

Portal 2.0: Towards a Next-Generation Archived Data User Service

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ABSTRACT

PORTAL is the official transportation data archive for the Portland metropolitan area and consists of a one-terabyte transportation database and a web-based interface that provides a wide variety of performance metrics and graphics designed to assist transportation practitioners and researchers. Originally developed as a research prototype, PORTAL has met its initial goals and is progressing towards a second-generation data archive. We describe initial work on Portal 2.0, the next-generation PORTAL. Portal 2.0 improves on the original PORTAL by providing an updated more-intuitive, customizable interface that leverages Adobe Flash and Google Maps technologies and provides improved data quality monitoring and control.

INTRODUCTION

The Portland Oregon Regional Transportation Archive Listing (PORTAL) was established in 2004 with a simple web interface and a single data source—freeway loop detector data from the Oregon Department of Transportation (ODOT). Since then PORTAL has grown into a large, complex system with a one-terabyte archive of transportation-related data and a web site with over 20 different pages featuring a wide variety of graphical and tabular displays of data (1). PORTAL is widely used by local transportation professionals; it has been used in the development of the Regional Transportation Plan, by the local news media, and in numerous research projects at the Intelligent Transportation Systems (ITS) Lab at Portland State University (PSU). PORTAL was originally developed as a research platform and has achieved its initial goals. Based on input from users, we are developing the next-generation PORTAL, which we call Portal 2.0, to include user interface upgrades and enhanced tools for use in travel demand modeling and performance measurement, support for both novice and experienced users and decision-makers and improved data quality monitoring and control.

In this paper, we describe the initial development of Portal 2.0. In particular, we describe the new Web 2.0 interface for PORTAL and improvements in data quality monitoring and control. The Web 2.0 interface uses Adobe Flash and Google Maps technology to deliver an intuitive, interactive and customizable interface. In terms of data quality improvements, we describe a web-based report developed for ODOT to aid in prioritization and efficient use of detector maintenance resources and we summarize a set of field visits that helped correlate physical detector problems with data anomalies. The Portal 2.0 web site is available at: <http://portal2.its.pdx.edu>.

PORTAL BACKGROUND

PORTAL is the official Intelligent Transportation Systems data archive for the Portland metropolitan region. PORTAL archives 20-second speed, count, and occupancy data from the approximately 600 inductive loop detectors in the Portland, OR and Vancouver, WA metropolitan region. Additionally, PORTAL stores other transportation-related data including data on weather, incidents, and variable message sign displays in addition to bus AVL and truck weigh in motion records. The ITS infrastructure in the Portland region also includes nearly 100 CCTV cameras, 138 ramp meters, transit signal priority, advanced bus dispatch system, and an extensive fiber optics network. The regional transportation agencies (including Portland State University) are connected via a high speed (gigabit) ethernet ITS network that facilitates data sharing and interoperability.

From an ADUS perspective, PORTAL follows the specifications from the National ITS Architecture, as it allows access to all these data sources in an integrated, well-formed, and systematic way (2), as well as providing several data quality metrics. As suggested in the FHWA ITS Guidelines, user access to PORTAL is via a web-based interface providing easy access to both raw data and a wide range of common summary data and standard performance measures. The PORTAL web site has over 20 different tabs (or pages) providing graphical and tabular performance information ranging from timeseries and contour plots of performance measures including speed, volume, occupancy, VMT, VHT, incident reports, bivariate plots, a performance dashboard, a transit speed map, traffic count information and more. Currently, PORTAL's users include transportation planners, metropolitan planning organizations (MPOs), traffic management operators, transit operators, and transportation researchers. PORTAL is made possible by the fact that transportation agencies in the Portland metropolitan region freely share their data, and make it available free to the public. This underlying philosophy is critical to the success of the system.

PORTAL 2.0 INTERFACE

In this section, we describe the new interface elements in Portal 2.0 and describe how the new pages provide a more intuitive and interactive graphical interface to the archived data.

The original PORTAL interface design was developed five years ago. Recently, the PORTAL team has begun developing a new interface for Portal 2.0. The new interface uses Adobe Flash graphs and Google Maps

technology to provide a highly-interactive, user-driven interface. Further, the new interface attempts to provide a richer, more intuitive way to navigate through the archive suitable for effectively displaying results that combine data from multiple diverse data sources.

A challenge in creating an interface for a data archive such as PORTAL is to support the wide variety of users served by such an archive. Portal 2.0 is designed to be intuitive and easy-to-use, particularly for the users who wish simply to quickly understand current conditions, while still supporting advanced options and customizations for users such as researchers and traffic managers who desire an in-depth understanding of the data and traffic conditions.

Design Motivation and Principles

The development of Portal 2.0 provides a unique opportunity to re-think the type of applications that can be made available to data archive users. Systems such as Portal 2.0 have a variety of users who have different needs and interests. Some users simply want to glance at current traffic conditions. Users such as traffic managers may wish for a more-detailed analysis or understanding of a current or recent traffic event. Users such as urban planners need trending and forecast information to help with the development of medium and long-term plans for the urban area. Finally, some users, including researchers and transportation department staff, wish to do in-depth, detailed analysis of the data, for example for research projects or performance reports.

