Coordination of Freeway Ramp Meters and Arterial Traffic Signals (FOT)

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12/13/2012
Outlines

- Where Are We?
- Demo: Conceptually Integrated System
- Interface with 2070 Controller
- Further Intersection Traffic Data Collection
- Simulation Development Based on New Data
- Project Review
- Next Step
Where Are We?

- Task 1: Develop a Project Team and Charter
- Task 2: Technical Literature Review
- Task 3: Developing Work Plan and Finalizing the ConOps
- Task 4: Site Selection, Data Collection and Modeling
- Task 5: Selecting/Developing Feasible Coordination Strategies
- Task 6: Preliminary Field Implementation of the ConOps
- Task 7: System Integration and Field Test
- Task 8: Demonstration and Preliminary Evaluation after Study
- Task 9: Preparing Study Report and Final Report
Demo: A Conceptually Integrated System
Interface with 2070 Controller: Traffic Signal Control

- Uses AB3418 protocol (a subset of NTCIP) over COM1 serial port
- Uses laptop/PC104 host in place of field master
- Currently is a simple utility for sending byte strings to serial port
- Eventually will use our publish/subscribe database (db_slv©) to interface to send timing from optimal control algorithm
- Can change max and min green for a given phase
Interface with 2070 Controller: Traffic Signal Control

• Uses laptop/PC104 host in place of field master
• Uses AB3418 protocol (a subset of NTCIP) over COM1 serial port
• Interface with AB3418 allows us to change
  – Minimum and maximum green ➞ set them equal to get the desired green time
  – Green extension
  – Cycle length and offset for local plans
  – Per previous discussion, will not change minimum green time

• Interface to the control algorithm is via interprocess messaging using PATH’s in-memory data pool (called db_slv for historical purposes). This is a publish/subscribe database that can block on data changes in any of its data inputs. (Blocking means that the CPU will “wait” until it receives a message that data is ready, thus freeing the CPU to do other things.)
Interface with 2070 Controller: Running URMS

• Currently we are sending ramp metering messages via Ethernet to the local 2070 ramp meter controller running URMS:
  – Open TCP/IP connection between laptop and 2070
  – Interface with control algorithm via db_slv
  – Wait for changes to lane metering settings
  – Send modified URMS message to 2070

• Functions
  – To get real-time data
    ➢ Mainline detector
    ➢ Onramp detector
  – To send ramp metering rate for each onramp
Further Intersection Traffic Data Collection on 09/05/12
Further Intersection Traffic Data Collection on 09/05/12

• Scheme with 3 Miovision VCU and 2 PATH Camera
  – Miovision VCU: intersection movement traffic count
  – PATH video camera: onramp and main movement queue length

• Data Covering Time:
  – Wednesday 09/05/12
  – Time: 4:00pm – 7:00pm

• Weather: fine, a little cloudy

• Traffic demand flow: high – intersection left turn pocket overflow sometimes
Simulation Development

• Incorporate new data
  – Use data collected by Miovision system. Data was aggregated over 5min
  – Aggregated 5min data from PeMS.

• Calibration
  – Search parameters to improve simulation performance.
Model Calibration

• Flow
  – Compute the percentage of acceptable simulated flow
  – Aggregated flow in 10min
  – Freeway: detector at upstream of Taylor SB on-ramp, 1 lane available
  – Intersection: 8 movements
  – Criteria
    ➢ Link flow quantity
      – 700vph < Flow < 2700vph, within 15%;
      – Flow < 700vph, within 100vph;
      – Flow > 2700vph, within 400vph;
    ➢ Link flow GEH
      – \( GEH = \sqrt{\frac{2(M-C)^2}{M+C}} \)

• Occupancy and Speed
  – Mean Square Root Error
  – Aggregated over 10min
## Calibration Result (Intersection)

