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

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Outlines

- Project Review - SOW
- Interface with 2070 Controller
- Further Intersection Traffic Data Collection
- Simulation Development
- ConOps Discussion
- Next Step
Project Review - SOW

- 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
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.
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
  – 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

- Simulation model
  - Road Network Modeling
    - Intersection: Taylor, San Pedro.
    - Freeway: both directions, Taylor and Julian.
    - Lane Extension for Total Travel Time Estimation
  - Driver Behavior Model Selection
    - Aimsun default model: Gipps model
  - Signal Control
    - Real intersection timing plans from D4 & San Jose
    - Real ramp metering plans from D4
Simulation Development

- Video Data at Taylor Intersection:
  - Manually Counted the Following Traffic State Parameters
    - Vehicle count for each movement of Taylor Intersection
    - Onramp Time Series Data
      - Inflow count
      - Outflow count
      - Ramp Meter Timing
      - Onramp HOV Lane vehicle count
    - All aggregated to 5min and used for calibration

- PeMS Freeway Data at 3 VDS Locations
  - 5min aggregated Data
  - 30s raw data
  - Flow, speed and occupancy
Simulation Development

• Software Upgrade
  – Upgrade from Aimsun 6.0 to Aimsun 7.0.
  – Upgrade driver behavior model.
  – More functionalities.

• Calibration
  – Search parameters to improve simulation performance.
Simulation Development - Model Calibration

- Flow
  - Compute the percentage of acceptable simulated flow
  - Aggregated flow in 5min
  - 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
    \[ GEH = \sqrt{\frac{2(M-C)^2}{M+C}} \]
## Simulation Development - Model Calibration

### Improvement (May 17 data)

<table>
<thead>
<tr>
<th>Performance</th>
<th>Criteria</th>
<th>Old</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway Flow</td>
<td>Percentage</td>
<td>73%</td>
<td>80%</td>
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<tr>
<td></td>
<td>GEH&lt;5</td>
<td>68%</td>
<td>73%</td>
</tr>
<tr>
<td>Intersection Flow (worst movement)</td>
<td>Percentage</td>
<td>67%</td>
<td>64%</td>
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<td>GEH&lt;5</td>
<td>70%</td>
<td>71%</td>
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<tr>
<td>Freeway Occupancy</td>
<td>Mean Square Root Error</td>
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<td>6.3%</td>
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<tr>
<td>Freeway Speed</td>
<td>Mean Square Root Error</td>
<td>14.1%</td>
<td>11.7%</td>
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</tbody>
</table>
Simulation Development

- Problem in Simulation Development: 
  - Software bug
ConOps Discussion

- Interfacing for Dynamic Ramp Metering Rate
  - URMS
- Interfacing for Intersection Traffic Signal Timing
Caltrans D4 Controller Running TSCP without a Field Master
Local RM Controller – 2070 Running URMS
Caltrans D4 Controller Running TSCP with a Field Master
Local RM Controller – 2070 Running URMS
Caltrans D4 Controller Running TSCP without Master
Caltrans D4 Controller Running TSCP with a Master
Next Step

- Traffic Data Processing (collected on 09/05/12)
- Further model calibration of modeling
- Control and coordination algorithm tuning for improvement
- Performance evaluation through simulation
- Interface with 2070 controller
- Building communication between two 2070 controller
  - One for Ramp Metering
  - One for intersection traffic control
- Start to integrate the system off-line at PATH