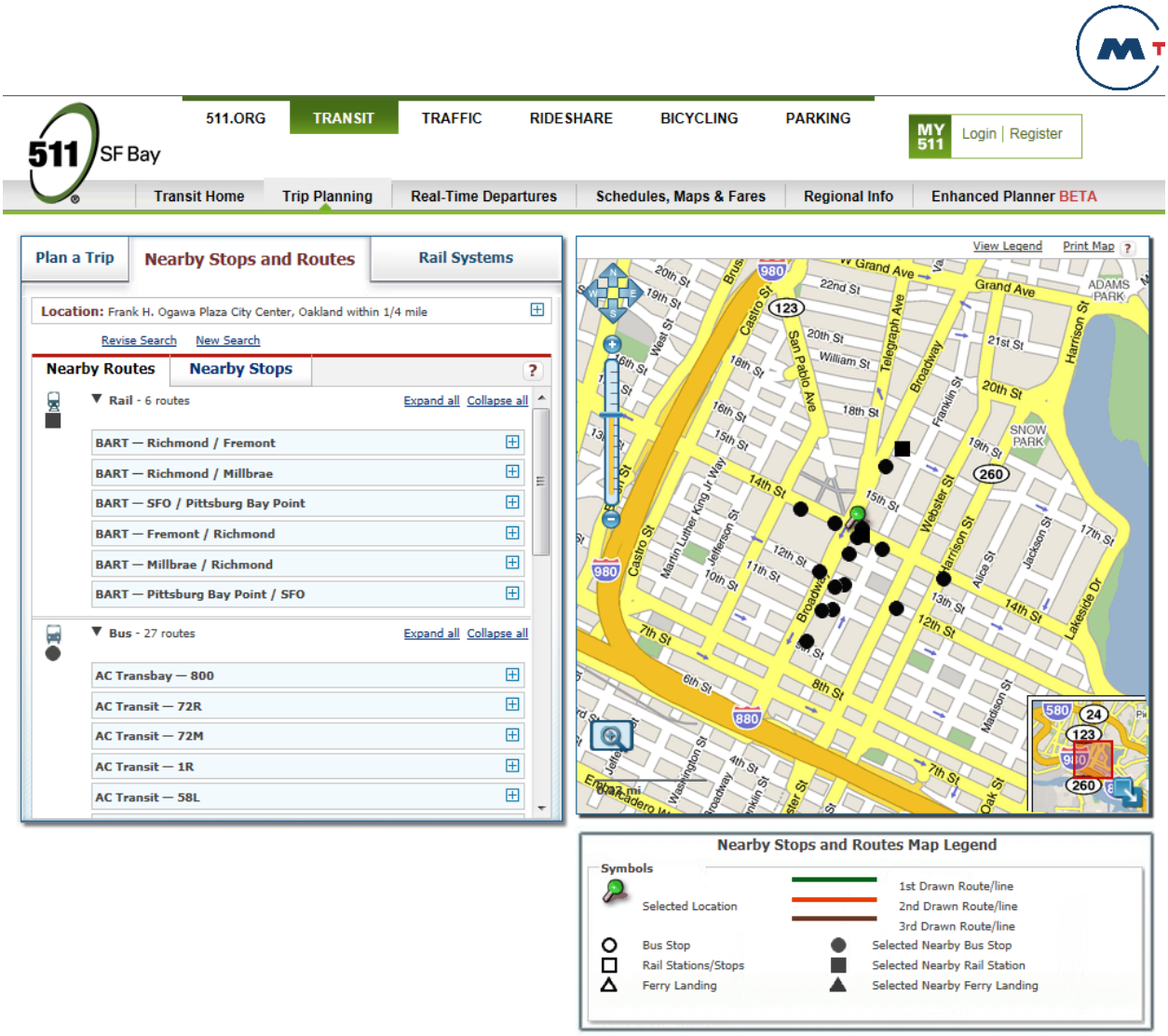

Figure 2 – Sample Nearby Stops and Routes Generated by 511 Transit

3.3 RAIL SYSTEMS

This feature lists all rail services in the Bay Area in various logical groups. Users can select services by an individual rail routes, provider names, or a types of services and display on a map. From the map, users can click a station to see station details, plan a trip to or from the station and/or see scheduled departures for that station. Users can also view a schematic for a selected rail line stations with listing of various amenities.

3.4 REAL-TIME DEPARTURES

While the 511 Traffic contractor operates and maintains the 511 real-time transit system (a.k.a., 511 Departure Times) including collection and processing of all real-time data, both the 511 Traffic (primarily) and the RTIS Contractors help disseminate the real-time transit information. 511 Transit website hosts a Departure Times prediction tool along with a stop ID lookup tool for the real-time system. It also provides helpful information about real-time texting/SMS feature. Once a query is submitted through the stop ID lookup tool, a numeric identification number for

the desired stop is provided. This stop ID can then be used on the 511 phone system to receive real-time departure times for routes serving that stop.

3.5 Schedules and Route Maps

This feature provides timetables and maps of routes for transit services in the Bay Area. Service data for almost all Bay Area transit agencies is stored in the Regional Transit Database (RTD). To facilitate the user's ability to select an agency, the agencies are organized by the type of transit service they provide (e.g., bus, rail, ferry). This organization is very useful to all users including tourists who may want to ride the ferry or a cable car.

Upon selecting an agency, the map displays the service area of the agency and lists the agency's routes. Selection of a route will display the schedule for that route along with the route map. Users can also view static route maps created and uploaded by the transit agency.

3.6 Fares

The 511 Transit website categorizes Bay Area transit agencies by transit mode (e.g., rail, bus, ferry etc.). Within each category, a user can select an agency and see a map of the agency service area. The fares tab lists the cash fares by rider category (e.g., adult, senior, child, etc.) for the selected agency.

3.7 Agency Profiles

The 511 Transit website categorizes Bay Area transit agencies by transit mode (e.g., rail, bus, ferry etc.). Within each category, a user can select an agency and see a map of the agency's routes and service area. Another tab presents fare information for the selected agency. The Agency Profile tab provides a description of the service area and other basic information including contact information for a selected transit agency.

