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

XY Lu , PATH, Project Manager and Principal Researcher
Dongyan Su, GSR
John Spring, Software Engineer
Alex Skabardonis, Project PI

PATH, U. C. Berkeley
08/15/2012
Outlines

• Project Review - SOW
• Traffic Signal Control Interface with 2070
• Simulation Development
• Discussion
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

- Caltrans will decide if the project will continue or not.

- 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.
Traffic Signal Control Interface with 2070 Controller

- 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
Traffic Signal Control Interface with 2070 Controller

• AB3418: what is it?
  – Assembly Bill No. 3418 is intended to facilitate the coordination of traffic signals operated by different jurisdictions.
  – The AB 3418 standard protocol supports remote control and monitoring functions only.
  – The control function is to enable the maintenance of signal coordination with adjacent intersections.
  – The monitoring function is to allow verification of controller operation.
Traffic Signal Control Interface with 2070 Controller

– The AB 3418 standard protocol does not provide comprehensive support of all control functions, including uploading and downloading.

– The AB 3418 standard protocol does not replace or supersede existing communications protocols.

– The AB 3418 standard protocol may coexist in a controller with any proprietary or otherwise non-standard protocol.
Traffic Signal Control Interface with 2070 Controller

• What we can do with AB3418 Protocol: Due to NTCIP (National Transportation Control/ITS Communications Protocol), AB3418 Implementation Committee limited the Protocol Messages Set to:
  – To controller -
    ➢ Current day, date, and time to be used to set the controller's clock.
    ➢ The number of a locally stored coordination timing pattern (or free, flash, or standby mode) to be operated.
  – From controller -
    ➢ The number of the current coordination pattern (including free or flash).
    ➢ The local cycle zero point.
    ➢ Any current alarms (e.g. detector fault, flash, preempt, etc.).
    ➢ The current green status of up to eight phases.
Traffic Signal Control Interface with 2070 Controller

- CTNET Field Protocol Specification - AB3418 Extended (AB3418E)
  - Change maximum and minimum green time
  - Change offset
Simulation Development

- Simulation model
  - Microscopic simulation
  - Network
    - Freeway: north of Taylor to south of Julian
    - Intersection: Taylor, San Pedro
  - Vehicle
    - General vehicles
    - HOV vehicles
  - Demand
    - 5 min data
    - PeMS
    - Video
  - Control
    - Default control is the real timing/metering plan
Simulation Development

- Model Calibration
  - Freeway
    - Flow, occupancy, speed
    - Measurement from loop detector upstream of Taylor on-ramp
  - Intersection
    - Flow of each movement
    - Queue
  - On-ramp
    - Queue
  - 10 runs
Simulation Development

• Control Strategy Implementation
  – Through Aimsun API
  – Ramp metering: ALINEA
    ➢ Based on occupancy measured from detector upstream of Taylor on-ramp
    ➢ Metering rate updates every 30sec
  – Intersection: Optimal control strategy
    ➢ Assume the demand of each movement is known
    ➢ Assume the queue of each movement can be measured
    ➢ Minimize the gap between desired green and given green
    ➢ Subject to constraints of minimum green time and on-ramp storage
    ➢ Green duration updates every cycle
Simulation Development

- System Wide Performance
  - Parameters used
    - TTD (Total Travel Distance)
    - TTT (Total Travel Time)
    - Accumulated average delay in hours per km
    - Accumulated average stop time in hours per km
    - Accumulated average number of stops per km
  - Results for default control and optimal timing + ALINEA RM
    - Mixed up: some replications are better and some are worse
    - Depending calibration results for the calibration: better calibration results usually have better performance in optimal timing strategy + ALINEA RM
System accumulated average performance per km, default (b), optimal control (t)
Accumulated system performance; default (b), optimal control (r)
System accumulated average performance per km, default (b); optimal control (t)
Simulation Development

• Problem in Simulation Development:
  – Inadequate data:
    ➢ Video data is too short in time
    ➢ PeMS (or D4) data at VDS402117 (mainline upstream of merging) only has one lane (Ln 2) data
    ➢ No detailed San Pedros movement data – the dynamic interaction of the two intersections is unknown (resolution to be 3~5min)

