Nevada Data Exchange (NDEX): An Internet Portal for Public and Strategic Partners to Publish their Data and Subscribe to NDOT's Traveler Information

2015 Western States Rural Transportation Technology Implementers Forum

Presented by
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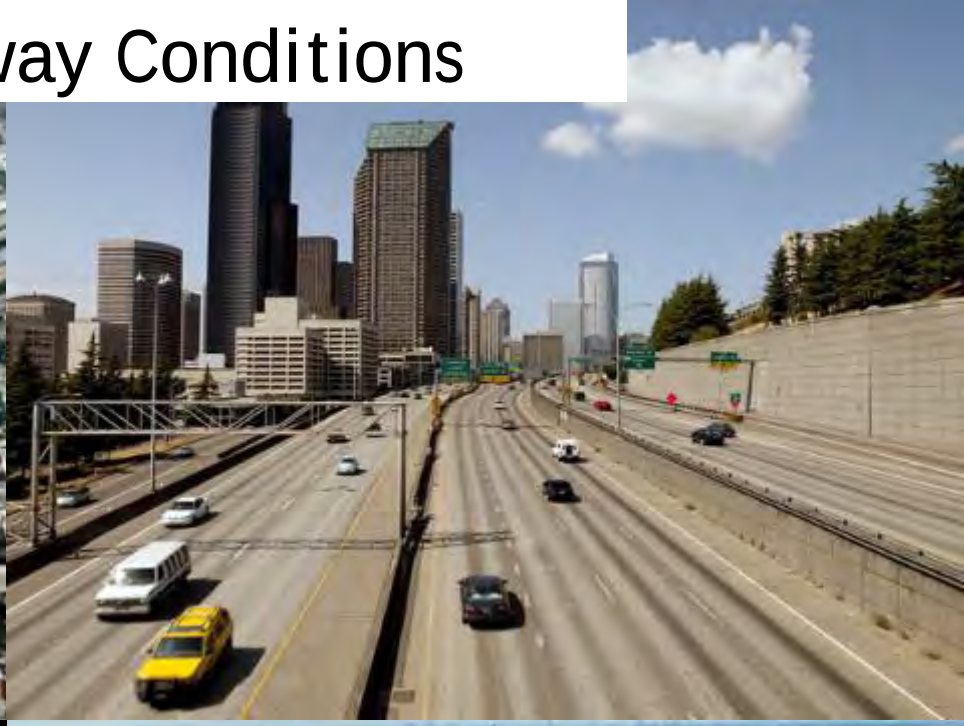
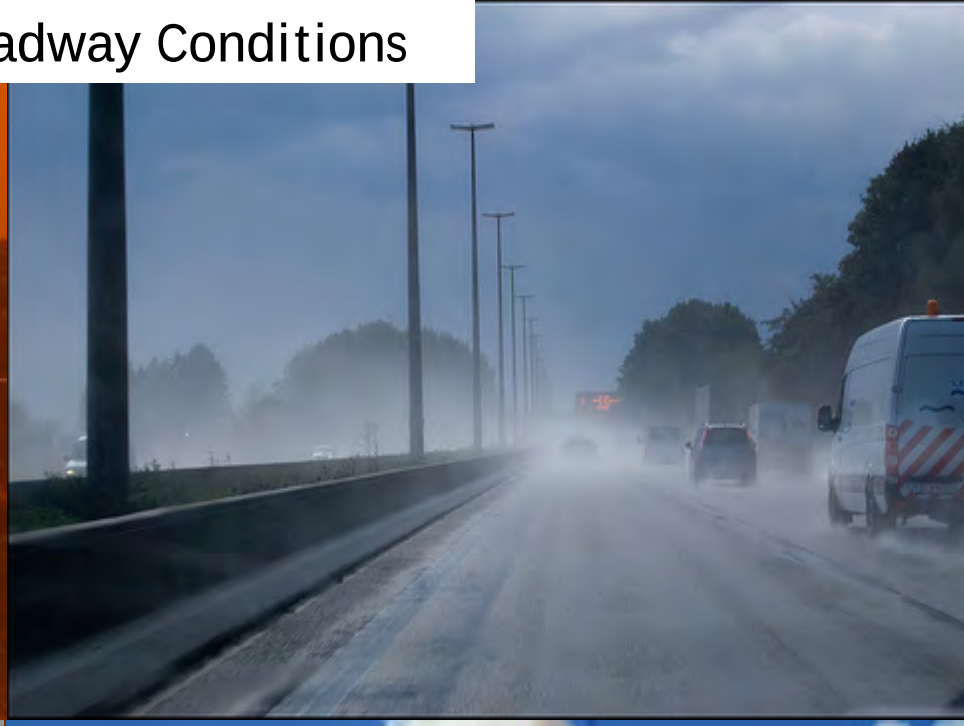
June 17, 2015 for
NDOT Traffic Operations Technology Section (TOTS)

