Adaptive Traffic Signal System
Lebanon County, PA

Ross Buchan, P.E.
Gannett Fleming
Harrisburg, PA

Craig Hinners, P.E.
Civilogix
Baltimore, MD

http://goo.gl/uVADt3
Project Overview

- CCIP Study conducted on US 422 in 2006 from Palmyra to Cleona

- Study results:
  - Minor roadway widening at Mill Street
  - Signal upgrades and retiming
  - Recommended Adaptive Signal System to improve travel times
Project Corridor

- 6.8 mile long corridor
- 4 municipalities
- 10 signalized intersections (5 new designs)
- 1 additional signal in corridor by developer
Multi-Jurisdictional Agreement

- Project spans 4 municipalities
  - Palmyra Borough (4 signals)
  - North Londonderry Twp. (3 signals)
  - Annville Borough (1 signal)
  - Cleona Borough (2 signals)

- County championed multi-jurisdictional agreement for municipalities
  - Discusses cost sharing for system
  - Agreement allows for expansion
  - North Londonderry agreed to house computer (Adaptive System Software)
  - County agreed to assist with cost sharing for maintenance of system

- Agreement was signed before design
Adaptive Signal System Requirements

- Only a few proven systems had been installed
- Researched capabilities of each installed system along with issues/concerns
  - All detector heavy
  - System maintenance was recurring theme for most failed systems
    - Communications
    - Detectors
- Originally going to sole source but implemented performance based requirements instead
Adaptive Signal System Requirements

- Wrote specs to meet performance requirements of stakeholders
  - Adjust timings in real-time on a cycle-by-cycle basis
  - Optimize splits and offsets
  - Access system remotely (VPN)
  - Manual override for special events/detours
  - Self-diagnostics to detect system failures
  - System will run even if detector failure occurs
  - Shall archive performance measures for future analysis
Communication System

- Minimize recurring and construction costs
- IP addressable/Ethernet-based communication
  - VPN access into system
- Performed a radio path study along corridor
- Conducted cost-benefit analysis for 3 systems
  - Fiber
  - Wireless
  - Cellular
Communication System

- Hybrid communication system
  - Wireless communication
  - Cellular modems

Diagram showing a network of connections with labels for Internet/VPN, Fiber (FiOS), Repeater, Cell Modem, and Wireless Radios.
Specifications

- Required a bench test for all systems before project began
  - Mitigate low-bid risk (rebid if necessary)
- Required acceptance tests and operational support
  - 30-day tests
    - Communications
    - Detectors
    - Adaptive signal system
  - 180-day test of entire system
    - Started at completion of all successful 30 day tests
Specifications

- Required the following during testing periods:
  - 24-hr on call support
  - Failed equipment replaced and operational within 24 hrs
  - Testing period restarts with failed equipment

- Phased payments based on successful completion of each test

- 1 year operational support after 180 day test
  - Software upgrades and support

- Required training for each system element
  - DVDs of training
System Map: http://goo.gl/5uZgWM
ACS Lite: Browser-Based Interface
ACS Lite Adaptive Settings

## Adaptive Configuration

<table>
<thead>
<tr>
<th>Global (All-Controller) Adaptive Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Offset Increment</td>
<td>2</td>
</tr>
<tr>
<td>Max Offset Deviation</td>
<td>10</td>
</tr>
<tr>
<td>Max Split Increment</td>
<td>10</td>
</tr>
<tr>
<td>Max Split Deviation</td>
<td>20</td>
</tr>
<tr>
<td>Adjustment Interval</td>
<td>10</td>
</tr>
</tbody>
</table>

## Controller-Specific Adaptive Parameters

<table>
<thead>
<tr>
<th>Controller</th>
<th>Description</th>
<th>Adjust Splits</th>
<th>Phase No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>US 422 &amp; Railroad</td>
<td>Timing</td>
<td>✔ ✔ ✔ ✔ ✔ ✔</td>
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<tr>
<td></td>
<td></td>
<td>Biasing</td>
<td>✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
</tbody>
</table>

Submit
ACS Lite Schedule

<table>
<thead>
<tr>
<th>Pattern</th>
<th>1</th>
<th>4</th>
</tr>
</thead>
</table>

**Display Day Plan**: Active

**Day Plan No.**: 2

**Description**: Weekday

**Status**: Enabled

**Day Plan Events**

<table>
<thead>
<tr>
<th>No.</th>
<th>Hour</th>
<th>Minute</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>00</td>
<td>00</td>
<td>254 = Free</td>
</tr>
<tr>
<td>2</td>
<td>06</td>
<td>00</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>00</td>
<td>4</td>
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<td>4</td>
<td>14</td>
<td>00</td>
<td>19</td>
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<td>5</td>
<td>22</td>
<td>00</td>
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<tr>
<td>6</td>
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</tr>
<tr>
<td>10</td>
<td>00</td>
<td>00</td>
<td>0 = No Event</td>
</tr>
</tbody>
</table>
ACS Lite Split Adjustments