Some of the uses described above are heavily parametric in nature and require many user-driven selections, while other uses require a good set of defaults and a very intuitive interface. A user simply wishing to assess the current traffic state does not need or want to make a lot of selections; in contrast, researchers are likely to want to make detailed selections and specifications. Supporting this range of user desires is challenging. The current design attempts to make the interface straightforward and intuitive for the user who wants limited information while providing more powerful options for the more advanced user who wants to do in-depth analysis.

System Overview

Following the lead of the original PORTAL web site, Portal 2.0 provides a wide variety of functionality and customizable graphs. These different functionalities in Portal 2.0 are grouped in several categories easily accessible at the top, arranged using similar design patterns to those found in web applications or the *ribbon* interface in Microsoft Office applications. In Portal 2.0, we have grouped functionality by freeway system subset, in contrast to the original PORTAL which grouped by type of graphic to be produced. We believe this re-grouping is more intuitive. The current default welcome screen is shown in Figure 1 below.

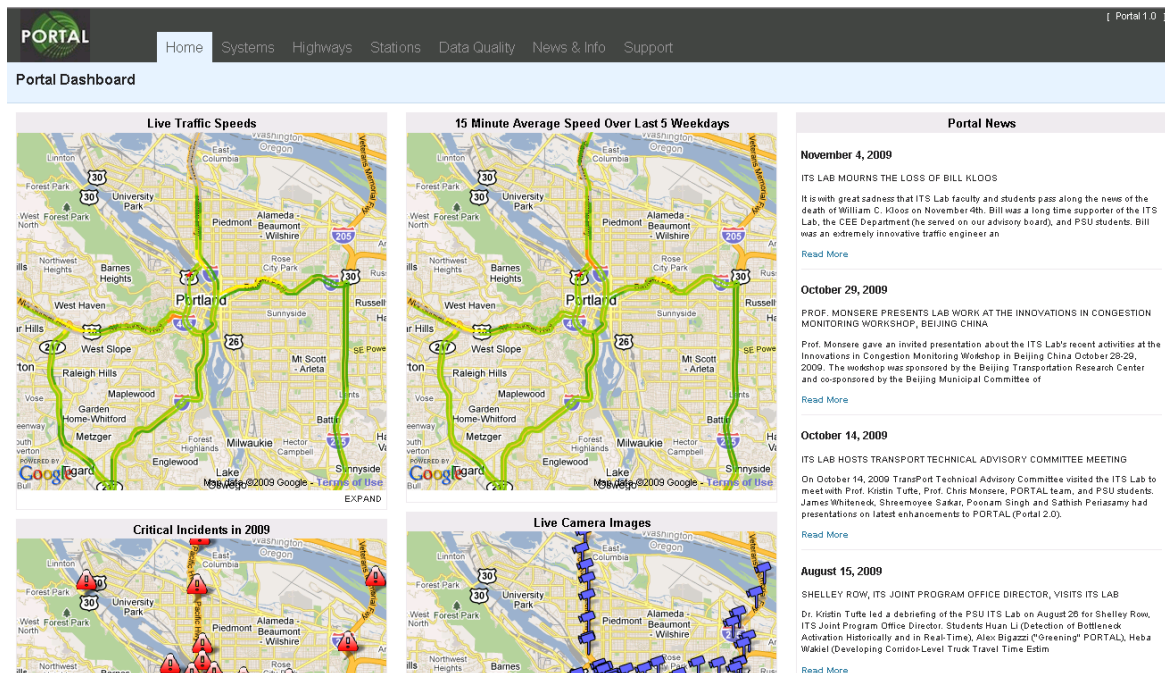


Figure 1 The Portal 2.0 Welcome Screen

The following pages are currently available in Portal 2.0:

- **Home:** The user-customizable landing page. The default page will provide a snapshot of the freeway system's current state. Users will be able to modify the content and layout of this page to create a personalized landing page.
- **Systems:** The systems page provides information about the performance of the system as a whole, in contrast to the highway- or station-level information provided by other pages. System performance graphs and statistics will be available on this page.
- **Highways:** The Highways page provides graphics and statistics that can be used to analyze entire highways. This page is expected to be converted to provide tools for analyzing user-selected corridors which will consist of subsets of existing highways or a combination of segments from multiple highways.
- **Stations:** The Stations page provides tools that focus on the analysis of an individual station; that is a particular freeway location.
- **Data Quality:** The Data Quality page provides information about detectors producing suspicious data.
- **News & Info:** The News & Info page provides news and information about the Portal 2.0 project and team members.
- **Support:** The Support page provides access to associated documentation and publications as well as a mechanism for submitting feedback and problem reports.

Interface Description

The primary pages in the current release of Portal 2.0 are described in this section.

Home Page

The Home page has been designed to provide a landing site that can be customized to a user's needs. This page has been created using customizable widgets and was inspired by such user-customizable pages as the Google Finance page (<http://finance.google.com>). Registered users will be able to customize the functionality, presence and placement of widgets on the Home page. The ability to customize will allow users to immediately see plots of specific interest to them when opening the Portal 2.0 web site. For users who do not wish to customize their Home page, the default plots on the pages will be plots that are perceived to be of the most general interest. Portal 2.0 provides the user with map-based access to many data sources. For example, the ability to access ODOT's live camera images by simply clicking on the camera icon on a Google map of the Portland Metropolitan Area. The Google Maps API (3) is used as a basis for map-driven explorations, leveraging web-user familiarity with the Google interface.