3.8 Clipper

Previously known as TransLink®, Clipper is the only regional smart card fare payment system for transit. This section of the website provides a brief overview of the Clipper smart card program and how it can be used. Also provided is a link to the Clipper website.

3.9 Transit Basics

This feature provides general information about transit services in the San Francisco Bay Area, regional transit highlights, basic know-how for planning a trip, and some background information about riding transit. This textual description includes many links to relevant internal and external information resources.

3.10 Popular Destinations

This feature categorizes popular destinations in the Bay Area into logical groups such as museums, transit hubs, parks & gardens, sports & events, etc. and provides a drop-down list of destinations within a category (e.g., Mount Tamalpais State Park under the "Parks & Gardens" category). When selected, location of the destination is shown on the map. Users can plan trips

to or from the selected popular destination or display nearby routes and services using links provided in a map bubble attached to the destination location.

3.11 ALL NIGHTER SERVICE

This feature provides consolidated information about the transit routes that provide critical connectivity throughout the region during late night/early morning hours when regular transit service is not available. Convenient links to timetables for All Nighter routes are provided.

3.12 ACCESSIBLE AND SENIOR SERVICES

This feature provides information about accessible transportation options in the Bay Area and how to utilize accessible transportation services offered by various operators.

3.13 ANNOUNCEMENTS

Announcements provide useful alert messages about incidents, detours, and service disruption about transit services in the Bay Area. Announcements are categorized as "Priority Alerts," "Regional Announcements" or "Agency Announcements." Priority alerts containing important/emergency transit service disruption information may also appear as a 'Breaking News' scrolling/ticker message on the 511 Transit website linked to an announcement. Priority alerts include transit delays of 20 minutes or more on fixed-route services. Regional announcements are those that affect multiple Bay Area jurisdictions, while agency announcements pertain to just one transit agency. Both types of announcements are less time-critical than priority alerts. They include information such as route detours, construction updates, or holiday schedules. Announcements can be attached to specific route(s) which will make them appear on transit trip itineraries that include that route. An announcement or alert may also appear on timetable and agency profile pages if they pertain to the schedules of specific route or agency being viewed.

3.14 TRIP PLANNER WIDGET

Trip planner widget, a.k.a. the Clean Interface is a user entry form that can be plugged into an external websites to provide quick access to the 511 transit trip planning software. External websites can integrate a code snippet provided by MTC that exposes the trip planner entry form and access to the 511 Transit trip planner. This feature allows any organization (e.g., an airport, sports/cultural venues) to provide transit trip planning services from its own website by taking advantage of the regional trip planning application and database.

3.15 CONTENT MANAGEMENT SYSTEM

The Content Management System (CMS) allows users to create and manage a number of items including transit service announcements, agency profile information, user accounts, popular destination information, etc. Transit agency users have the ability to manage basic transit route information and upload static transit maps.

3.16 ENHANCED TRIP PLANNER BETA

MTC currently has an Enhanced Trip Planner in the development BETA stage but is available to the public for use. It has all the same transit trip (including walking portion) features of the existing Transit Trip Planner; but the Enhanced Trip Planner also offers directions, pricing and time estimates for:

- transit-only,
- drive-to-transit,
- or drive-only trips.

The new Enhanced Trip Planner will enable users to compare a driving trip, a transit trip, and a trip of driving to transit facilities, parking or dropping off transit riders there, and continuing their trip using transit. Other features include the estimated pricing comparison for each trip, information (where available) about rates at adjacent major parking facilities and a carbon calculator for each trip and trip type. The enhanced trip planner is a more powerful and robust tool for travelers that desire specific itineraries that fit more specific travel needs.

The Enhanced Trip Planner is available through the 511 website by clicking on the "Enhanced Planner BETA" links on various pages of 511.org. Figure 3 shows a sample generated enhanced trip plan.

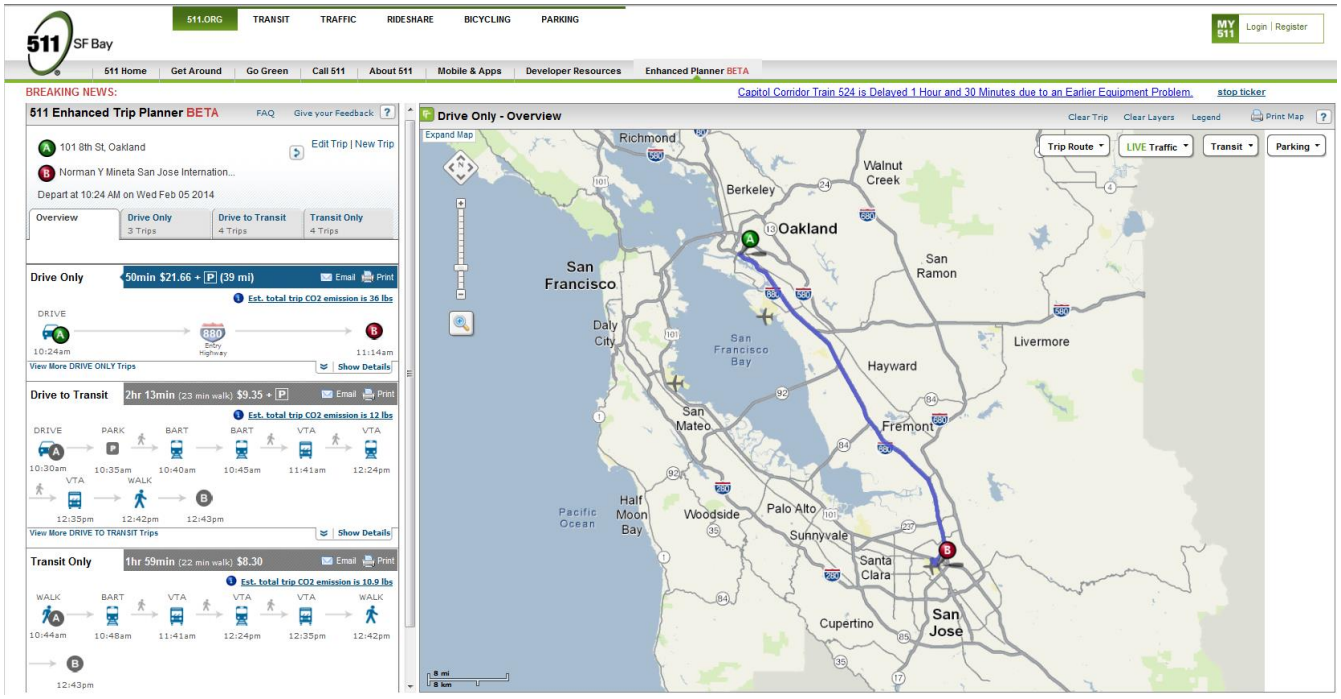

Figure 3 – Sample Trip Itinerary Generated by 511 Enhanced Transit Trip Planner BETA

