**Lab II Product Specification Outline**

CS 411W

Prototype Product Specification

For

Current ITS

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1. Introduction

Transit authorities around the country face a multitude of problems when beginning to implement a light rail system to service their host populations. Not the least of these problems is accurate, real-time communication between the rider, the local businesses that surround the light rail, and the transit authorities themselves. Unfortunately, when planning these systems, often the cost associated with them leaves features unfinished or omitted. In the case of Hampton Roads Transit (HRT) and The Tide, there is no way for riders to accurately know the following: the location of trains relative to them, the current rider capacity the trains are at, and any potential problems along the rail line that may impact their travel.

HRT also has no way to accurately track where the trains are, even in downtown Norfolk, a densely populated area. If a train de-rails, human operators have to manually call in the event, which then is relayed to the control center located near Norfolk State University (Messina, 2011). There is no way for those affected by the derailment to automatically reroute themselves to their destination using HRT’s other services, such as the busses. HRT has no way to accurately size their deployment of trains with their existing system, which results in wasted man hours and potentially under/over provisioning of trains.

The local businesses along the line wish to attract potential customers who ride the light rail, but have no way to target the riders in a meaningful way. This results in a loss of riders who are frustrated about a lack of information on what this new transportation service could offer to them. The current level of functionality of The Tide leads to a loss of revenue for HRT who has to constantly justify their light rail project to the local tax paying populace. It is also a loss in potential revenues for the local businesses along the rail line (SIR 2011). This indicates potential problems when it comes to expansion of the rail line into neighboring Virginia Beach, whose main motivator for doing so would be in the benefits the rail line could have to its local businesses and large naval population. These benefits include an alternative to the already overburdened highway system, and boosts to the local economy.

Current intelligent transportation system (ITS) is being developed with free flow of information between the rider, HRT, and local businesses in mind. This system will result in The Tide seeing higher ridership retention levels. Transit authorities like HRT will now have a good handle on their efficiently running system. Additionally, prosperous local business owners will benefit from educated riders visiting their businesses.

* 1. Purpose

Current ITS is a highly modular system, accommodating any existing ITS infrastructure that the transit authority has deployed. Primarily, it works by relaying real-time global positioning system (GPS) data, and automatic people counting (APC) information about the train system to the riders and to the transit authority through a web interface. In addition to the web, riders with smartphones will be able to use a mobile application to view the status of trains, local events and places of interest, routes to their destination, as well as receive real time alerts. This provides a platform for instant feedback to the transit authority. For HRT, collection of this GPS and APC data allows for trending and prediction in order to accurately provision train cars according to anticipated demand. This prediction can also show where riders are going to most often, allowing for future rail expansions to be more quickly determined. Current ITS helps local businesses advertise to riders who are headed near their place of business by providing a backend platform for uploading and tracking advertisements for their business. These advertisements are then deployed through the web interface to the various users (i.e. the mobile application and kiosks near stations). Ultimately, these features save the riders from wasting their time on a transit solution they know nothing about, transit authorities from running an inefficient and incomplete service, and assists local businesses in attracting customers, helping them inject money and life into the local economy.

* 1. Scope

The prototype of Current ITS aims to provide the most functionally complete product it can while remaining within the constraints of the time & data allotted. It will be at a reduced scope and feature set than the real world product, but it will be functionally complete. The three roles – HRT, the rider and the local business owners will each be acted out by a member of the Current ITS development team. Current ITS will be modeled after the real world, but will be simulated using prepopulated data and controlled using a test harness. Thus, no physical hardware is needed to execute the prototype. This prototype’s objective is to provide the “transit authorities” with the simulated information they need to make informed decisions, to assist “riders” in making efficient travel plans, and to model a location-based advertising platform for local “business owners.” The functionality will be provided so that the actors may view the simulated current state of the trains, as well as prepopulated historical data in the form of reports. In order to promote themselves and to notify the transit authorities, business owners will have an interface to post fake upcoming events along with their locations. These features will demonstrate how all end users can save time and money using Current ITS.

* 1. Definitions, Acronyms, and Abbreviations

GSM: Global System for Mobile Communications - technology that is used in cellular devices

today to enable wireless communication.

Android: Google’s widely-used, open-source platform for mobile applications.

OSI Application Layer: This layer interacts with software applications that implement a communicating component.

Automatic Passenger Counter (APC): Sensor that uses infrared cameras to count passengers

entering and exiting the train door.

Automatic Vehicle Location (AVL): System that sends GPS coordinates of vehicles.

CentOS: Community Enterprise Linux.

Database Server Hardware that stores information in a relational database management system

(RDBMS).