The portion of the landing page shown in Figure 1 shows five widgets: current and historical speed maps, incident and cameras maps and a news module. The left-hand speed map display current live traffic speeds in the Portland metropolitan area derived from data received from the Oregon Department of Transportation (ODOT); the right-hand speed map displays historical speeds from the most recent five weekdays for comparison purposes. The cameras map (partially visible in Figure 1) consists of clickable camera icons, each icon indicates the location of an ODOT camera and can be clicked to create a pop up window that displays the current image from the camera. The news widget on the right-hand side provides recent news from the Portal team. With the exception of the news widget, the widgets on the Home page can be dragged and moved around and organized as the user desires. Further, each individual plot has two modes *Compact* and *Expanded*. Compact mode allows its inclusion in the various tabs using minimal screen real estate. Expanded mode opens a larger window and reveals a set of advanced options that user can use to customize the plots to their needs. An expanded version of the street cameras map is shown in Figure 2.

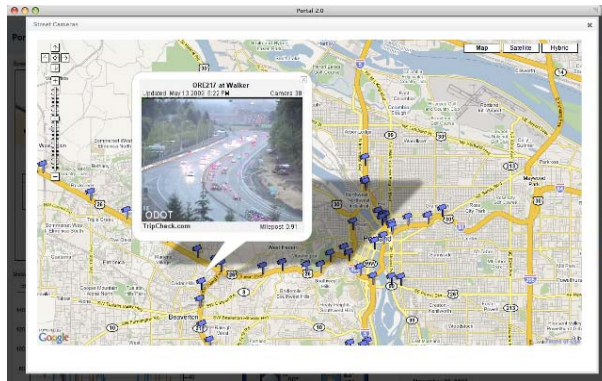


Figure 2 The Street Cameras map in Expanded mode.

Portal 2.0 is designed to incorporate data from various sources with minimal user interaction. While the widgets on the current version of the Home page show only one type of data—speed, incident or camera data, the Expanded Systems Map, accessible by clicking the Expand button on the left-hand (Live Traffic Speeds) map and discussed in the next section, incorporates speed, camera and incident data all in one map. This integration of data is key to next-generation archived data user systems as a single data source becomes significantly more interesting when placed in the context of other related data sources.

Systems Page

The Systems page, shown in Figure 3 contains a tool that uses a Google Map interface to provide comparison of travel speeds at a single selected time versus a speed average over a selected historical period of time. The maps in Figure 3 show speeds for bi-directional traffic on the Portland-area freeways. The left-hand map displays speed for a selected date and time range. In the figure, the selected time range is the AM peak (7AM-9AM) on May 12, 2009. The right-hand map displays speed for a comparison historical period. In the figure, the comparison is with the AM peak for the five weekdays prior to May 12, 2009. By selecting the 15-minute interval radio button, the user can see speed map data at a 15-minute granularity and gains the ability to step one-by-one through the 15-minute intervals within the selected peak.

In Figure 3, the selected day during the AM period performs comparably to the previous five weekdays in the archive, with a noticeable exception in one segment. The orange color on the horizontal US-26 segment in the left map in contrast with the yellow color of this segment in the right map indicates that traffic on this section was worse than over the comparison period. This quick comparison is useful to traffic operator attempting to answer questions about previous days traffic patterns. In addition to the comparison maps, the systems page includes a plot showing the weather, which is useful for determining if an unusual traffic pattern is due to inclement weather. In the future, a display of incidents will be added to these maps so a user can tell if an unusual traffic pattern was caused by an accident, construction or other incident.

Highways Page

The Highways page, shown in Figure 4, displays a speed and volume plot and a speed contour plot for a selected freeway corridor; I-5 NB in this figure. The left-hand speed and volume plot shows aggregate speeds and volumes for the entire corridor for the current day. The right-hand plot is a speed-contour plot showing speeds along the freeway for the current day; the horizontal axis is time and the vertical axis is milepost. The selected highway can be changed using the pull-down in the upper left corner of the page.

Following our design principles, the maps on the Highway page display speed and volume, as those are perceived to be the quantities of most common interest. As with most graphics in Portal 2.0, both of these graphs support an *Expanded* mode with additional options. In Expanded mode, the user can select the quantity to be displayed and, in the speed and volume plot, can toggle between displaying aggregated values for the full corridor versus a plot showing a line plot for each station along the corridor. Quantities available include speed, volume, occupancy, vehicle miles travelled, vehicle hours travelled, delay and travel time.

