Transit Signal Preemption and Priority Treatments

Peter Koonce, PE
Portland, OR
Transit signal priority presents an opportunity to partner with an agency that isn’t always recognized as a stakeholder.

By seeking mutually beneficial solutions for transit preferential treatments we can build partnerships that upgrade our traffic signal systems.

Emerging technology should facilitate implementation.
Transit Signal Preemption/Priority

- TSP provides transit vehicles preferential treatment at a traffic signal

- Preemption and Priority are distinctly different
Definition of the Problem

- Buses are often in traffic, slowed by single occupant vehicles
- Prioritization of buses (>40 people) results in a more efficient transportation system
Presentation Overview

- **Background**
- **Transit Signal Priority**
  - *Seek First to Understand in order to be Understood*
    - Key Issues In Traffic Operations
    - Policies First, then Details
  - *Traffic Engineering for Transit*
  - *Evaluation and Implementation Issues*
- **Traffic Signal Preemption**
What is TSP?

Definition:
- TSP is an operational strategy that facilitates the movement of in-service transit vehicles, either buses or streetcars, through traffic-signal controlled intersections.

An Overview of Transit Signal Priority
ITS America, 2001
Basic Signal Priority Operation

1. Contact is made between bus and traffic signal.
2. Signal waits for crosswalk to clear.
3. Signal gives travel movement currently being serviced at least a minimum amount of green time.
4. Traffic signal turns light green for bus.
5. Traffic signal loses contact with bus.
6. Traffic signal maintains signal coordination.
7. Traffic signal prohibits other buses from requesting priority for one entire cycle.
8. End bus signal priority sequence.
Traditional signal timing considers traffic moving from intersection to intersection.

Primary objective is minimizing delay for vehicles.
Traffic engineering for transit would consider transit capacity and person delay.
Engineer’s Transit definition

- Exclusive Right-of-way
- Guaranteed priority or preemption

**Light Rail**

- Mixed Traffic
- Limited amenities and preferential treatment

**Bus**
Traffic Signal Preemption

- Preemption: transfer of normal operation of a traffic control signal to a special control mode of operation – MUTCD, 2003

- Preemption differs from priority which merely shortens or extends green to pass a priority vehicle through the signal
Preemption worked well, perhaps too well.

Our history has been discontinuous.

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<td>Extension, Truncation</td>
<td>7% bus travel time reduction</td>
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<td>12-23% bus travel time reduction</td>
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<td>Portland, OR</td>
<td>Extension, Truncation</td>
<td>5-12% bus travel time reduction</td>
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Preemption for Transit History in Baltimore

- Preemption installed after LRT system start up
- Cycle length increased to accommodate preemption
- Preemption resulted in uncoordinated operations for intersections
Pre-Existing Howard Street Operations

- Preemption disabled due to traffic impacts
  - *LRT delays up to 80 seconds due to cycle length*
- In the off-peak, the signal systems remain nonresponsive to train operations
The Conflict

- Traffic Engineers
  - Preemption disrupts signal coordination
- Transit Planners
  - Preemption improves performance

COMPROMISE

Use Priority rather than Preemption...
Timing of the Priority Call

Bus Priority Timers 1 and 2 are associated with extension of bus phase and recovery, Timer 3 truncates the non-bus phase if WALK and FDW allow.

Call for extension must be received before yield point for activation.

Call for truncation after \( \Phi_4 \) WALK and FDW is complete will activate Priority Timer 3, forceoff of non-bus phase.
Bus Priority Timers 1 and 2 are associated with extension of bus phase and recovery, Timer 3 truncates the non-bus phase if WALK and FDW allow. Call for extension must be received before yield point for activation. Call for truncation after \( \Phi_4 \) WALK and FDW is complete will activate Priority Timer 3, forceoff of non-bus phase. Truncation reduces phase time for \( \Phi_4 \) by an amount equal to the length of extension. Time for \( \Phi_4 \) shifts under extension and may also be reduced.
Most cities reserve preemption for trains or exclusive lanes.
Portland Transit Signal Priority Concept

1. Smart bus knows location and schedule status
2. Bus communicates priority request to signal
3. Local controller provides priority
Portland Transit Signal Priority Concept

1. Smart bus knows location and vehicle status
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Transit Signal Priority Parts

1. Traffic Signal Controller
2. Bus Detection
3. Supporting System to Inform Request
Transit Signal Priority System Components

- Traffic Signal Systems
- Bus Detection
- Support Systems / Management Centers
Signal Priority Overview “in the controller”

› Basic premise:
  – *If arrive on green*, extend 5 to 30 seconds more
  – *If arrive on red*, shorten other phases to return earlier

› Portland, OR implementation
  – *Over 240 intersections, 25% of City*
  – *5% to 12% travel time reduction*
  – *Improved on-time performance, reduced travel time variability*
Transit Signal Priority – Red Truncation

- Opens windows of opportunity for transit vehicles to reduce signal delay
- Signal controllers have different levels of functionality
Transit Signal Priority – Green Extension

- Opens windows of opportunity for transit vehicles to potentially eliminate signal delay
  - “Borrow or Take”
Transit Signal Priority

- Opens windows of opportunity for transit vehicles

Diagram:
- Red truncation
- Green extension
Application of TSP on two intersections
Transit Signal Priority Implementation

- Adjusts signal timing after detecting bus arrival
  - *Bus phase extension*
  - *Non-bus phase truncation*
- Under our current implementation strategy:
  - *each traffic signal remains coordinated with adjacent signals*
  - *changes are limited in some locations*
Key Implementation Issues

