Implementing Traffic Signal Priority for Buses in Portland

By

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In this era of promoting alternative transportation modes, traffic signal professionals need to develop and implement methods to provide improved transit operation. The City of Portland and the Tri-County Metropolitan Transportation District of Oregon (Tri-Met) have a long history of joint efforts for improving transit operations, including traffic signal priority. This paper will detail recent efforts to design and implement a city wide system of traffic signal priority for buses.

Earlier Bus Signal Priority Efforts in Portland

Portland has had a long history of providing signal priority for transit. The light rail system, which began revenue service in 1986, has emergency vehicle like preemption at many of the signals in Portland. The level of priority was actually increased at 11 signals approximately two years after initial start up. Today light rail generally enjoys stop-free travel between stations.

Prior bus priority experience in the City of Portland has been less extensive. Two separate bus priority tests have been conducted in the City of Portland - the Powell Boulevard test in 1993 and the Multnomah Boulevard test in 1994. These projects included evaluation of the technology to transmit priority requests from the bus to the traffic signal controller and tests of priority algorithms. The transmission technologies have included the TOTE system by McCain, the LoopComm system by Detector systems, and the Opticom by 3M. The signal priority algorithms included the "green extension / red truncation" method and queue jumps. An additional test of Opticom with green extension / red truncation control was implemented by ODOT in west suburban Portland region in 1996 (TV Highway Study). All tests were done at traffic signals with Type 170 controllers and Wapiti IKS software, which is a general standard used throughout the Portland region.

Some of the basic conclusions and lessons learned from these tests included:

- The method of transmitting a priority request from the bus to the traffic signal should not require bus driver intervention. During the Multnomah and TV Highway tests, bus operators often failed to call for priority at near side stops as they were typically too busy with their duties in collecting fares and driving the bus.

- The Opticom system worked reasonably well in signaling the presence of the bus to the traffic signal. One advantage of selecting Opticom is that many traffic signals in the Portland region already have Opticom receivers installed for emergency vehicle operations, which should make future expansion of bus priority much easier to accomplish.

- The green extension / red truncation algorithm in the Wapiti IKS Type 170 software was limited in its flexibility. While a signal could be kept in coordination, the left turn phase lengths had to all be driven to minimum values, which was unacceptable for the major intersections included in the Powell Boulevard test. The City and Oregon Department of Transportation (ODOT) determined that the software needs further enhancements before additional more green extension / red truncation bus priority is implemented in Portland.

- Detector placement at intersections in an important factor in the proper operation of bus priority measures – particularly for near-side stops.

- Tests found that traffic signal priority devices do provide a net reduction in round-trip bus travel times. Overall, benefits may add up to improved fuel costs, less equipment wear, and lower operator fatigue and stress.

In addition to these tests the City in conjunction with Tri-Met conducted the Transit Preferential Streets study. The purpose of this study was to:

- Develop a toolbox of potential bus priority techniques. These techniques included other non-signal related concepts such as queue by pass lanes, bus stop relocations, curb extensions, etc.

- Analyze five major transit corridors in Portland and recommend a range of treatments to consider for providing bus priority.

This study provided a planning framework to determine where and how bus priority (not just bus signal priority) would be provided in Portland. Both the City and Tri-Met have agreed to embark on an aggressive overall program to provide bus priority on the most congested corridors in Portland. Our goals for transit priority are to reduce bus travel times and to improve schedule reliability, hopefully leading to increased bus ridership.

Techniques identified in the Transit Preferential Streets Study are being aggressively applied to the highest priority corridors in Portland. Bus signal priority is only one part of providing preferential treatment for transit and the reader needs to remember to address all aspects for a successful program. However, the remainder of this paper will deal with just the signal priority aspect.

Current TEA-21 High Priority Project Funding

As part of the TEA-21 High Priority Project category, the City of Portland will receive an estimated $4 million in federal funds to provide signal priority for emergency and transit vehicles (with 20% local match the total project cost is approximately $5 million). This project will build upon two key existing elements - Tri-Met's successful automated vehicle location (AVL) system and the City's optical emitter system for providing signal priority for fire vehicles. Project elements include:

- Install optical emitters on Tri-Met's entire standard bus fleet (775 fixed route buses) and revise the on-board AVL system logic to activate the emitter at appropriate time and location.