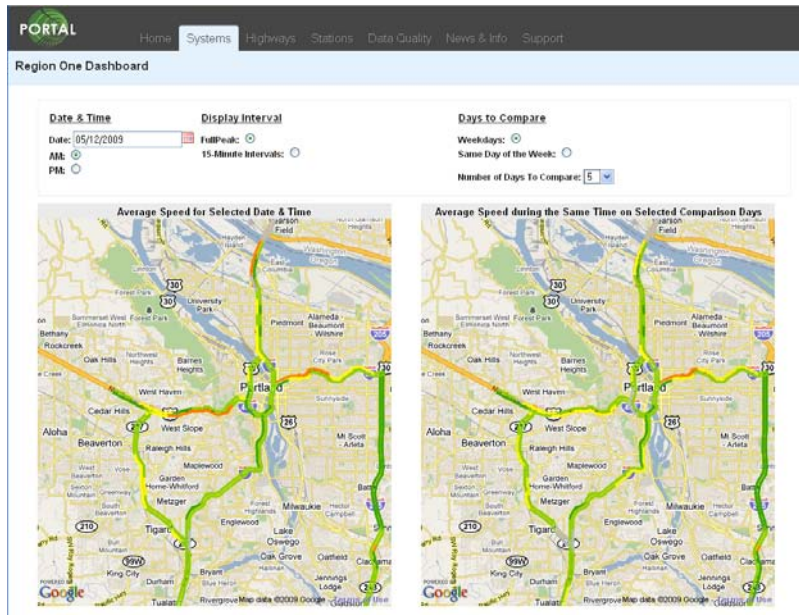


Figure 3 The Systems Page.

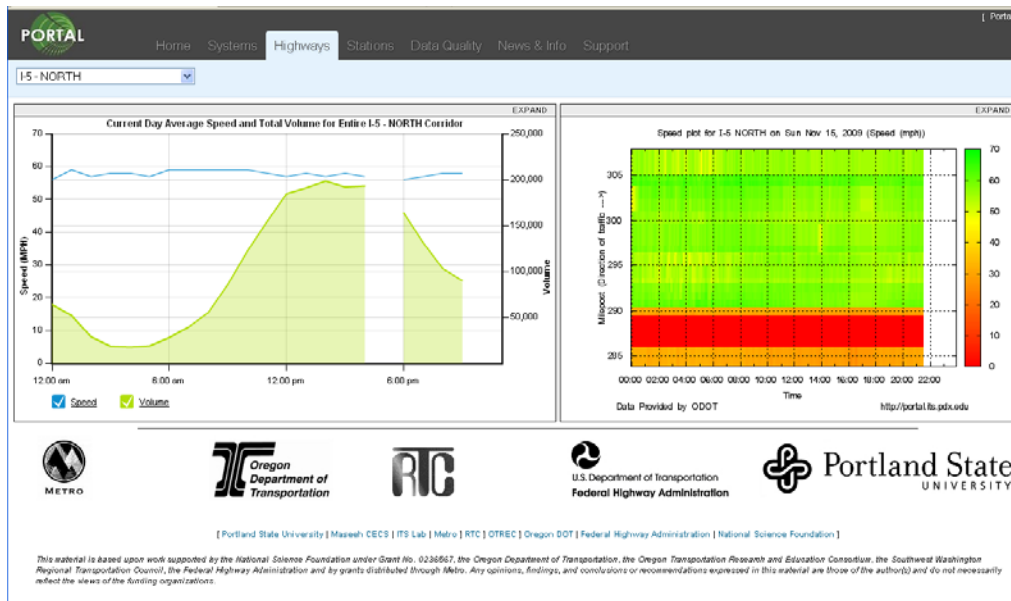


Figure 4 The Highways Page.

Stations Page

The Stations tab has four tools to enable per-station exploration and is shown in Figure 5. Consistent with other tabs, there is a pull-down on the top left corner that can be used to change the station for which graphs and maps are displayed. The text in the upper left corner of Figure 5 describes the station and includes information such as the number of lanes at the station, its geographical location, the milepost, and the length of the influence area of the station. (Influence areas are calculated using the standard midpoint method which assumes that a station is a good representation for the area from halfway between the closest upstream station to itself and the region between the station and halfway to the closest downstream station.) Additionally, the station location is shown on a Google Map in Satellite View. The map can be zoomed in and out and navigated around in.

The graph in the lower left provides a snapshot of station performance. The graph shows volume in terms of vehicles per lane per hour in a timeseries to give a quick representation of demand at that particular location. In addition, the graph shows congestion frequency by time of day at the station. The default plot shows performance over the most recent month. As with the timeseries plot on the Highways page, mouse over displays the values in small pop-up windows and click-and-drag functionality enables zooming into the timeseries plot as shown in Figure 5. Such interactivity is supported by the use of Flash charts. Currently Portal 2.0 uses Adobe Flash (4) technology from amCharts.com (5). The graph in the lower right displays timeseries of speed and volume for the station. The expanded mode of this tool allows the user to select the time period of interest.

Expanded Systems Map

As discussed above, a goal of Portal 2.0 is to integrate a variety of data into a single display. The Expanded Systems Map, shown in Figure 6, displays speed, cameras and incident data on a Google Map. Users can toggle the camera and incident layers on and off as desired. Additional layers, such as VMS message displays, will be added in the future. A complication of making the Custom System Map was in displaying speeds for both directions of each highway. The Google Maps API does not expose the ability to directly create lines that follow a highway. Instead, the API supports creating lines based on a series of latitude, longitude points and width information. Latitude, longitude traces of both directions of the highways were available to us from probe vehicle runs for a previous project. However, simply creating lines with those traces did not work as the lines overlapped in zoomed-out views. Our algorithm, takes a set of points, derived from the probe vehicle runs, and draws two parallel lines on each side of that set of points. In the current map, there is a separate line for each freeway “segment”; each segment is associated with a detector station and each line is then colored specifically to current conditions. Finally, the Expanded Systems Map allows the user select a specific time and day to display.