Decision Engine (DE): Component of Current ITS that can generate trends and predictions of ridership and delays.

Global Positioning System (GPS): Satellite-based navigation system that provides location and time information from space.

GNU/Linux: A free, widely-available open-source operating system.

Google Places: Third-party source for local business locations.

Graphical User Interface (GUI): How the end user will interact with the application.

GTFS: Google Transit Feed Specification, an industry standard in transit reporting.

Intelligent Routing Algorithm: An algorithm inside Current ITS that determines the best path to take in the event of a delay or other incident.

Intelligent Transportation System (ITS): general term for advanced management applications in transportation systems.

Machine Learning: A branch of artificial intelligence concerned with programming computers to change behaviors based on historical data and make predictions based off many types of algorithms.

MySQL: the worlds most used RDBMS.

Open Systems Interconnect (OSI): It characterizes and standardizes the functions of a [communications system](http://en.wikipedia.org/wiki/Communications_system) in terms of [abstraction layers](http://en.wikipedia.org/wiki/Abstraction_layer). Similar communication functions are grouped into logical layers.

OSI Presentation Layer: establishes context between application-layer entities.

RDBMS: Relational Database Management System.

Secure Sockets Layer (SSL):  a cryptographic protocol that provides communication [security](http://en.wikipedia.org/wiki/Security) over the [Internet](http://en.wikipedia.org/wiki/Internet) at the Application Layer.

OSI Session Layer: The [session layer](http://en.wikipedia.org/wiki/Session_layer) controls the connections between computers.

Structured Query Language (SQL): Special purpose programming language used to make queries to a database server.

Tables: Logical collections of data stored on a database server.

Training Set: A collection of historical, actual data used to make predictions about future events.

OSI Transport Layer: The [transport layer](http://en.wikipedia.org/wiki/Transport_layer) provides transparent transfer of data between end users, providing reliable data transfer services to the upper layers.

Web Application Engine (WAE): The main interactive component of Current ITS that can process various requests including DE predictions, checking delays, etc.

* 1. References

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Southeastern Institute of Research, Inc. (2011). *Hampton Roads Transit: Light Rail Marketing Research Study.* Norfolk: Southeastern Institute of Research, Inc.

Lutz, Nathan. Lab I - Current ITS Product Description. Old Dominion University CS411 Professional Workforce Development II. Norfolk, VA. 2012.

* 1. Overview

This product specification provides the hardware and software configuration, external interfaces, capabilities and features of the Current ITS prototype. The information provided in the remaining sections of this document includes a detailed description of the hardware, software, and external interface architecture of the Current ITS prototype; the key features of the prototype; the parameters that will be used to control, manage, or establish that feature; and the performance characteristics of that feature in terms of outputs, displays, and user interaction.

1. General Description

The goals for the prototype are to show the functionality of the Real World Product (RWP) in a reduced fashion. Similar to the RWP, the prototype will have several interfaces that the potential end users may interact with. Actors playing out the transit authorities will still be provided with a web GUI through which they can view the status of their trains, alerts, train’s current position and occupancy, trends in ridership and on-time performance. Any upcoming events or alerts that may affect service will be posted to the interface for resolution. Simulated business owners will be given access to the web application through a GUI that will allow them to create an advertising profile, upload advertisements, and associate with a given station. All users will have the ability to view the simulated current positions and coarse occupancy of trains relative to their current position, and report accidents/feedback.

* 1. Prototype Architecture Description

The Current ITS prototype architecture is composed of the following major components: Test Harness, Database, Decision Engine, and Web Application Engine as can be seen in Figure 1. The Test Harness is a program specifically designed for the prototype. It is responsible for the data generation that must take place to prepopulate the Database, as well as simulating various scenarios to demonstrate the completeness of the prototype approach. The Database holds all prepopulated data generated by the Test Harness, and is available for querying by the Web Application and Decision Engines.

The Database is the key to the Current ITS prototype, holding records of historical data that powers the train performance and occupancy reports in the Decision Engine, and providing a backend for the Web Application Engine. The Decision Engine works with the Web Application Engine to generate reports on ridership levels, train on-time performance, and train delay estimation. It can also predict future values of ridership based on past levels and events. The Web Application Engine provides the interfaces to the end-users. It works with the Database to provide access control and authentication, as well as storing the business information and advertisements.