- Install intersection optical detectors at intersections without Opticom and install an upgraded 170 controller or a "2070" generation controller at all intersections. The upgraded 170 software will have an improved red truncation/green extension algorithm. The new "2070" controller software will have additional bus priority algorithms. About 190 intersections will receive Opticom while a total of nearly 250 intersections will receive the new controllers. The project should provide complete signal priority for 5 major bus routes in Portland.

By equipping the entire bus fleet with emitters at this time, signal priority can eventually be extended to other corridors by merely updating the signal controllers, not only within the City of Portland, but at other suburban intersections as well.

The "Smart bus" Concept in Portland

The key element to the Portland bus priority concept is Tri-Met's AVL system developed by Orbital Sciences Corporation, which is called the Bus Dispatch System (BDS). The BDS is based on the 'smart bus' concept where each bus determines its location within 5 meters using an on-board GPS receiver. The GPS receiver as well as many other bus functions are connected to the bus' on-board computer, or central logic unit (see figure 1). The central logic unit has all route and schedule information and is able to determine if the bus is late or early. The bus reports itself "early" or "late" (to the dispatch center) if it is outside of a variable window usually set at 2 minutes early or 7 minutes late. For requesting signal priority, the initial late threshold will be one minute, although this parameter can be changed later.

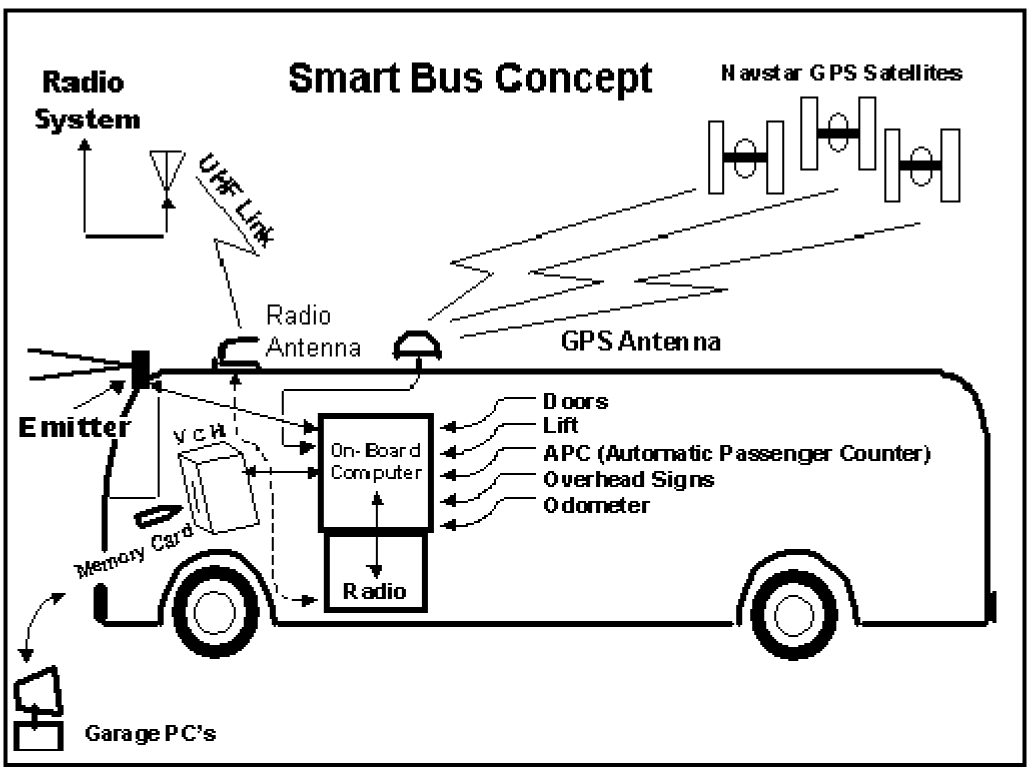

Figure 1 – Diagram of on-bus equipment

The project plan is to have the smart bus activate the Opticom emitter (or bus to wayside communication device) only when the bus determines that it is late. This device is discussed further below.

An additional element of the BDS is its outstanding data gathering capabilities. Throughout the day each bus logs its arrival and departure time at every bus stop or about every three blocks as well as passenger activity and the maximum speed reached since the last stop. This data is written to a PCMCIA memory card. At the end of the day the operator brings the PCMCIA card back into the garage office where the trip data is downloaded to a central database. This database provides a wealth of information on the performance of each bus on reach route. When aggregated this data will provide an excellent evaluation tool to determine the transit benefits of signal priority through extensive before and after data.