Custom APIs - R

The PORTAL data is used by many researchers at the ITS Lab at Portland State University and many of these researchers develop interesting graphics using the PORTAL data. The goal of the Custom APIs sub-project is to allow graphics developed by ITS Lab researchers to be easily integrated into Portal 2.0. The ITS Lab has selected the R statistical software and graphics package (6) as its primary graphics tool. The PORTAL team has implemented a framework so that graphical data displays written in R can be nearly-automatically integrated into Portal 2.0. This framework requires only that researchers write their R graphics to a simple specification. The researchers do not need to know or understand Portal 2.0 or web development. In such a way, Portal 2.0 is modular so that many people can effectively contribute to the project.

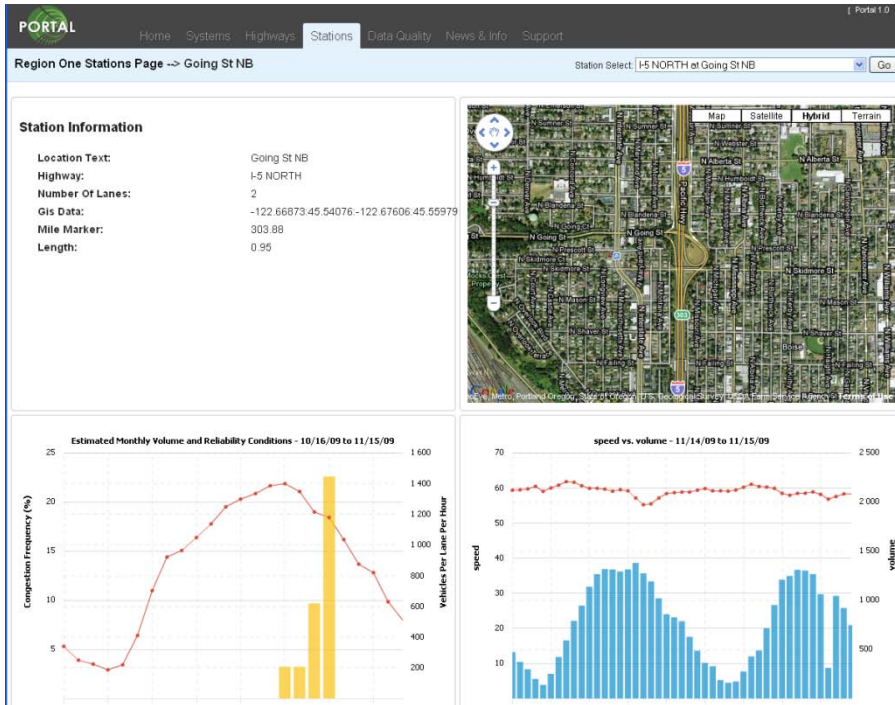


Figure 5 Station Page Detail.