CS Dept Virtual Machine



Web App

Engine

Decision Engine



**DB**

Test Harness

Simulated GPS Data

Simulated APC Data

Figure 1. Prototype Major Functional Component Diagram

* 1. Prototype Functional Description

The Current ITS prototype’s function is to demonstrate the completeness of the design of the RWP, but in a reduced manner. The Test Harness prepopulates its data using boundaries defined by existent HRT data sets, so that an accurate simulation can be attained. Because the GPS and APC data sources are a part of the Test Harness, it will provide the ability to simulate failure of those sensors to show how the prototype handles such a situation. It will also serve to directly control the Database, simulating adding and removing vehicles from service, incidents or catastrophes. It also functions to test the resilience of the prototype by allowing for controlled introduction of malformed data sets, or data errors.

The algorithms designed for the Decision Engine must function in the same manner as they would in the RWP to show that they accurately model the real world. These algorithms receive requests from the Web Application Engine’s modules. It will support a ridership trend report for the past or future dates. The future date’s ridership levels are approximated using a moving-average technique. The logic flow for this algorithm can be seen in Figure 2.

The Decision Engine is also functionally responsible for a train delay calculator, which uses the current position of trains relative to stops in addition to the status of alerts on the system to calculate a probable delay time value. This is used by the Web Application Engine to provide delay times to simulated end users. Finally, the Decision Engine provides an interface from the Web Application Engine to generate reports on the trains on-time performance.

The Web Application Engine (WAE) is the frontend interface that all simulated users will interact with using Current ITS. It must provide the functionality to create and remove users of different access levels, lowest being a rider or general user and highest being an HRT admin. The WAE has built-in user authentication, which logically separates the three GUI screens and sets of functions that comprise Current ITS.

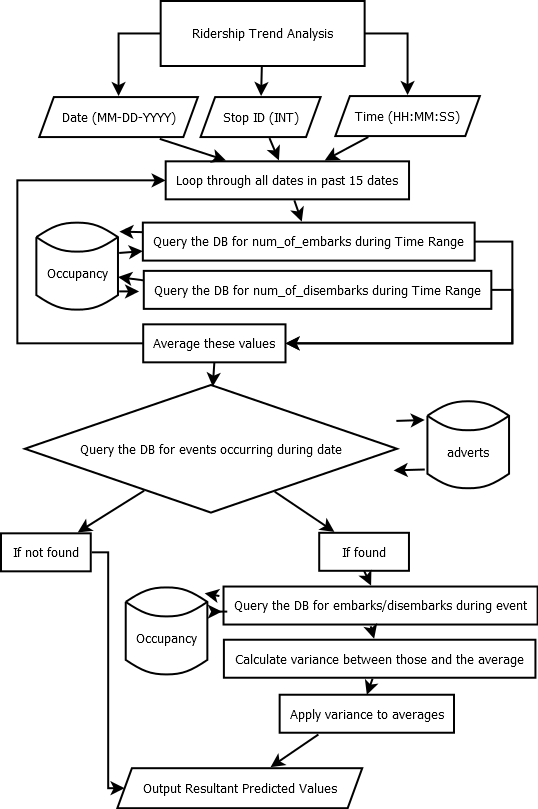


Figure 2. Ridership Trend Analysis Logic Flow

* 1. External Interfaces

This section defines the external interfaces that the Current ITS prototype will employ. Each interface type is unique and not every type will be used by the prototype.

* + 1. Hardware Interfaces

Due to Current ITS’ nature, it is entirely modeled in software. No physical hardware save the virtual host itself and a physical display is needed to interact with the prototype.

* + 1. Software Interfaces

Each of the major components in Figure 1 resides on an ODU Computer Science Virtual Machine. This Virtual Machine is running CentOS 6.0. The Test Harness, Decision Engine and Web Application Engine interface with the Database using the standard MySQL port, 3306. The Web Application Engine listens on port 80 without Secure Socket Layer (SSL) for insecure connections as well as port 8080 with SSL for secure connections outside of the CS network. The Decision Engine and the Web Application Engine interface using the PHP: Hypertext Preprocessor (PHP) language.

* + 1. User Interfaces

The simulated end-users: rider, HRT admin, and local business owner each have a unique user GUI when using Current ITS. But all three use the same interface to connect – a web browser. The Users will connect using HTTP to the prototype Virtual Machine in order to access Current ITS.

* + 1. Communications, Protocols and Interfaces

The following protocols will be employed in the Current ITS prototype:

* HTTP Protocol (Application/Presentation Layer of the OSI stack) for communication to the Web Application Engine
* TCP/IP (Session/Transport Layer of the OSI stack) for communication to the Virtual Machine.

1. Specific Requirements

This section is not included in this document, but is a reference to the collaborative Lab II Section 3 document. Please see this document for functional requirements of Current ITS.