TCRP A-16A: Improved Traffic Signal Priority for Transit

TRB Signal Systems Committee
TSP Workshop
2002 Annual Meeting

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Siemens Gardner Systems
Project Objectives

• Survey existing and previous approaches to traffic signal priority for transit
• Identify objectives and related measures of effectiveness that characterize TSP strategies
• Develop new strategies for TSP
• Evaluate, using simulation, promising and new strategies
Scope

• Phase I
  - Review Literature/State-of-Practice
  - Develop Scenarios
  - Identify Priority Objectives
  - Formulate Priority Strategies

• Phase II
  - Develop TSP Algorithms
  - Simulation/Evaluation
  - Develop Implementation Plan
Approach:
Literature/State-of-Practice

• Literature
  - Where’s the [REAL] literature?
  - UTCS/BPS

• State-of-Practice
  - Controller Manuals
  - Projects
    • Cermak Road
    • King County Metro
    • Houston Metro
Approach: Scenarios

• Based on Real Networks
  - Cermak Road
  - Speedway Blvd, Tucson, AZ
  - Bellaire Blvd, Houston, TX

• Characteristics
  - Signal spacing
  - Stop locations (near-side, far-side)
  - Demand (traffic and transit)
  - Headway/Schedule
Approach: Objectives

• Stakeholders
  - Transit Operators /Providers
  - Transit Passengers
  - Traffic System Operators/Providers
  - Vehicle Operators

• QFD (Quality Functional Deployment)
TSP Strategies

- **Components:**
  - Agency Operating Policy
  - Operational Scenario Characteristics
  - Transit Priority Logic
    - Parameters
    - Methods

- **Parameters**
- **Methods**

- **Strategy**
  - Agency Operating Policy
  - Operational Scenario
  - Transit Priority Logic
Transit Movement along a Route
Effects of Random Delay
TSP Strategy Characteristics

- Operate within a coordinated signal system
- Manage multiple priority requests
- Adapt to the frequency of priority requests
- Provide flexibility through user selectable parameters
- Consider Transit as a NORMAL component of the traffic stream!
- Coordinate Transit and Traffic Management Operations
Technological Environment

Transit Management
- Scheduling
- Fleet Management
- Reporting/Analysis

Traffic Management
- Signal Timing
- Event Management
- Reporting/Analysis

Integration

Customers!
Technological Components

- **Transit Detection Systems**
  - Point Detection
  - Zone Detection
  - Location Detection

- **Traffic Signal Controllers**
  - Actuated Control
  - Real-Time Control

- **Communications**
  - Central - NTCIP
  - Peer-to-Peer
Priority Signal Timing

• Hierarchical Structure
  - Network Priority Logic
  - Local Intersection Priority Logic

• Families of Logic
  - Passive Network Priority
  - Anticipatory Network Priority
  - Local Intersection Priority
  - Real-time Optimizing Priority
Strategies for Signal Priority

• Passive Priority
  - Develop timing plans with priority in mind

• Active Priority
  - Local intersection priority through split allocations
  - Predictive Network Priority:
    • Prepare for transit priority as well as, or instead of, recovering from it
    • PEER-TO-PEER COMMUNICATIONS
Passive Network Priority

As a minimum, consider the flow of buses along the route. Choose cycle times, offsets, and splits to assist bus movement.
Predictive Network Priority

Provide **REQUESTS FOR PRIORITY SERVICE** in advance of when they are required and use **detection information** to reduce uncertainty.
Framework for Predictive Priority

Basic Model as adopted by the NTCIP SCP Committee
Transit Request Generator

- Primarily concerned with Transit Objectives
  - Schedule Adherence
  - Run Times
  - Run Time Variance

- Logic [can] considers factors such as
  - Lateness
  - Permissions
  - Passenger Count
Signal Timing Algorithm

• Must accept **Request for Priority** for advanced service
  - Request contains the desired service phase/movement
  - Request contains the desired time of service

• Must operate within the structure of the controller logic
  - dual ring 8-phase
A Model for a Signal Controller

Dual-Ring, 8-Phase Model

Graph-based Model
Priority Requests

Request 1 Received for Phase 2

Desired Time of Service for Req. 1
Priority Requests

• A Request for Priority is received at time \( t_1 \)
• The Request for Priority contains Time of Desired Service (in the future)
• Requests can be updated (Cancel, Change Time of Desired Service, Change Priority Level, ...)

SIEMENS
Consider a Single Arc (Phase)

Walk
Min
SCP Min

Ped Clear
Extension (MAX)

SCP Max

Earliest Time

Latest Time

TCRP A-16A
Framework

• Consider this in a “Project Management” framework
• Task (Phases) can be “crashed” to finish early (for Early Green)
• Task (Phases) can be “extended” to provide service
• Graph-based model provides a structure for decision making
Priority Requests

Request 1 Received for Phase 2

Desired Time of Service for Req. 1

Delay associated with the service of Request 1
Multiple Priority Requests

A “crash” of phases 2(6), 3(7), 4(8), and 1(5) to provide an early green for Request 1 could result in extra delay for Request 2. Requires a trade-off.
Real-time Optimizing Priority

- Hierarchical Structure (same)
- Network Level Anticipation
- Local Level Optimization
  - Minimize weighted delay
  - Bi-level Optimization
    - Minimize Intersection Delay
    - Maximize Bus Progression
Simulation Evaluation Issues

• Selection of the Simulation Model
  - VISSIM vs. CORSIM
    • Dwell modeling
    • Schedule modeling
  - Other Models

• Need accurate representation of controller logic (actuated control, coordination)

• Complex Experimental Design
Simulation Evaluation

• VISSIM
  - Transit Operations
  - Passenger Dwell
  - Transit Performance

• Virtual NextPhase™
  - Real Controller Logic
  - Actual Transition
## Network Statistics - Transit

<table>
<thead>
<tr>
<th>Measure: Average Bus Delay at Signals (Seconds/Route)</th>
<th>Strategy</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline Network with Coordination</td>
<td>81.62 sec</td>
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<tr>
<td></td>
<td>Coordinated Network with Basic Preemption</td>
<td>66.46 sec</td>
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<td>Green Extension for Transit</td>
<td>77.35 sec</td>
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<table>
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<th>Measure: Average Bus Travel Time (Seconds/Route)</th>
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<tr>
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<td>Baseline Network with Coordination</td>
<td>417.0 sec</td>
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<td></td>
<td>Coordinated Network with Basic Preemption</td>
<td>362.6 sec</td>
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<td>Green Extension for Transit</td>
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## Network Statistics - Vehicles

<table>
<thead>
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<th>Measure:</th>
<th>Average Car Speed (MPH/Cars-Link)</th>
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<tbody>
<tr>
<td></td>
<td><strong>Strategy</strong></td>
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<tr>
<td></td>
<td>Baseline Network with Coordination</td>
<td>14.64 MPH</td>
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<td>Coordinated Network with Basic Preemption</td>
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<td>Green Extension for Transit</td>
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<table>
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<td></td>
<td><strong>Strategy</strong></td>
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<td>Baseline Network with Coordination</td>
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<td>Green Extension for Transit</td>
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Application to Practice (Anticipated Research Products)

• Strategy Recommendations
• Support for decision making for system developer, integrators, and operators
  – Data, methodology, logic, guidelines
• Improved understanding of the benefits and impacts of TSP
Suggestions for Further Research

- Standards, Standards, Standards
  - Communications
  - NTCIP (Class A & C)
- More Logic/Algorithms
- Improved Simulation Models
- Field Experience
Questions?