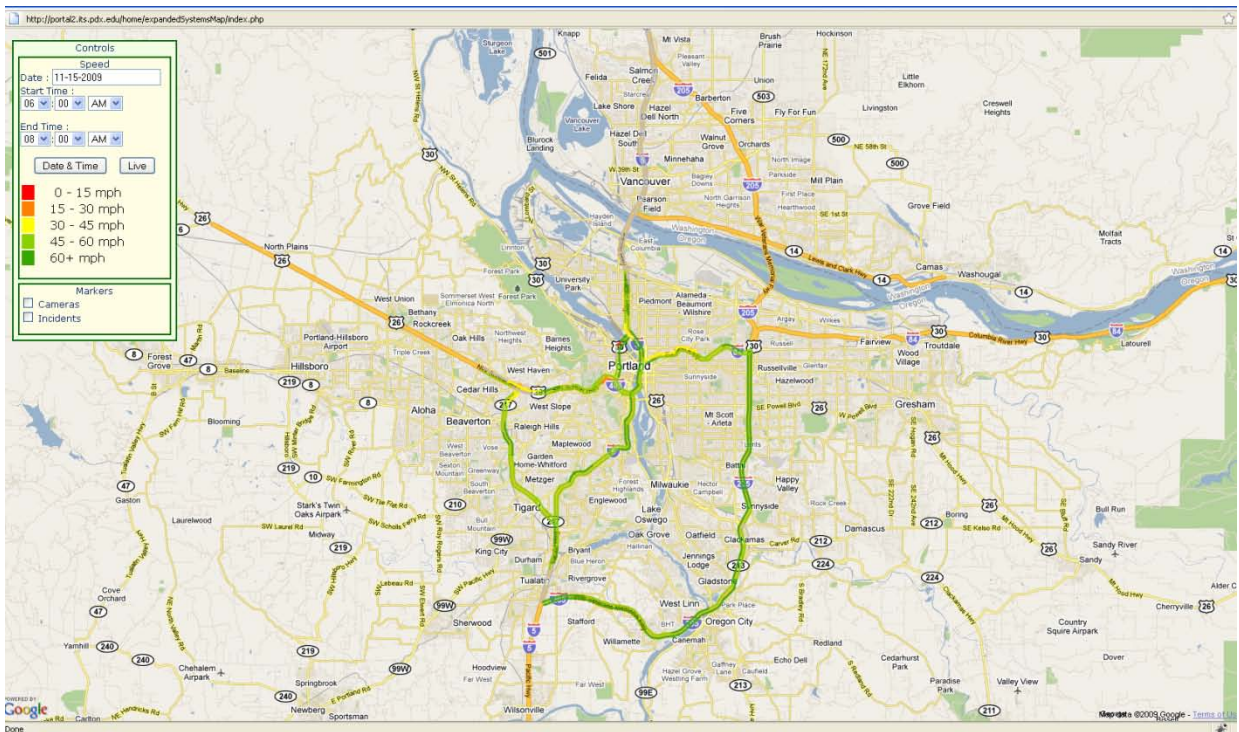


Figure 6 The Expanded Systems Map

DATA QUALITY

Understanding, managing and dealing with data quality is crucial in an Intelligent Transportation Systems (ITS) data archive. Inductive loop detectors are a primary source of ITS data; however, inductive loop detectors may produce planned or unplanned poor quality data for several reasons such as detector or controller misconfiguration, communication failures, construction activities, and sporadic data errors. Currently, each loop detector in the Portland area freeway system is (ideally) visited once a year for preventative maintenance. In between, preventative maintenance visits, detectors are only visited if a complaint is filed or if the detectors stop producing data entirely. However, loops may provide poor quality data for a long period before they stop producing data. When a loop detector degrades or becomes un-calibrated, that problem can often be seen simply by observing the data produced by the detector. Existing work at PSU (7) and by the Texas Transportation Institute (8) has identified a set of data quality tests that can potentially be used to identify malfunctioning detectors. Researchers at PSU have developed a web-based tool that identifies detectors potentially in need of maintenance and have conducted a series of field visits to attempt to correlate data anomalies with physical detector problems. Proactive, automatic identification of detector malfunction through the use of tools such as our web-based Quality Control page will allow agency field maintenance staff to identify problematic detectors without having to inspect each detector station in the field.

This work builds on existing data quality research including ITS archive guidelines (9,10) and quality control methods and procedures (11,12) developed by Turner, a Federal Highway Administration (FHWA) document on Traffic Data Quality Management that provides guidelines for calculating data quality measures (13). Early work in data quality involved threshold tests developed by Jacobson et al. (14) and by Turochy and Smith (15). The PeMS project has proposed an algorithm that analyzes a day's worth of detector data to determine if the detector is performing well (16). Finally, there is a body of work that uses items such as loop signatures and event-level data to improve data quality (17). Our work is directed at using existing data quality tests to produce a web-based data quality report directly usable by ODOT staff and at correlating data anomalies with physical configuration issues.

Data Quality Web Page

Based on previous data quality research and metrics (7), a web page called 'Detector Data Quality Control' has been developed. This tool identifies detectors that may be performing poorly based on anomalies observed in the data, such as a detector consistently reporting a high percentage of speed readings greater than 100 mph, or a detector reporting low occupancies even during congestion. Specifically, the Quality Control web page lists detectors having large percentages of readings that fail a set of data quality tests. The criteria used by the PSU team to identify suspicious data readings are listed below; the first four criteria were adopted directly from the publication "Monitoring Urban Freeways in 2003: Current Conditions and Trends from Archived Operations Data (8). In addition sites reporting large numbers of Communication Failures or No Traffic Readings are also reported. While theoretically a No Traffic reading is valid, in the ODOT ATMS system communication failures often masquerade as No Traffic readings; thus the reason for their inclusion in the data quality reports.

- Volume > 17 (• 3060 vplph)
- Occupancy > 95%
- Speed > 100 mph
- Speed < 5 mph
- Low maximum occupancy
- Low average occupancy during peaks

Figure 7 shows an image of a portion of the page listing detectors with unusually high percentages of volume readings > 17. The table provides information about the detector, its location and lane and the percentage of volume > 17 readings observed for the selected day (July 31, 2009 in this figure). The detectorid is clickable and when clicked loads a series of graphs for that detector; graphs included are timeseries speed, volume and occupancy plots and a bivariate flow vs. occupancy plot. These plots are intended for use in debugging detector issues. Quality Control reports can be produced at the day, week or month granularity.

During the field visits, it was noted several detectors were known to be mal-functioning and in need of physical repair. Examples include loops ground out or paved over due to construction or serious detector malfunction. Such detectors cannot be fixed by maintenance staff, but instead must be fixed by contractors and are such detectors are likely to be out of service for a long period of time. It is not useful, to continually include these

detectors in the data quality reports as maintenance staff cannot make any improvements to these detectors. To this end, damaged or failed detectors are logged in the PORTAL database and are excluded from the Quality Control report. A table at the bottom of the Quality Control page provides a listing of the damaged detectors.

Detector Data Quality Control

You can [click](#) on a detectorid to see more detailed graphs corresponding to the detector. (It may take a while to load.)

The following tables were constructed by processing loop detector data on 2009-07-31.

