Southeast Michigan Project Architecture
Connected Vehicle Project Architecture

- A Design Tool, *not* a Design
Other Engineering Disciplines have Graphical Tools


ITS National Architecture


- Broadcast and Peer-to-Peer data exchanges
- Enable Big Data
- Multiple wireless communication media
Complete Architecture shown in a set of views

- Physical view [THINGS] – overviews and specifics of objects and the information that flows between them, hierarchically arranged to show varying levels of detail.

- Enterprise view [PEOPLE] – includes installation, operations, maintenance and certification diagrams for each physical diagram

- Communication views [INFORMATION] – one for each information flow
Architecture Tool - Screenshots
Blank Project Opening Screen
Physical Layer 0
Physical Layer 1
Alt Physical Layer 1
Enterprise
P-Object Edit (Physical)
Stakeholder Assignment (Enterprise)
CVRIA Application Browsing

The Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE) application employs communications technologies to provide warnings and alerts relating to incident zone operations. One aspect of the application is an in-vehicle messaging system that provides drivers with merging and speed guidance around an incident. Another aspect is providing in-vehicle incident scene alerts to drivers, both for the protection of the drivers as well as incident zone personnel. A third aspect is an infrastructure based warning system for on-scene workers when a vehicle approaching or in the incident zone is being operated outside of safe parameters for the conditions. Additional information such as arriving and staging of additional responders would also be provided to assist in staging decisions and response to the incident.
Output

Concept of Operations
Architecture Document
Requirements Specification
Interface Specification
Verification Plan
Validation Plan

A fictional project that is used to support CPAT scenario and prototype development, which in turn supports requirement discovery and in-process validation.
Message Sequences

Phases of a Peer-to-Peer Data Exchange Message Sequence

- **Initiating Object**
- **Establishing Object**
- **Primary Servicing Object**
- **Secondary Servicing Object**

### Awareness
- Service Awareness

### Trust Establishment
- Service Request
- Service Details General

### Data Exchange
- Service Details Specific
- Details Confirmation
- Secondary Confirmation Request
- Secondary Confirmation Ack

### Nonrepudiation
- Confirmation Acceptance
- Acceptance Receipt
Message Payloads

```
Main Code | Description
----------|-------------
257       | Stopped traffic
560       | Truck stuck under bridge
7427      | Use right lane
7723      | And
7438      | Allow emergency vehicles to pass

Road Side Alert Message

- 2049: Abnormal load
- 2051: Long load
- 2052: Slow vehicle
- 2053: Farm equipment
- 2054: Horse drawn vehicles
- 2055: Overheight load
- 2056: Overweight load
- 2057: Tracked vehicle
- 2058: Vehicle carrying hazardous materials
- 2059: Slow moving maintenance vehicle
- 2060: Convoy
- 2061: Military convoy
- 2062: Refugee convoy
- 2063: Motorcade
- 2064: Mobile situation repositioning
- 2065: Winter maintenance vehicles
- 2066: Snowplows
- 2172: Slow moving maintenance vehicle
- 2173: Exceptional load warning cleared
- 2174: Hazardous load warning cleared
- 2175: Convoy cleared
```
Project Architecture Scope

- An Implementation, *not* THE Implementation
- Finite, well-defined scope that is part of the implementation process
Southeast Michigan Project Architecture

- Physical View
  - Layer 0: The physical objects that participate, the interconnects between them
  - Layer 1: The project-specific functions performed by each physical object, and the data exchanged between them
  - Layer 2: Application-specific; shows only those objects that are part of the application, with more detail on the flow of data

- Enterprise View
  - Layer 0: The people and agencies that own and operate physical objects
  - Layer 1: The people and agencies that own and operate physical objects and application objects

- Communications View
  - For each information flow in the Physical View, the layered communications protocols necessary to implement the information flow
Physical View Architecture Constructs: Objects

Application objects are also categorized according their implementation within the project.
Physical View Architecture Constructs: Flows

- Which device initiates the flow?
- What is the communication pattern?
- Does the flow exist?
- What type of security does the flow require?
Physical View Layer 0 Example
today's area of focus
Physical View – LC Enhanced Situation Data

From this snippet we can see that the LC enhanced vehicle situation data flow has the following characteristics:

- The Connected Vehicle OBE initiates this data exchange
- This flow is encrypted and signed
- This flow is part of the testbed development
# Communications View – LC Enhanced Situation Data

<table>
<thead>
<tr>
<th>Southeast Michigan Connected Vehicle OBE</th>
<th>Vehicle OBE Situation Data Generation</th>
<th>Roadside Equipment</th>
<th>Southeast Michigan Local Current Situation Data Warehouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>(session layer unused)</td>
<td>(session layer unused)</td>
<td></td>
<td>ASN.1 BER</td>
</tr>
<tr>
<td>UDP</td>
<td>IPv6</td>
<td>IPv6</td>
<td>UDP</td>
</tr>
<tr>
<td>IPv6</td>
<td>1609.3, 802.2, 802.11p</td>
<td>1609.3, 802.2,</td>
<td>IPv6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>802.11p</td>
<td>1609.3</td>
</tr>
<tr>
<td></td>
<td>5.9 Ghz wireless (802.11p) / 1609.4</td>
<td>5.9 GHz wireless</td>
<td>Backhaul PHY$^2$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(802.11p), 1609.4</td>
<td></td>
</tr>
</tbody>
</table>

2: An Internet connection or private network connection that is routable between the RSE and the Southeast Michigan Local Current Situation Data Warehouse.
Enterprise View Architecture Constructs

Enterprise objects (people, organizations) are shown as boxes with thick black borders, color coded by their relationship to the transportation environment.

Physical objects are color coded the same as in physical view diagrams, but shown as rectangles with dashed lines.

Formal coordination between people and/or organizations, documented in some contract or other form of written agreement that both parties acknowledge.

Information coordination between people and/or organizations, usually undocumented.

Relationship between people and/or organizations (e.g., member of) or between people/organizations and physical objects (owns, operates, maintains, installs, certifies etc.)

Relationship between physical objects that is relevant to people and/or organizations: includes, extends
Enterprise View – Life Cycle

- Certification Phase: application and device approval, adherence to standards
- Installation Phase: deployment of applications and devices
- Operations Phase: operation of applications to provide benefits to end users
- Maintenance Phase: maintenance of applications and devices, and feedback of performance
Enterprise View – Southeast Michigan 2014
Enterprise View Layer 0 Example
Project Architecture Tool Support

- All Southeast Michigan project architecture diagrams were drawn using the CVRIA Mini-Tool
- Short-term use method for drawing CVRIA-like diagrams, using the viewpoint specifications defined in the CVRIA
- Enables a common language
- Enables information exchange and re-use
- Provides a rich backdrop of work that has already been done to define the 85+ applications USDOT has already considered in some fashion
Contact Information

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