Controller 9 - US 422 & White Oak
Estimated Controller Time: 07:10:24 AM
Display split time (sec)

<table>
<thead>
<tr>
<th>Timestamp</th>
<th>Control Mode</th>
<th>Operational Mode</th>
<th>Transition Method</th>
<th>Pattern</th>
<th>Baseline</th>
<th>Cycle</th>
<th>Offset</th>
<th>Split Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon May 19, 2014 07:02:51 AM</td>
<td>System Control</td>
<td>Coordination</td>
<td>Other</td>
<td>103</td>
<td>1</td>
<td>110</td>
<td>70</td>
<td>13 56 31 13 56 31</td>
</tr>
<tr>
<td>Mon May 19, 2014 07:01:01 AM</td>
<td>System Control</td>
<td>Transition</td>
<td>Other</td>
<td>103</td>
<td>1</td>
<td>110</td>
<td>70</td>
<td>13 56 31 13 56 31</td>
</tr>
<tr>
<td>Mon May 19, 2014 06:42:41 AM</td>
<td>System Control</td>
<td>Coordination</td>
<td>Other</td>
<td>106</td>
<td>1</td>
<td>110</td>
<td>70</td>
<td>13 53 35 13 53 35</td>
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<tr>
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<td>Transition</td>
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<td>13 53 35 13 53 35</td>
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<tr>
<td>Mon May 19, 2014 06:22:31 AM</td>
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<td>Coordination</td>
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<td>70</td>
<td>13 50 37 13 50 37</td>
</tr>
<tr>
<td>Mon May 19, 2014 06:20:41 AM</td>
<td>System Control</td>
<td>Transition</td>
<td>Other</td>
<td>103</td>
<td>1</td>
<td>110</td>
<td>70</td>
<td>13 50 37 13 50 37</td>
</tr>
<tr>
<td>Mon May 19, 2014 06:02:21 AM</td>
<td>System Control</td>
<td>Coordination</td>
<td>Other</td>
<td>1</td>
<td>1</td>
<td>110</td>
<td>70</td>
<td>13 48 39 13 48 39</td>
</tr>
<tr>
<td>Mon May 19, 2014 06:00:02 AM</td>
<td>System Control</td>
<td>Transition</td>
<td>Other</td>
<td>1</td>
<td>1</td>
<td>110</td>
<td>70</td>
<td>13 48 39 13 48 39</td>
</tr>
<tr>
<td>Mon May 19, 2014 12:00:00 AM</td>
<td>System Control</td>
<td>Free</td>
<td>Other</td>
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<td>0</td>
<td>- - - - - - - -</td>
</tr>
<tr>
<td>Sun May 18, 2014 10:01:03 PM</td>
<td>System Control</td>
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<td>0</td>
<td>0</td>
<td>- - - - - - - -</td>
</tr>
</tbody>
</table>
Split Adjustment Example
ACS Lite Offset Adjustments

Shifting the controller 5 offset by \(+T(-T)\) seconds shifts the start downstream green phases by \(T(-T)\) seconds.
Iteris Video Detection Interface
Motorcycles Detected!
Radar Interface
Communications Network

- 100% IP based
- The importance of organization
  - Cabling
  - IP addressing (shared document)
Router
Monitoring the Monitor
Is the UPS up?
Cellular Modem Interface (Browser)
### Point-to-Point Radio Interface

<table>
<thead>
<tr>
<th>Location</th>
<th>Mill East</th>
<th>Center West</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radio Interface:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSS [dBm]</td>
<td>-71</td>
<td>-73</td>
</tr>
<tr>
<td>Dynamic Tx Ratio [%]</td>
<td>50.0/50.0</td>
<td>100</td>
</tr>
<tr>
<td><strong>Ethernet Service:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated Throughput [Mbps]</td>
<td>51.7</td>
<td>51.7</td>
</tr>
<tr>
<td>Rx Rate</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tx Rate</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Managed Switch Interface (Browser)
Is 8 Enough?
Future Enhancements

- Additional intersections
- Remote adjustment of video detection zones
- 4G instead of 3G
- Additional switch capacity
  - Preemption devices
- Staged shutdown during power fails
Problems/Issues

- Detector failures
- Upholding requirements documented in specs
- Public sentiment towards additional delays on side streets
- No way to document motorist complaints/concerns
Successes

- Improved travel times along US 422
  - AM Peak - 13% reduction
  - MID Peak - 21% reduction
  - PM Peak - 12% reduction

- Pleased stakeholders

- Municipalities and County cooperation to deliver a successful project

- Example project for MPO/County to span multiple municipalities
Lessons Learned

● Under budgeted construction management
  ○ Needed to have monthly status calls throughout testing periods
  ○ All stakeholders (Municipalities, PennDOT, County)

● Holding the contractor to the specs

● Better public outreach
  ○ Explain purpose of project and realistic expectations
    ■ Some intersections at capacity during peaks
  ○ Create website to document concerns
Questions?

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