Date: July 31 2009 Resolution: day [view tables](#)

Configuration Errors

Volume > 17 — Volume Too High						
detectorid	stationid	highwayname	locationtext	ATMS lane number	field lane number	percentage
1393	1051	I-205 SOUTH	StarKWashington SB	1	3	6.37
1291	1033	I-5 SOUTH	Going St SB	1	3	4.95
1228	1025	I-5 NORTH	Janzen Beach NB	1	3	2.80
1466	1060	I-84 WEST	58th WB	3	1	0.81
1717	1095	US 26 WEST	Murray Rd WB	3	1	0.67
1835	1122	US 26 WEST	US26 WB @ I-405 Count Station	1	1	0.28
1131	1013	I-5 NORTH	Terwilliger Blvd NB	3	1	0.25
1139	1014	I-5 NORTH	Bertha NB	3	1	0.25
1058	1006	I-5 NORTH	Upper Boones NB	2	2	0.25
1803	1115	I-205 SOUTH	10th Street to I-205 SB	1	2	0.21

Occupancy > 95 — Detector Always Occupied						
detectorid	stationid	highwayname	locationtext	ATMS lane number	field lane number	percentage
1237	1026	I-5 SOUTH	Janzen Beach SB	2	2	99.75

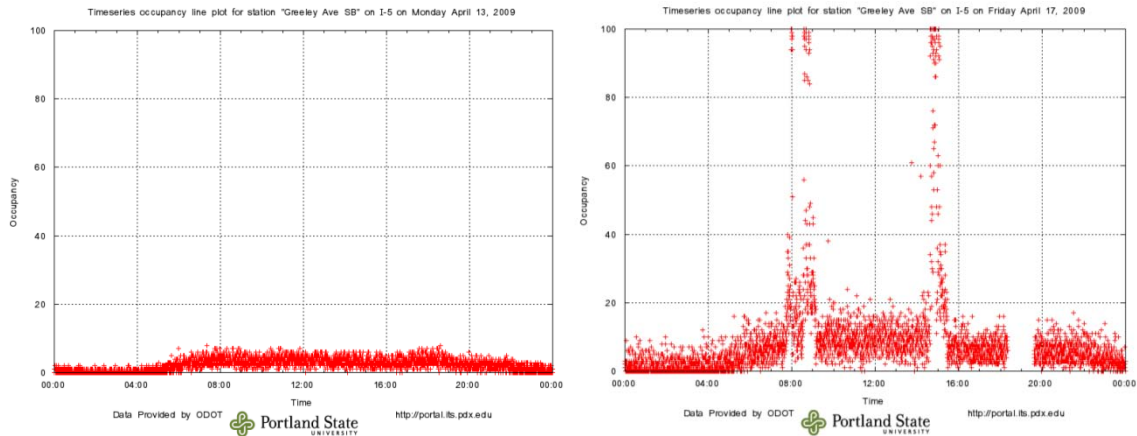
Figure 7 Detector Data Quality Control Web Page

Field Visits and Maintenance Work

The Quality Control web page lists detectors that are failing data quality tests at the highest rates. While this information is useful, it is even more valuable if those test failures can be correlated with physical problems in the field. To this end, on Tuesday April 14, 2009, PSU and ODOT staff visited three detector stations with suspicious behavior. Various tasks were performed at various stations including changing loop amplifier cards and amplifier card settings and replacing a controller. Following the April 14 field visit, ODOT staff made visits to and changes at several other stations. The results of the visits and detector updates are summarized below.

Unusually Low Maximum or Average Occupancy

In several locations, unusually low maximum occupancy has been correlated with detectors in pulse mode vs. presence mode. In particular, the location at I-5 SB Greeley was visited on April 14, 2009. Before the visit, Lane 2 at this station exhibited unusually low occupancies as shown in Figure 8 (a). During the visit, 3M Canoga loop amplifier cards were replaced with EDI cards. Figure 8 (b) shows an occupancy plot from after the visit. One can observe that the low occupancy in Lane 2 appears to have been resolved. It is suspected that the low occupancy problem was caused by the 3M Canoga card being in pulse mode instead of presence mode, which is appropriate for freeway loops. This low maximum occupancy problem has been associated with detectors in pulse mode at other locations.

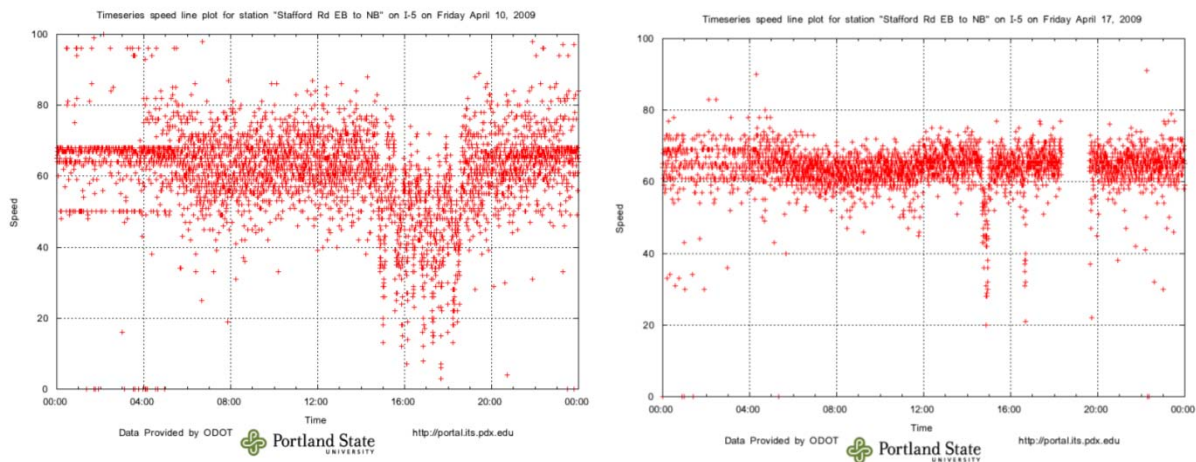


(a) Lane 2 – Occupancy – April 10, 2009 (Before) (b) Lane 2 – Occupancy – April 17, 2009 (After)