- Location of detection range
  - *Key to effectiveness*
  - *Relationship with bus stop locations*
- Signal timing strategies
  - *Traditional engineering concerns considered in concert with bus operations*
  - *Limitations of existing algorithms*
- Iterative scheduling
  - *Issues with SMART Bus Concept*
Other Opportunities for Implementation
Passive Signal Priority

- Reduce cycle length
  - Reduces delay at signalized intersection by reducing potential length of red time
- Increase phase split
  - Gives buses more time
- Modify offsets
  - Improve arrivals at intersections
Reduced cycle length

Train or bus departure is variable due to dwell time

Delay is a function of the length of red time and cycle length
Transit Signal Priority Application

- Recognize its not so important how much green for transit, but green at the right time!
  - Shorter cycle lengths in a traffic signal system reduce delay for transit vehicles
  - Signal priority also provides greater flexibility
Vehicle Detection Systems

- Various technology alternatives based on system architecture
  - Optical detector
  - Radio based
  - WiFi
Bus Detection Technology – Infrared Optical

Advantages
– Existing equipment on all many intersections
– Proven technology
– Lower Costs if already installed for Emergency Vehicle Preemption

Disadvantages
– Line of sight
– Limited information transmitted
– Proprietary
Comments on the Portland, OR System

- First in, first out
  - *Does not provide opportunity to handle conflicting calls from multiple buses*
  - *No feedback of lateness or other information*
- Immediate “transition” in signal controller logic limits effectiveness
- Latency of messages from detection
- No integration of on-board bus stop request
Purpose of “COP”

– Clarify what the system will do from the users’ point of view
– High level summary of entities and capabilities
Detailed Requirements
- AVL and schedule is integrated on bus
- Bus requests priority at local controller
- Priority Granted at local controller and feedback is provided to transit and traffic management center
On-board Systems

- **Automatic Vehicle Location**
  - Voice and data via radio
  - Information tracking

- **Other Systems – APC, other**
  - Passenger data
  - Location information
On-Board Bus Systems - Example

- Centralized GPS based system
- Communication via radio a 2-minute polling cycle rate
- Experience:
  - “Dropped buses”
  - Communications system maintenance
  - Proprietary radios
Existing AVL Criteria

Is bus within the City of Portland?
  Yes
  Is the bus on its proper route?
    Yes
    Are the bus doors closed?
      Yes
      Has the request already been sent?
        Yes
        Is the bus on schedule?
          Yes
          Request Priority
          No
          Is the bus behind schedule?
            Yes
            Priority Disabled
            No
            Priority Disabled

  No
  Is the bus on its proper route?
    Yes
    Are the bus doors closed?
      Yes
      Has the request already been sent?
        Yes
        Request Priority
        No
        Request Priority
        No
        Priority Disabled

  No

Are the bus doors closed?
  Yes
  Has the request already been sent?
    Yes
    Request Priority
    No
    Request Priority
    No
    Priority Disabled

Is the bus on schedule?
  Yes
  Request Priority
  No
  Request Priority
  No
  Priority Disabled

Is the bus behind schedule?
  Yes
  Priority Disabled
  No
  Priority Disabled
Additional Possible Criteria

- Is the bus going to stop at a nearside location?
  - Bus stop requested?
  - Vehicle diagnostics?
- What is the current ridership?
  - Did the bus stop here yesterday?
  - Does it normally stop?
- What time of day is it?
  - Is there traffic congestion?
  - Are we competing with other buses?
Priority Request Server Information

- Measure traffic conditions to “update” green time available
- Accept priority request when bus is in range based on anticipated speed and estimated queue
- Utilize travel time information to determine aggressiveness of priority
- Provide feedback between agencies
Practical Benefits of a TSP System: Building the ITS Network through Shared Goals

- Decision for TSP (circa 1997)
  - Helped enable Fire Preemption System and Opticom system (security) upgrades
- Decision for TSP – Today
  - Wireless network based
  - TSP could enable communication to intersections previously unconnected
Implementation Issues

- unconditional vs. conditional?
- centralized vs. decentralized control?
- strategies (green extension, red truncation, etc.)?
- integration with Emergency Vehicle?
- detection and communication technologies?
How to Assess Potential Benefits and Impacts of TSP?

- What TSP measures of effectiveness?
- Do we need to simulate traffic impacts?
- How does TSP relate to MUTCD and Transit Capacity Manuals?
How to build a solid partnership with traffic counterparts?

Should TSP be integrated with AVL or other ITS transit systems (new and/or retrofit)?

How to address near-side stops?

Can transit scheduling take advantage of TSP?
ITS Standards to Support Implementation

- NTCIP C2C: NTCIP Center-to-Center Standards Group
- NTCIP 1201: Global Object Definitions
- NTCIP 1202: Actuated Signal Control
- NTCIP 1211: Objects for Signal Control Priority

Approved & Working Draft Standards

www.ntcip.org
Regional Considerations

- Regional policies that are supportive of transit provide leverage for traffic engineers
- Establish policies consistent with the vision of the overall system
- Build partnerships with traffic engineering community through various means
Conclusions

- Implementation requires significant attention to details
- Transit priority has the potential to provide substantial benefits
- Requires coordination between transit and traffic staff
- Iterative process requires continuous feedback
Partnerships are needed to build the transportation system to meet the goals of tomorrow. Emerging objectives related to advancing infrastructure "connectedness" will result in improved signal priority.

Questions