4 RTIS NETWORK

RTIS is an integrated system of hardware, software, and network components that together works as the single, comprehensive source of transit information for the San Francisco Bay Area. As discussed above, the 511 Transit website, the public interface to the wealth of transit information hosted by RTIS, provides much more than trip planning, schedules, and route maps. The system was completely redesigned in 2007 with a new, more flexible trip planning software and a dual node system that not only provides necessary failover but also increased system capacity by more than 50%. System capacity is enhanced by upgrading existing equipments, adding new equipments, adding load balancers and clusters, and adding Oracle RAC. A detailed breakdown of the RTIS with nodes on the network, inventory of equipments and software, and the information flow through the system are provided below.

4.1 DEVELOPMENT AND STAGING ENVIRONMENTS

The RTIS includes development, staging, and production systems. Data is first loaded into the development system where it is compiled, validated and quality checked using data maintenance tools before it is transferred to the staging and then to the production database. Updated software and bug fixes are first deployed in staging for review and then deployed in the production system. Both development and staging environments are located in Oakland, CA at the RTIS Contractor's offices and are comprised of maintenance databases for Regional Transit Database (RTD), the trip planning software (mdv), and a 511 Transit website backed by a staging database for review of new and modified features. The development environment is situated within the RTIS contractor's office network and can only be accessed by authorized network users. The staging environment at the contractor's office is configured on a publicly accessible network segment outside of the contractor's corporate network. The staging environment is connected to the primary RTIS production environment through a dedicated point-to-point (P2P) line that facilitates deployment of data and software updates.

4.2 PRODUCTION ENVIRONMENTS

The production system is a fully redundant dual node system to ensure the system meets its high performance standards and is available to serve the public in the event of an emergency, such as an earthquake or flood. (The performance standards are discussed in *The RTIS Operations Manuals, Volumes I & II.*) The primary production system is located at a data center in Sacramento, CA. A fully functional secondary production system with more than 50% of the primary system's computing capacity is located in the MTC office building in Oakland, CA. The primary and secondary systems are both live and sharing the 511 Transit website traffic distributed by load balancers at both ends. The primary and secondary systems are connected through a dedicated point to point (P2P) network.

5 FUNCTIONAL ARCHITECTURE

From a functional architecture perspective, the features and functions described in Section 3 are provided to the public on 511 Transit website either from the trip planner servers or other standard web servers. Trip planner servers are proprietary web servers serving the 511 Transit home page and a number of trip planner associated services. Table 4 below lists major services provided by trip planner and standard web servers. Figure 7 below illustrates the functional architecture for the RTIS system, showing the multiple layers and some of the main components in each layer.

Table 4 – 511 Transit Services

Trip Planner Associated Services	Other 511 Transit Services
511 Transit Public interface • 511 Transit home page • Plan a Trip • Nearby Stops and Routes • Rail Systems	511 Transit Public Interface • Schedules, Maps and Fares • Transit Basics • Popular Destinations • All Nighter Service • Accessible and Senior services • Announcements • Real-Time Departures
Trip Planner Call Center Interface Trip Planner Widget ICS Admin Interface	
	Content Management System Static Data Exporter Service Announcements Publisher Service

Data Maintenance Applications

- WebDMS
- XML Engine

RTIS monitoring services

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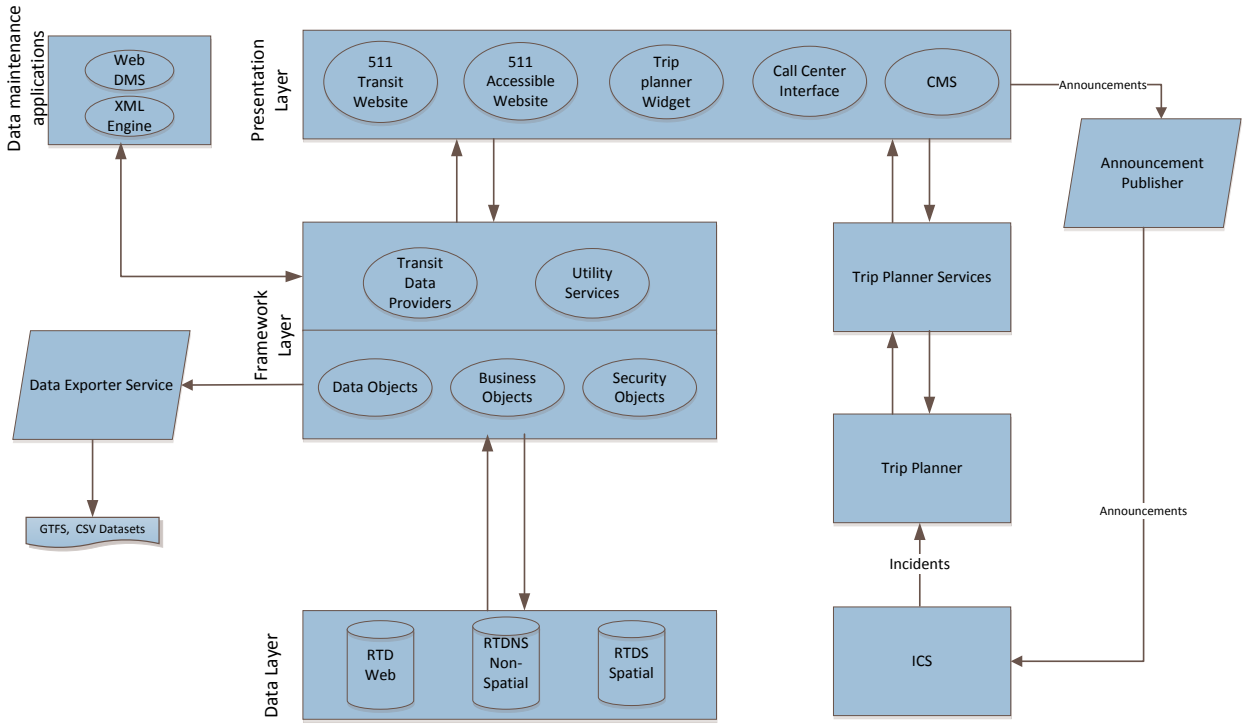

