Design of a Fault-Tolerant, Real-Time Traffic Statistics Reporting System

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Description of OOCEA System

- Agency of the State of Florida created in 1963
- Orange County, FL (Orlando Metropolitan area)
- OOCEA Operates:
  - 106-centerline miles of expressway
  - 14 mainline toll plazas
  - Over 900,000 daily transactions
OOCEA Expressway Management System

- CCTV Cameras
- Dynamic Message Signs
- Travel Time System
- Fiber Optic Network
- Road Ranger Service Patrols
- Dedicated Florida Highway Patrol Coverage
What’s Missing? Real-Time Volume

• **Current method:**
  – Portable counters with pneumatic road tubes
  – Comprehensive data collected once annually
  – Transaction data (mainlines and tolled ramps) provide weekly snapshot of volume trends
  – Used for financial and traffic planning purposes

• **Proposed method:**
  – Permanent, automated collection of systemwide data
  – Available on-demand
  – Can be used for financial, traffic planning, and operations
Design for Resiliency

• Maximum accuracy of data is critical
• Things will go wrong
  – How can the system compensate?
  – How can issues be identified quickly and addressed?
• System-level approach to accuracy and reliability
  – Accurate Sensors
  – Fault-tolerant architecture
  – Appropriate data processing
Design for Resiliency

Data Processing and Filtering

Fault-Tolerant Architecture

Accurate Sensors

- ITS Field Devices (including Traffic Monitoring Stations)
  - UPS and remote monitoring of battery voltage
  - EAPS (automatic failover for switches)
  - 24x7 Core network monitoring
  - Email alarms for system and device issues
  - Data filtering and link-based aggregation
  - Clustered Servers
  - Redundant Core Switches

- FIELD SWITCHES
  - AGGREGATION SWITCHES
  - CORE SWITCHES
  - SUNGUIDE™ SERVER
  - REPORTING SERVER
  - END USER

- Accurate Sensors
  - 24x7 Core network monitoring
  - Email alarms for system and device issues
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Accurate Sensors: Project history

• Concept study to identify state of the practice
  – Volume and classification

• Authority requirement: non-intrusive sensor
  – Eliminated loops and other in-pavement technologies

• Microwave and infrared technologies emerged as contenders

• Wavetronix SS125 (HD) sensors selected
  – High accuracy and reliability, cost-effective solution
Accurate Sensors: Project History

• Pilot project conducted to independently verify volume accuracy
• Compared Wavetronix SS105 and SS125 (HD)
• Pilot project results provided guidance for sensor deployment criteria
Fault-Tolerant Architecture

- Optimized sensor placement
- Redundant sensors
- Link-based mainline volumes (at reporting level)
- Sensor data also archived
Fault-Tolerant Architecture

• Power failure
  – Common cause of site outages

• Uninterruptible Power Supply
  – Backup power for up to six hours
  – Issue: no reliable remote notification of power outage

• Remote Battery and Environmental Monitoring
  – Add-on monitoring unit sends alert for partial battery discharge, tripped SPD, and opened doors
Fault-Tolerant Architecture

- Network utilizes gigabit Ethernet field rings
  - Redundant network architecture
  - Physically redundant fiber optic cable
  - Can tolerate one switch outage or fiber cut per ring
Central Software

• **SunGuide™ Software**
  – Traffic Management Center Software (FDOT)
  – OOCEA is a participating member agency
  – Controls OOCEA DMS signs
  – Will serve as the database for TMS count and classification data
  – Email alerts for system failures (new enhancement)
Data Processing

• Raw sensor-level data stored in SunGuide™ database
• Data rolled up into filtered link-level information for reporting purposes
• External process would filter data and store it in separate database
• Original data is preserved, filtered data set is much smaller and can be queried faster
Data Processing

- Proposed Data Filtering Methodology
  - Start with sensor-level data
  - Perform timeshift adjustment
  - Remove bad sensor-level data
  - Filter for outliers
  - Average remaining data
  - Store link-based data in separate database table
## Data Processing: Time Shift

<table>
<thead>
<tr>
<th>T1</th>
<th>V1T1</th>
<th>V2T1</th>
<th>V3T1</th>
<th>V4T1</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>V1T2</td>
<td>V2T2</td>
<td>V3T2</td>
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</tr>
<tr>
<td>T3</td>
<td>V1T3</td>
<td>V2T3</td>
<td>V3T3</td>
<td>V4T3</td>
</tr>
<tr>
<td>T4</td>
<td>V1T4</td>
<td>V2T4</td>
<td>V3T4</td>
<td>V4T4</td>
</tr>
</tbody>
</table>
Data Processing: Time Shift

\[ V_1 T_1 \]
\[ V_2 T_2 \]
\[ V_3 T_3 \]
\[ V_4 T_4 \]
Data Processing: Filtering

Remove bad sensor level data

Remove outliers

Average Link Volume
Information in Real Time

• Filtered data viewed through reporting system
  – Volume
  – Point speed
  – Occupancy
  – Summary Classification (length-based)

• Format
  – Graphical and tabular

• Uses
  – Planning and operations
Foundation for Enhanced Performance Measures

• OOCEA currently reports travel time based performance measures on a monthly basis

• Real time volume data will allow direct calculation of:
  – Vehicle Miles Traveled (VMT)
  – Level of Service (LOS)

• Increased sensor density and spot speed detection
  – New data to improve operational performance measures
Timeline

- October 2010: Sensor Deployment - Design
- August 2011: System Deployment - SunGuide™ Deployment
- March 2012: Sensor Deployment - Bidding
- June 2012: System Deployment - Reporting System Deployment
- Early 2013: Sensor Deployment - Construction
Conclusion

• **OOCEA approach to system design**
  – Identify need for high quality data
  – Develop comprehensive approach to system resiliency
    • Reliable sensor equipment
    • Resilient device and network architecture
    • Data filtering and analysis

• **Will benefit the Authority by**
  – Providing real-time comprehensive system information
  – Supporting enhanced performance measures
  – Improved safety (elimination of portable count activities)
Questions

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