Distributed control concept

Early in the design process Tri-Met and the City discussed the possibility of using the central dispatch system and the central signal system for communicating the need for priority. Under this scenario a late bus would radio a priority request to the central BDS computer. The BDS computer would pass the priority request on to the City's Series 2000 central signal control system. The Series 2000 system would then pass the request for priority to the local intersection controller.

Tri-Met and the City determined that this method had too high a reliance on communications among the various systems and any problem with one element would negate the signal priority request. Tri-Met and the City have determined that the best choice is a simple, distributed system where a smart bus communicates directly with a smart traffic controller, not a more complicated center-to-center design.

Bus to wayside communication

As noted above, the early tests of Opticom were satisfactory. Combined with the existing installed base of Opticom intersection detectors, the City and Tri-Met have decided to use Opticom for communicating the request for priority from the smart bus to the smart intersection. The buses will use Opticom emitters with visible light screens so that other transportation system users don't see a flashing strobe on the buses. Also the buses will only receive 'low' priority through the Opticom system. All emergency vehicles will have 'high' priority that will always override any low priority operation.

The BDS uses the SAE J1708 data bus standard for communication between smart devices on the buses. The Opticom emitter will be connected to the bus through this J1708 interface. The bus' on-board computer will actually set the Opticom bus class and ID numbers (class = 0-9; ID=0-999). For now the combined class/ID code will be the actual bus inventory number. An alternative numbering method is to set the class # the same for all buses and the ID will be the bus route number. In the future we anticipate using the class number as an indicator of the level of priority, based on such things as lateness or route importance. These differing class or priority values can then be used by the traffic controller to determine which bus should get the higher priority when two conflicting routes cross each other.

As noted above, the bus' on-board computer will initiate the request for priority any time the bus determines that it is falling behind schedule. Initially the emitter will be activated anytime the bus is late (initially defined at 1 minute behind schedule) and is within the city limits for Portland. After a future system upgrade, each route will have specific 'activation zones' noted in the route database. When this upgrade is in place, the bus will activate the emitter only when the bus is in the activation zone and only when the bus is late. Also, to address near-side bus stop issues, the emitter will be deactivated anytime that the door is open.

As could be expected, Orbital Sciences Corporation and 3M are close partners with the City and Tri-Met in making this bus-Opticom interface a reality.

Controller Priority Algorithm

The final key element to the whole program is implementing an improved bus priority algorithm. The existing limited memory in the Type 170 controller with the Motorola 6802 chip has been a constraint in adding enhancements to the existing Wapiti IKS program. As a result, the City worked with Wapiti Micro Systems to develop an improved version of Wapiti's IKS program that runs on the HC11 chip for the 170. Part of the software upgrade will include providing a more robust green extension / red truncation algorithm than exists in the current software. The overall key will be to provide several variables that provide the traffic engineer with a wide range of operating choice.

In the future the City of Portland intends on using a 2070 level controller with still more improved software. Wapiti, in conjunction with the NW Wapiti Users Group, has defined improvements to all priority and preemption operations by developing a wide range of recovery options. These improved recovery options allow the local traffic controller to use a logic tree in determining how and when to transition back to normal operation. For instance, the controller may allow those phases that were skipped or minimized during preemption or priority to receive additional time following a preemption or priority operation. The recovery tree may also allow a variable return phase based on where the controller was just prior to preemption or priority. This 2070 level software is still a year away from being a reality.

Current schedule

The bus emitter installation and bus software modifications will be completed by March 2001. The Opticom upgrade for the first corridor was completed in fall 2000. The controller upgrade and installation on that pilot corridor will begin in March 2001. We plan to have all 71 intersections on this corridor activated for bus priority by mid-April 2001. All five corridors (about 250 total intersections) should be completed by the early 2002.

After this High Priority project is completed, the City and Tri-Met will work on analyzing other corridors in need of bus signal priority. Also Tri-Met will use the results of the Portland project to work with other local jurisdictions and ODOT to extend bus signal priority beyond the city limits of Portland.

Tri-Met and the City of Portland are excited about this important project. We believe that this large scale bus priority installation may well serve as a model for other cities considering similar investments in making bus transit work better.

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