Figure 7 – RTIS Basic Functional Architecture

5.1 REGIONAL TRANSIT DATABASE (DATA LAYER)

The Regional Transit Database (RTD) is the repository for all transit data maintained and disseminated by the RTIS. It contains both spatial data, for mapping and geocoding, and non-spatial data, for schedules, route information, popular destinations, transit provider profiles, etc. Figure 5 shows the functional architecture of the RTD. Three database schemas are created to store the data – RTDNS for non-spatial data, RTDS for spatial data and RTDWEB for data that is created and edited through the content management website (such as Carrier profile, Route names and route maps, announcements, etc)

For detail information about RTD schema and dictionary, refer to the *RTIS Architecture Manual Volume 2: RTIS Data Architecture*. Data in the RTD is categorized as follows:

5.1.1 TRANSIT SERVICE DATA

Transit service data is provided to the RTIS by transit agencies operating in the San Francisco Bay Area. It describes routes, schedules, fares, stops, and time points among other information. This data is maintained in the RTDNS database schema within the RTD. The data needed for the 511 Transit features considered "Other 511 Transit Services" (as identified in Table 4) is generated directly from the RTD servers. (See the *RTIS Architecture Manual Volume 2: RTIS Data Architecture* for more information about data flow.)

5.1.2 BASEMAP AND SPATIAL DATA FOR TRANSIT SERVICES

Basemap data for the Bay Area is licensed from TeleAtlas and is shared by both the trip planning software and the RTD dynamic map rendering (overlaying additional layers such as route lines on the base map). Additional spatial data layers for transit services such as stop/timepoint locations, route lines, transit agency service areas and fare zones, popular destination locations, etc. are also maintained in RTD within the RTDS database schema. The trip planner software maintains its own indices for address ranges and landmarks to identify trip origin and destination locations.

Trip planner uses a proprietary mapping engine to provide dynamic maps for trip planner associated services. Maps for other 511 Transit services are supported by the ESRI ArcGIS Server.

5.1.2.1 GEOCODING DATA

RTIS provides location identification services for three types of user inputs:

- Street address or intersection with or without city name
- Landmark name with or without city name
- Rail or ferry stations with or without city name

The location matching services are based on TeleAtlas digital basemap data. The data for landmark matching is stored separately in the RTD.

5.1.3 WEB CONTENT DATA

Additional content for the 511 Transit website is managed through the Content Management Website (CMS) and is stored within the RTDWEB schema within RTD. This data includes carrier profiles, route maps, system maps, transit announcements, web statistics and reports and also profiles of CMS users. This schema also stores the suggestions and feedback provided by 511 Transit website users and other content such as Promo images and emergency messages for the 511 Transit website.

5.2 TRANSIT TRIP PLANNER

Transit trip itineraries are generated by the mdv (Mentzdataverarbeitung) trip planning software hosted on eight different servers in the primary and secondary production environments. Information requests for the 511 Transit features identified as "trip planner associated services" in Table 4 above are forwarded to one of the mdv servers. The mdv trip planner is a proprietary system with its own web server, mapping software, and a proprietary database. The trip planner associated services are described below.

5.2.1 511 TRANSIT PUBLIC INTERFACE (SECTION 1)

The following features of the 511 Transit public interface is hosted through the trip planner servers and are collectively termed as "Section 1" of the Public Interface

- 511 Transit Home page
- Plan a trip
- Nearby Stops and Routes
- Rail Systems

Refer to Section 3 of this document for a description of the above features. The "Section 1" features are implemented using XML/XSLT technology – the HTTP request to the trip planner servers result in an XML output that is translated to HTML using the XSLT transformation.

5.2.2 TRIP PLANNER CALL CENTER INTERFACE

The call center interface is a customized version of the 511 Transit Trip planner interface for use by the 511 call center personnel. It requires a user id and password to login and provides easier access to all the trip planning options. There are additional features provided such as the ability to save the trip planner preferences and custom schedules that allow the user to quickly access the scheduled departures from a stop on a particular route. Figure 8 below shows the call center interface.