<table>
<thead>
<tr>
<th></th>
<th>EB Left</th>
<th>EB Throug h</th>
<th>EB Right</th>
<th>WB Left</th>
<th>WB Throug h</th>
<th>SB Left</th>
<th>NB Left</th>
<th>NB Right</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean acceptable case</strong></td>
<td>100%</td>
<td>86.9%</td>
<td>68.8%</td>
<td>78.1%</td>
<td>93.8%</td>
<td>100%</td>
<td>100%</td>
<td>95.6%</td>
</tr>
<tr>
<td><strong>GEH&lt;5</strong></td>
<td>94.4%</td>
<td>86.9%</td>
<td>76.9%</td>
<td>81.9%</td>
<td>95%</td>
<td>98.8%</td>
<td>100%</td>
<td>98.8%</td>
</tr>
<tr>
<td><strong>Best acceptable case</strong></td>
<td>100%</td>
<td>93.8%</td>
<td>93.8%</td>
<td>87.5%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Worst acceptable case</strong></td>
<td>100%</td>
<td>75%</td>
<td>50%</td>
<td>68.8%</td>
<td>87.5%</td>
<td>100%</td>
<td>100%</td>
<td>87.5%</td>
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</tbody>
</table>
## Calibration Result (Freeway)

<table>
<thead>
<tr>
<th></th>
<th>Flow</th>
<th>Occupancy</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean acceptable case</td>
<td>93.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEH&lt;5</td>
<td>88.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best acceptable case</td>
<td>93.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worst acceptable case</td>
<td>87.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Square Root Error</td>
<td></td>
<td>4.9%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Smallest Error</td>
<td></td>
<td>4.5%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Largest Error</td>
<td></td>
<td>5.2%</td>
<td>5.4%</td>
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Model Calibration

- Improvement

<table>
<thead>
<tr>
<th>Performance</th>
<th>Criteria</th>
<th>May 17 data</th>
<th>Sep 05 data</th>
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<tbody>
<tr>
<td>Freeway Flow Percentage</td>
<td>80%</td>
<td>93.1%</td>
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<tr>
<td>GEH&lt;5</td>
<td>73%</td>
<td>88.8%</td>
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<tr>
<td>Intersection Flow Percentage</td>
<td>64%</td>
<td>68.8%</td>
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<tr>
<td>GEH&lt;5</td>
<td>71%</td>
<td>76.9%</td>
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<tr>
<td>Freeway Occupancy Mean Square Root Error</td>
<td>6.3%</td>
<td>4.5%</td>
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<tr>
<td>Freeway Speed Mean Square Root Error</td>
<td>11.7%</td>
<td>5.0%</td>
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Model Calibration – Next Step

- **Calibration**
  - The queue lengths are too long.
  - Deviations of flows at intersection are large.

- **Control**
  - Test control algorithm.
Project Review: Objectives – Long Term

• Large scale system problem:
  – Freeway corridor traffic and control
  – Related arterial(s) intersections traffic and control
  – Dynamic interaction between the two

• To resolve any (or potential) inconsistency and conflict between the two traffic control systems;

• To balance the traffic flows overall system for accommodating more traffic in peak hours;

• To eventually minimize Total Travel Time (TTT) system wide and to improve mobility, reduce emission and energy consumption;
Project Review: Objectives – Short Term

• To coordinate one (feeding) intersection and one onramp meter
• To identify
  – Where and when coordination is necessary
  – Where and when is feasible
  – Technical hurdles in coordination of the two subsystems
  – Conflict of interests between the two and how to resolve
• To hopefully improve the performance of the system in some aspect in some level which could be quantified;
• To set an example for overcoming any hurdle(s) caused by multiple jurisdictions;
• To laid down a good foundation for a large project involving a freeway corridor and related arterial corridor(s) if it is successful.
Next Step

- Further model calibration
- Control and coordination algorithm tuning for improvement
- Performance evaluation through simulation
- Closely work with D4 freeway and intersection traffic engineers
- D4 for field installation of a 2070 Controller at Taylor Intersection (need HQ Traffic Division to provide a controller)
- Get PeMS real-time data and intersection data through interface
- Develop traffic data processing modules for freeway and intersection data
- Start to build wireless communication