Figure 8 I-5 SB at Greeley Before and After Amplifier Card Update

High Variability in Speed Readings

At a loop detector station located at I-5 NB at Stafford Rd exhibited high variability in speed readings as well as a large number of unusually high speeds. On April 16, 2009, this station visited and a 170E controller was replaced with a HC11 controller. Figures 9 (a) and 9 (b) shows before and after Speed plots, respectively, for this location. After the controller replacement, the speed readings appear much improved; there is less variance in the 20-second readings and fewer abnormally high speeds. It is theorized that the improved controller reduced the speed variance and presence of unusually high speeds. Additional controller replacements are being performed to validate this theory.



(a) Lane 2 – Speed – April 10, 2009 (Before) (b) Lane 2 – Speed – April 17, 2009 (After)

Figure 9 I-5 NB at Stafford Rd Before and After Controller Update

Zero Speeds Overnight

Lane 1 at the loop detector station located on I-205 SB at Glisan was observed to regularly report speeds of 0 mph during the overnight period. These zero overnight speeds can be seen in Figure 10 (a). This station was visited and ODOT staff discovered that the loop amplifier card in lane 1 had the frequency set the same for both loops. The frequencies were adjusted and the prevalence of zero speeds overnight was greatly reduced as can be seen in Figure 10 (b). It is theorized that crosstalk was causing the incorrect zero speeds to be reported during the low-traffic overnight periods. Several other stations in the Portland area have a high prevalence of low overnight speeds. Investigations are on-going at those stations to see if crosstalk issues are present at those stations also.

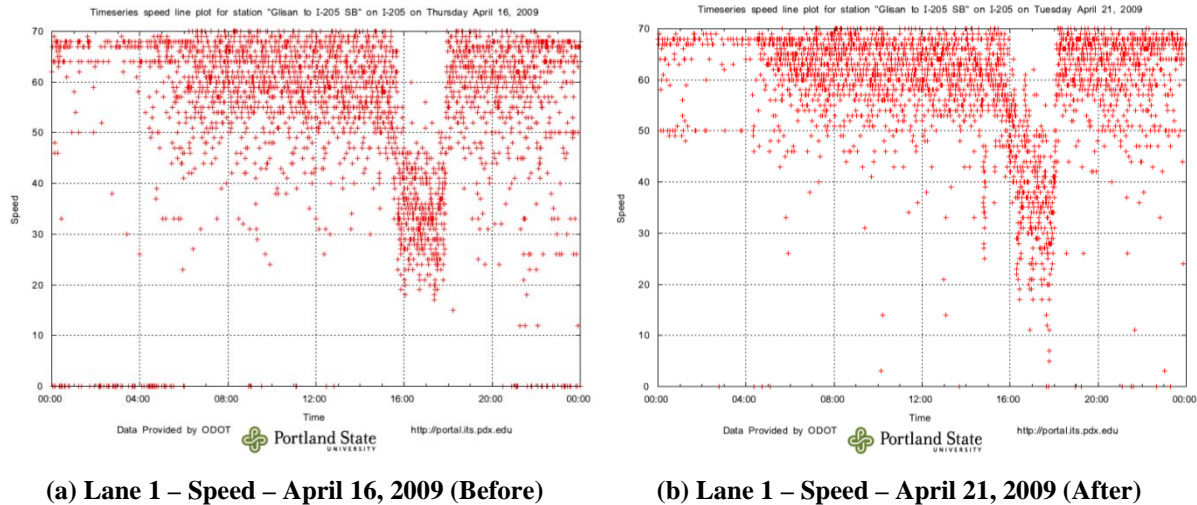


Figure 10 I-5 SB at Glisan Before and After Amplifier Card Frequency Changes

CONCLUSION

We have presented the first prototype of the Portal 2.0 ADUS. We have detailed our motivation in designing a meaningful Web 2.0 interface for a variety of users, leveraging their familiarity with commonly-found web paradigms, and focusing on intuitiveness, interactivity and customization. Work continues on the development of the Portal 2.0 interface. Next steps will include completion of Portal2.0 prototype, training and feedback sessions with local agency staff, implementation of tools for analysis of Bus Automatic Vehicle Location data, and further expansion of the data and tools available for the Vancouver, WA area. Further, we have described development of a Quality Control web page and field visits conducted to identify correlations between detector configuration errors and malfunctions and data anomalies. This work should lead to improved effectiveness of ODOT maintenance and higher quality data for the PORTAL archive. Future work will improve the Quality Control web site and develop a system-level data quality metric for Portland-area freeways.

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