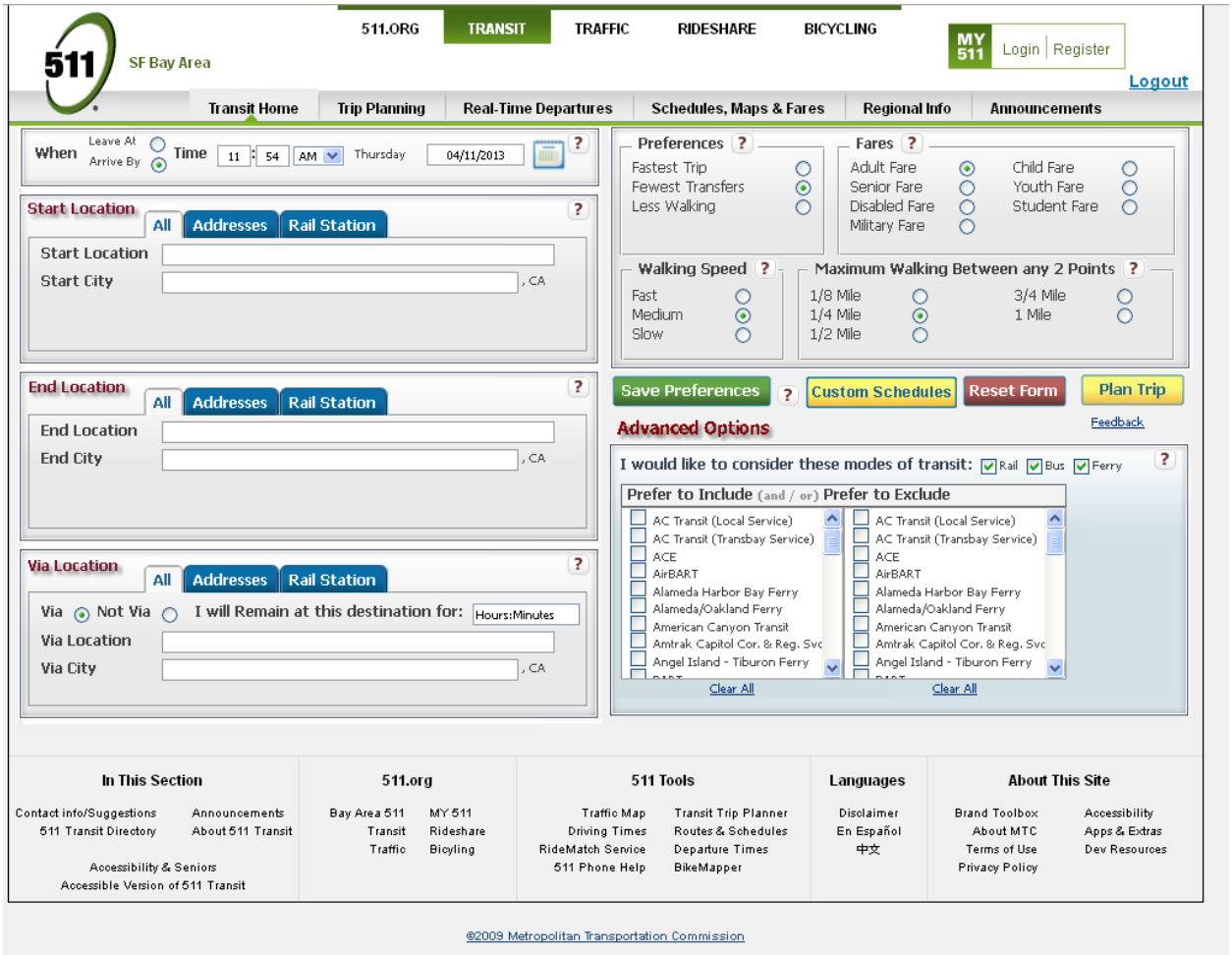

Figure 8 – Call center interface

5.2.3 TRIP PLANNER WIDGET

The trip planner widget (also known as '511 Transit Clean Interface Widget') allows other websites to place 511 Trip planner entry form on their website. When users submit the trip planner request, the request gets forwarded to the Transit trip planners to compute and present the itineraries. The widget is built using HTML along with Javascript and CSS. Detailed instructions are provided for the developer to easily integrate the widget into a website. An example of the trip planner widget used by Tri Delta Transit (http://www.trideltatransit.com) is shown in Figure 9.