• Next Step:
  – Extensive data collection at the two intersections necessary
  – Data collection at VSD402117 for other lanes necessary
    ➢ Needs help of D4 to fix the loop faults for other lanes
  – Data collection for merging area using video camera
Discussion

- ConOps
- Interfacing for Dynamic Ramp Metering Rate
- Interfacing for Intersection Traffic Signal Timing
Interfacing for Dynamic Ramp Metering Rate

- Direct Interface with D4 TMC Computer
  - To get real-time data
    - Mainline detector
    - Onramp detector
  - To send ramp metering rate for each onramp
Interfacing for Intersection Traffic Signal Timing

- SR87-Taylor Intersection of Caltrans D4 running TSCP
- Caltrans D4 Controller Running TSCP without a Master
- Caltrans D4 Controller Running TSCP with a Master
- San Jose Intersection 2070 Controller running Fourth Dimension Software
- San Jose Intersection 2070 Controller running SCATS
• According Zhongren meeting with Caltrans HQ engineers:
  – To be able to coordinate using a field master with cycle length and offset fixed
  – If no field master, a PATH computer could be configured to run as a master
Caltrans D4 Controller Running TSCP without Master
Caltrans D4 Controller Running TSCP with a Master
San Jose Intersection 2070 Controller running Fourth Dimension Software

• Controller at the following Locations will still run Fourth Dimension firmware
  – San Pedro St.
  – First Street
• Discussed with Tod on 11/17/2011
• To send Tod a full set of the parameters we want to set and read;
• Tod will modify the Fourth Dimension firmware to accept a specially formatted Ethernet packet formatted with those parameters and apply them using his software;
• He will send us the firmware and we should load it into a 2070 for testing provided that San Jose Transportation agree to do so.
San Jose Intersection 2070 Controller running Fourth Dimension Software

City of San Jose
Intersection Traffic Control Cabinet

2070 Traffic Controller
Offset
Cycle length
Green time
Traffic detector
or controller

Running ATCS of Fourth Dimension

PATH Computer:
Master
Traffic signal
control algorithm
Traffic data
processing
GPRS modem

Local RM
Cabinet

Ramp metering
controller

TMC Ramp
Meter Computer
Ramp metering
rate
Traffic data
server

PATH Computer
Ramp meter algorithm
Coordination
algorithm
Traffic data
processing
GPRS modem
San Jose Intersection 2070 Controller running Fourth Dimension Software

**City of San Jose**

**Intersection Traffic Control Cabinet**

- 2070 Traffic Controller
- Offset
- Cycle length
- Green time

**Local RM Cabinet**

- Ramp metering controller

**PATH Computer: Master**

- Traffic signal control algorithm
- Traffic data processing
- GPRS modem

**TMC Ramp Meter Computer**

- Ramp metering rate
- Traffic data server

**PATH Computer**

- Ramp meter algorithm
- Traffic data processing
- GPRS modem

**Interface**
San Jose Intersection 2070 Controller running SCATS

- SCATS has 2 control levels: *Strategic Level* at TMC and *Tactic Level* at local control cabinet. It is feasible to dynamically assign the Green Distribution for an intersection from the Strategic Level at TMC;

- According to Lily (05/22/12):
  - Implementation of ATCS in San Jose is limited to 52 intersections in the City, not city-wide;
  - I280-Saratoga intersections will run SCATS in this summer;
  - Lily has arranged an engineer to find out how the traffic is controlled at San Pedro and First Street (upstream from CA 87 on Taylor)
San Jose Intersection 2070 Controller running SCATS

Tactic Controller Cabinet

2070 Traffic Controller

Traffic detector or controller

Running SCATS

Strategic Controller At San Jose TMC

Offset
Cycle length
Green time

Traffic signal control algorithm

Traffic data processing

GPRS modem

PATH Computer

Local RM Cabinet

Ramp metering controller

Ramp metering rate

Traffic data server

Ramp metering controller

TMC Ramp Meter Computer

PATH Computer

Ramp meter algorithm

Traffic data processing

GPRS modem

Coordination algorithm

Interface

Interface

Running SCATS
Further Consideration for Interface with 2070 Controller

• If AB3418 only allows us to change
  – Minimum
  – maximum green
  – Offset
for each phase, what we can do for coordination project?

Is it adequate for control and coordination purposes?