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

Session #3: Transit Priority Standards and Research
TRB Signal Systems Committee
Summer Meeting
1999

Larry Head
Gardner Systems
Tom’s Rules

- Project Objectives
- Scope
- Approach
- Findings
- Lessons Learned
- Application To Practice (Technology Transfer)
- Suggestions for Further Research
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 (started June 1, 1999)
  – 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
    • …..
Approach: Scenarios

• Based on Real Networks
  – Cermak Road
  – Speedway Blvd, Tucson, AZ

• 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)
QFD: Waterfall Relationships

Stakeholder Objectives

System Characteristics

"How's"

"What's"

Measures of Effectiveness

Strategy Characteristics

"How's"

"What's"

Measures of Effectiveness
### Objectives: QFD Analysis

#### Stakeholder Objectives/System Characteristics

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Objectives</th>
<th>System Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transit Operators/Providers</strong></td>
<td>Improve Quality of Service</td>
<td>✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td></td>
<td>Reduce Operating Costs</td>
<td>✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td><strong>Transit Customers/Passengers</strong></td>
<td>Reduce Waiting Time</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td></td>
<td>Reduce Trip Time</td>
<td>✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td><strong>Traffic Signal System Providers</strong></td>
<td>Provide Safe Operations</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td></td>
<td>Manage Congestion</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td><strong>Vehicle Operators/Passengers</strong></td>
<td>Reduce Trip Time</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td></td>
<td>Avoid Congestion</td>
<td>✓ ✓ ✓</td>
</tr>
</tbody>
</table>

#### Hows?

<table>
<thead>
<tr>
<th>Hows?</th>
<th>Reduce Number of Buses</th>
<th>Reduce Run Time</th>
<th>Reduce Run Time Variance</th>
<th>Provide Transit Priority</th>
<th>Improve Schedule Adherence</th>
<th>Provide Progression</th>
<th>Reduce Signal Delay</th>
<th>Coordinate Signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholder Objectives</td>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
</tbody>
</table>

#### Whats?

| Whats? | ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ |

TCRP A-16A
TSP Strategies

- **Components:**
  - Agency Operating Policy
  - Operational Scenario Characteristics
  - Transit Priority Logic
    - Parameters
    - Methods
Transit Movement along a Route
Effects of Random Delay
Effects of Random Arrivals

image of a diagram showing the effects of random arrivals over time for a transportation system.
TSP Strategy Characteristics

• Operate within a coordinated signal system
• Manage multiple priority requests
• Adapt to the frequency of priority requests
• Provide flexibility through use selectable parameters
• Consider Transit as a NORMAL component of the traffic stream!
System Structure for Priority

- Transit Management
- Traffic Management
- Transit Demand
- Transit Operations
- Traffic Operations
- Traffic Flow

Transportation Network Characteristics

(Integration)

TCRP A-16A
Events in Priority

- Request Received
- Initiate Service
- (Service Cancellation)
- Service Commitment
- Start of Service
- End of Service
- Completion

Events

- Monitor
- Preparation
- Service
- Recover
- Monitor

Service Intervals

TCRP A-16A
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
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
Passive Network Priority

As a minimum, consideration for flow of buses along the route

Bus Bands?
Use detection **information** to reduce uncertainty and provide requests in advance of when they are required.
Signal Timing for Transit Priority

Latest Start of Compatible Phases

Maximum Early Green

New Force Off 4

New Force Off 3

New Force Off 2

Request for Priority

Normal End of Compatible Phases

Compatible Transit Phases

Force Off 4

Force Off 3

Force Off 2

Force Off 1

TCRP A-16A
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
Lessons Learned

- Need more **documentation** of past, present and future projects/experiences
- Need more useable, accurate **simulation** models
- Need **tools** to support signal timing with TSP considerations
- Considerable **opportunity** for improve priority for transit without severe traffic impacts
- Need **standards** to define & support the development of TSP logic: priority signal timing and transit request generation
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?