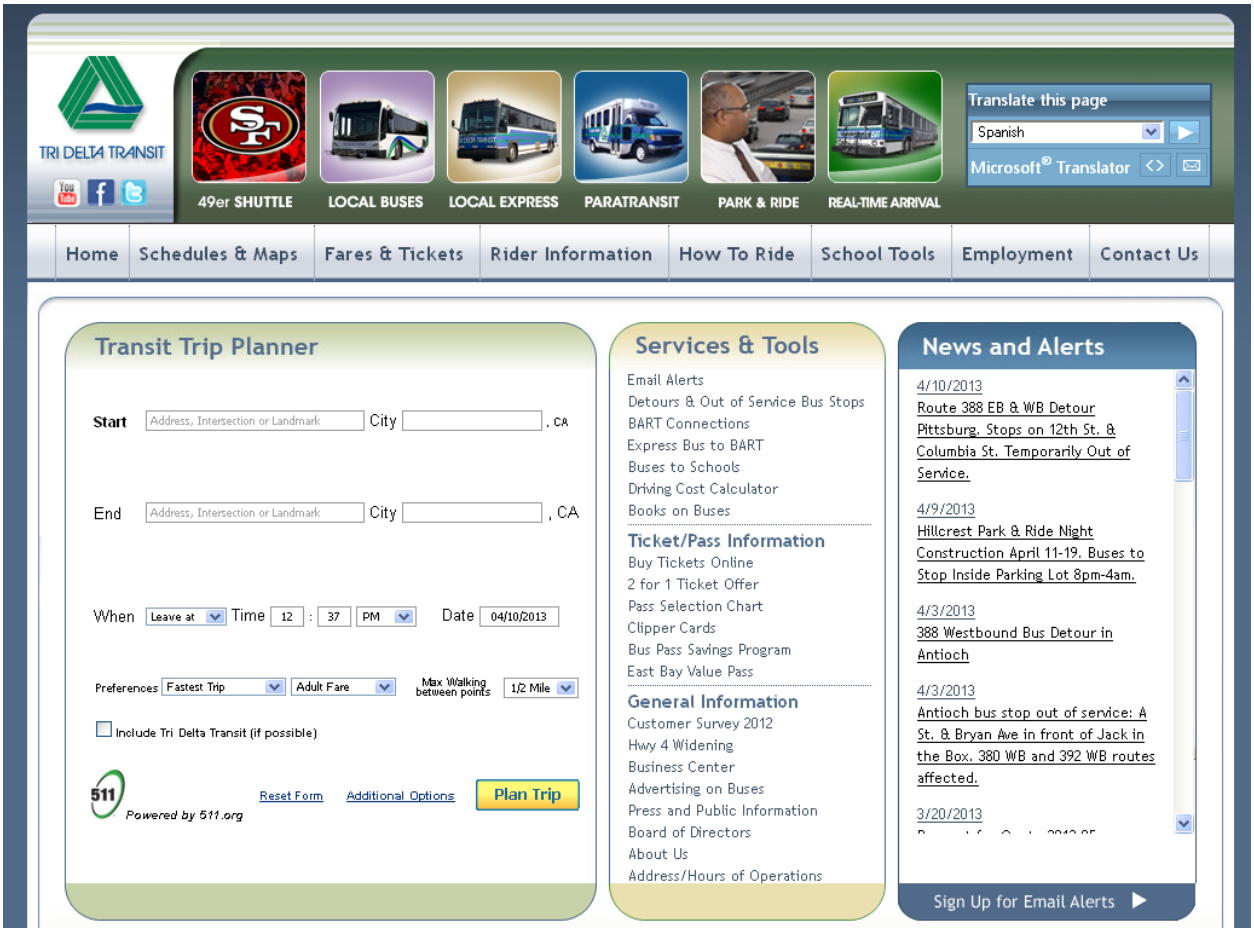

Figure 9 – Trip Planner Widget

5.2.4 ICS ADMIN INTERFACE

Incident capturing system (ICS) is an mdv proprietary system that captures incidents and other real-time information and disseminates it to other channels such as the trip planner. RTIS uses ICS to transfer real-time transit announcements to the trip planner. Announcements are created in RTIS through the CMS website. The IncidentsPublisher (AnnouncementsPublisher) publishes posted announcements to the ICS, which passes it on to the trip planner. Thus announcements published within RTIS are available in the trip planner itineraries almost immediately. The ICS provides and admin interface to view the published incidents and edit them if required.

5.3 RTIS FRAMEWORK LAYER

As depicted in the Functional Architecture diagram (Figure 4), RTIS system contains multiple layers in order to minimize dependencies between subsystems and introduce layers of abstractions that can be easily modified when needed without affecting other parts and subsystems. Each of the layers accesses lower layer for services or data and doesn't communicate "upstream" – e.g. framework layer doesn't call presentation layer components. This way layers remain independent and could be deployed on separate physical servers without large additional development effort. Changes in one layer implementation will not affect other layer functionality as long as communication protocols and data exchange structures remain unchanged.

A robust middleware/framework layer has been designed using .NET technology to provide data and services and serve as a single codebase for all the RTIS applications. The major components in the framework are described below.

5.3.1 DATA OBJECTS

Data objects are created to mirror the data structures in the Oracle database and provide data representations to the presentation layers and other services. Data objects are created for every data type within the RTIS such as Carrier, Route, Pattern, etc.

5.3.2 BUSINESS OBJECTS

Business objects derive from the data objects and add business rules to the data objects. For example, the Announcement business object has additional functionality to represent itself in the RSS format

5.3.3 SECURITY OBJECTS

Security objects provide authentication and authorization features for interfaces where login functionality is required, such as CMS. Permissions are assigned to logged-in users based on their roles.

5.3.4 TRANSIT DATA PROVIDERS

Transit data providers provide data functions to the presentation layer and other applications. For example, Announcements Provider can provide list of emergency announcements, carrier announcements, regional announcements, etc.

5.3.5 UTILITY SERVICES

Utility services include common functions such as configuration management, report writing and error logging that are used by the presentation layer components and other applications.

5.4 RTIS PRESENTATION LAYER

Presentation/ user interface tier consists of various web and client/server applications that provide data and services to the end users (both public and system operators/administrators).

5.4.1 511 TRANSIT PUBLIC INTERFACE (SECTION 2 AND UP)

The features of the 511 Transit public interface that are not hosted through the trip planner are covered here, namely

- Schedules, Maps and Fares
- Transit Basics
- Popular Destinations
- All Nighter Service
- Accessible and Senior services
- Announcements
- Real-Time Departures

Refer to Section 3 of this document for a description of the above features.

5.4.2 511 TRANSIT PUBLIC ACCESSIBLE INTERFACE

The 511 Transit public website includes some features that use javascript and interactive mapping, not all of which may be fully usable with electronic screen readers for those who are visually impaired. The 511 Transit Accessible website is specifically designed to be more accessible and can be used with electronic screen readers. Figure 10 shows the Accessible website.

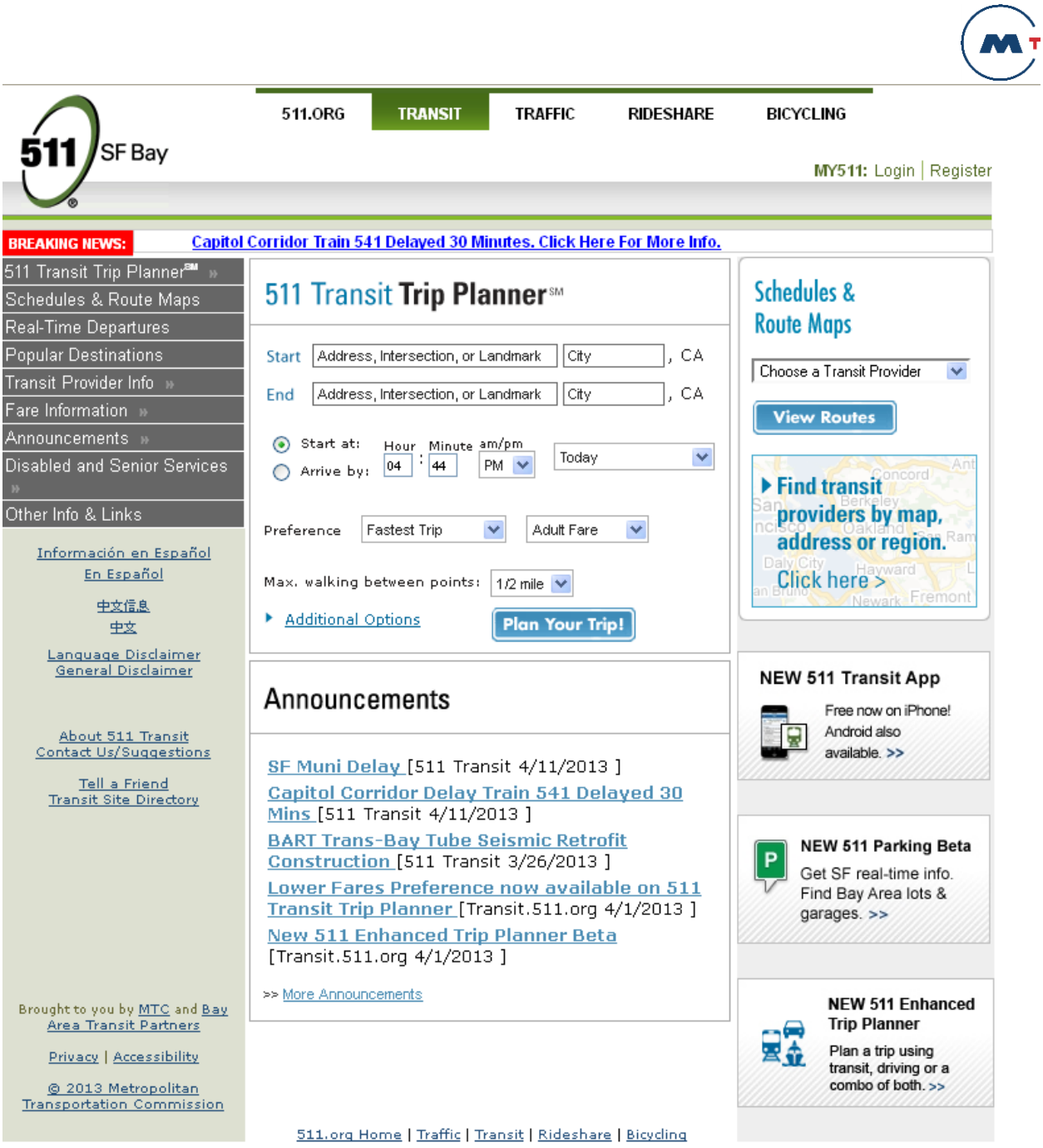

Figure 10 – 511 Transit Accessible interface

5.4.3 CONTENT MANAGEMENT SYSTEM

The Content Management System (CMS) is a web based custom system supporting three primary functions: 1) It facilitates management of certain types of website content including transit route description and static maps, announcement, user feedback, popular destinations, and transit agency profile; 2) It tracks and summarizes usage and error statistics of the 511 Transit Web site, and 3) It facilitates transit data download for external stakeholders.

The content management function of the CMS allows authorized users (RTIS contractor staff, MTC staff, and transit operator staff) to add and edit content for the 511 Transit Website through a web interface based on their access privilege. Data maintained through the CMS interface is hosted in the RTD.

For detail information on CMS operating procedures, refer to both volumes 1 (*RTIS Systems Operations*) and 2 (*RTIS Data Operations*) of *RTIS Operations Manual*.

5.5 Static Data Exporter Service

The static data exporter is a Windows service that exports the agency dataset from RTD whenever the data for an agency changes. The datasets are exported in the CSV(comma separated values) and the GTFS(General Transit Feed Specification) formats and are available for registered CMS users to download via HTTP.

5.6 Announcements Publisher Service

The announcements publisher is a windows service that pushes the transit announcements created via CMS to the ICS (Incidents Capturing System) which in turn transmits the announcements to the trip planner. As a result, the announcements posted or updated through CMS website are available within the trip planner itineraries in a near real-time fashion.

5.7 Data Maintenance Applications

The Regional Transit Database consists of data for over 30 transit agencies. All these agencies have regular "signups" during which they publish new services and schedules. Applications have been developed to automate many of the signup processes and assist in the data maintenance and updates.

5.7.1 XML Engine

XML Engine is a Windows application that is highly modular and used in a variety of data processes:

- It is deployed at many of the transit agencies' sites to convert data from the agencies' raw file formats such as output files from scheduling systems like HASTUS and Trapeze and converts it to the RTD XML format. XML Engine also allows agencies to combine or split routes, or rename routes before converting it to RTD XML format. The XML files are automatically uploaded to an FTP site where it can be downloaded and imported into the RTD database. The following agencies use XML Engine to provide data to RTD : AC Transit, SamTrans, Golden Gate Transit, Wheels and County Connection.
- It is used to import GTFS formats into RTD XML format.
- It is used to import RTD XMLs provided by transit agencies into the RTD database.
- It is used to run quality checks on the data loaded.
- It is used to transfer data between development, staging and production databases.
- It is used to compare agency data in multiple databases or between a database and RTD XML.

- It is used to generate a merged RTD XML to load into the trip planner database. The merged XML holds data for current and future signup.
- It is used to compare the real-time configuration data within RTD against the data in the real-time system(RTT).

Figure 11 shows a screenshot of XML Engine interface.

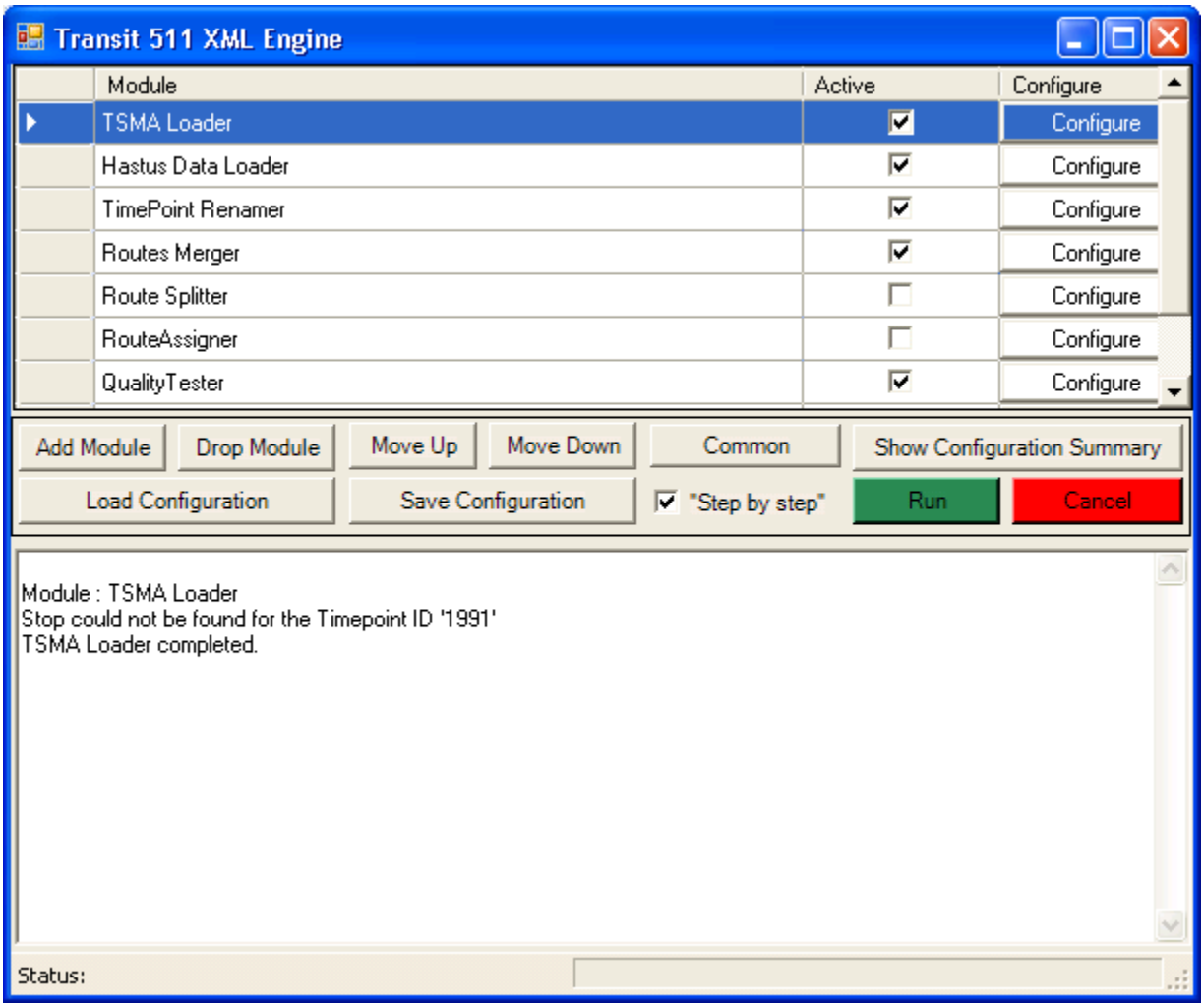

Figure 11 – XML Engine application

5.7.2 WebDMS

WebDMS is a web based application that is used internally to edit the transit data. Following are some of the features provided in WebDMS

- List and edit stops for an agency

- List the routes for an agency
- Edit route, add new patterns, edit pattern stop signatures
- Edit timetables for a route – add and delete trips, change time values
- View and edit fares for an agency
- View and edit landmark information

Figure 12 shows a screenshot of the WebDMS application.

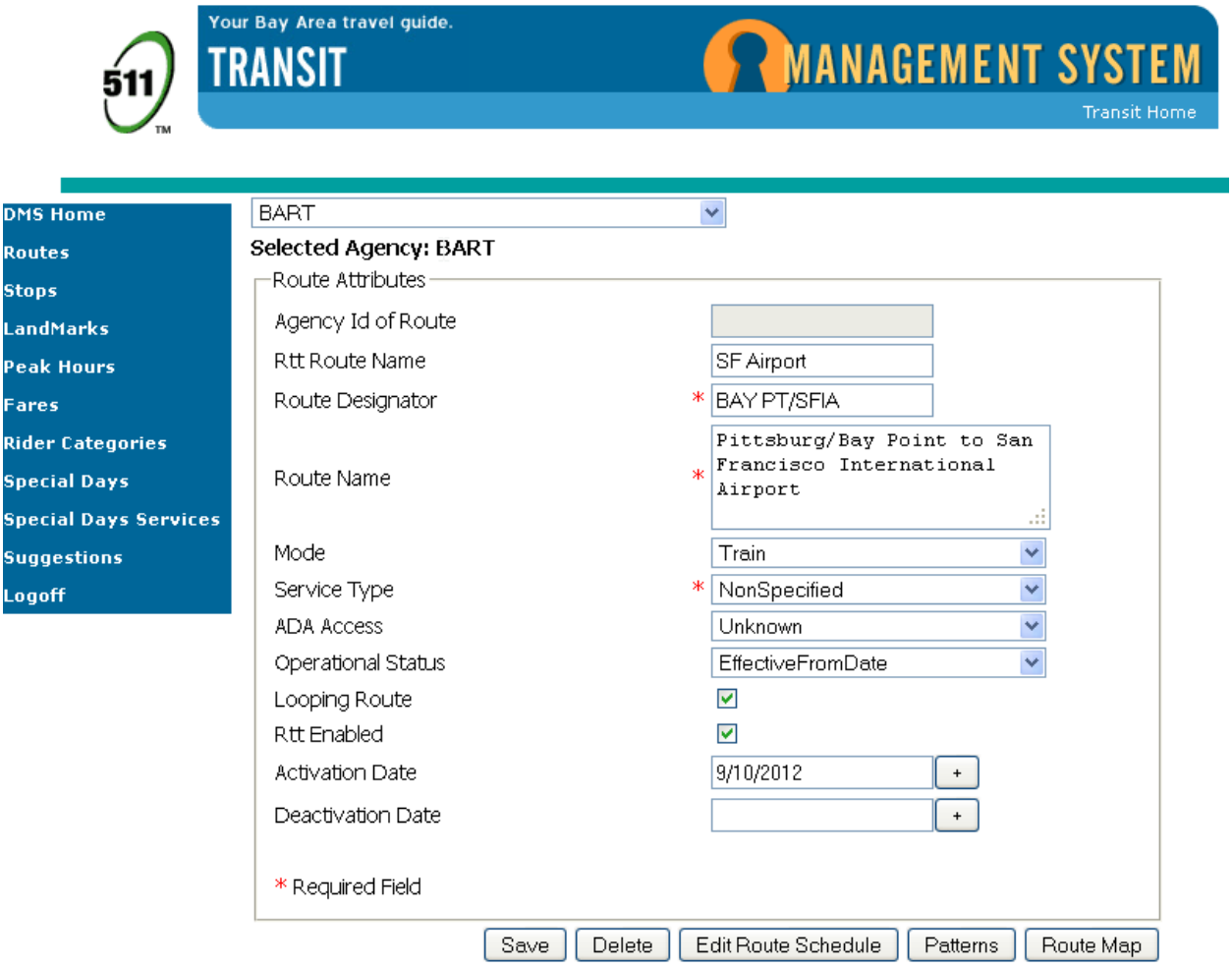

Figure 12 – WebDMS application