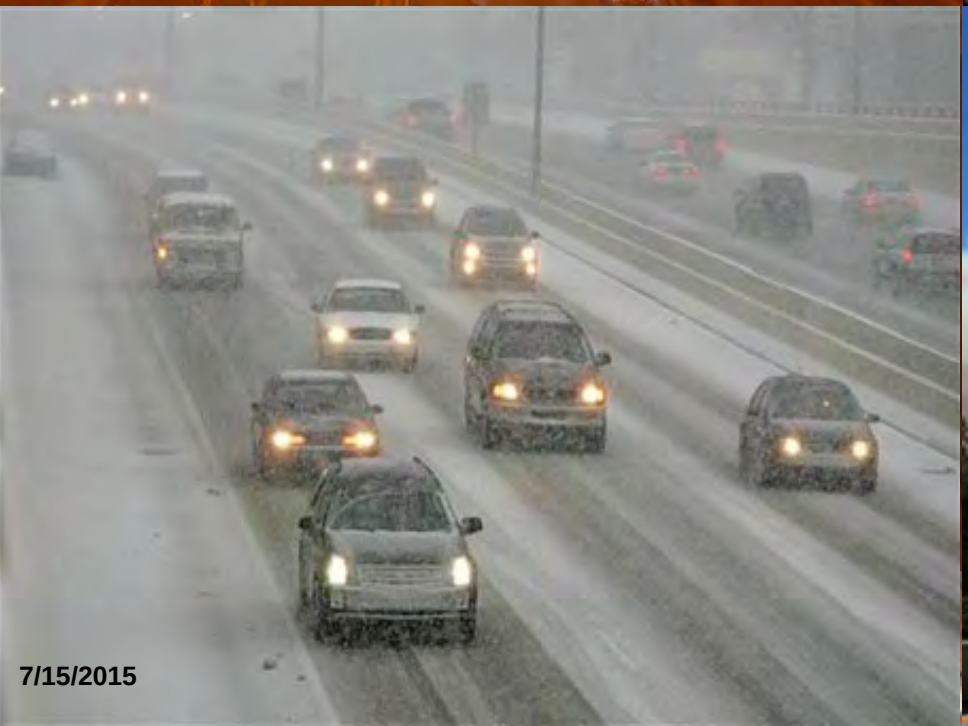
Normal Freeway Conditions



Congested Freeway Conditions

Freeway and Roadway Conditions





Incidents Related to Freeway Conditions

Freeway Conditions or Incidents can make it feel like….

High Level Needs and Requirements

An NDOT perspective

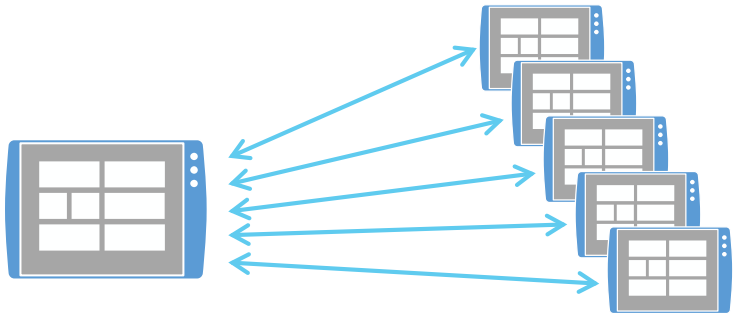
High Level Needs and Requirements

Inefficiencies in app architecture require the following:

- Operators must check multiple platforms for information
- Operators must enter a single event in multiple platforms
- On-call developers are tasked to create multiple individual interfaces to share information between specific applications (1:1)

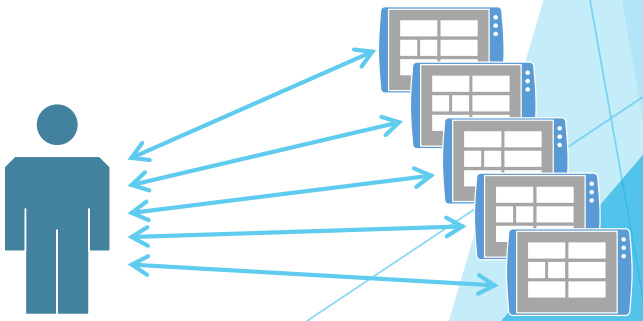
High Level Needs and Requirements

Inefficiencies in app architecture require the following:



Operators must enter a single event in multiple platforms

Operators must check multiple platforms for information



High Level Needs and Requirements

Inefficiencies in app architecture require the following:

- Very few systems can provide information in a bidirectional method (internal network)
- Some ITS applications do not have an Application Program Interface (API)
- Established standards for sharing information are not used
- Very few systems can receive historical data

High Level Needs and Requirements

Inefficiencies in app architecture require the following:

- NO API
- NO bidirectional data
- NO historical data

High Level Needs and Requirements

What is the result of these inefficiencies:

- No set standard set of libraries or tools for development
- No common data dictionary
- No common application requirements
- No ability to share bidirectional information outside the network

High Level Needs and Requirements

What is the result of these inefficiencies:

- No common ITS libraries or tool kits (Example: openFrameworks)
- No common data dictionary
- No common requirements
- No bidirectional internet sharing

Reference: http://openframeworks.cc/about/

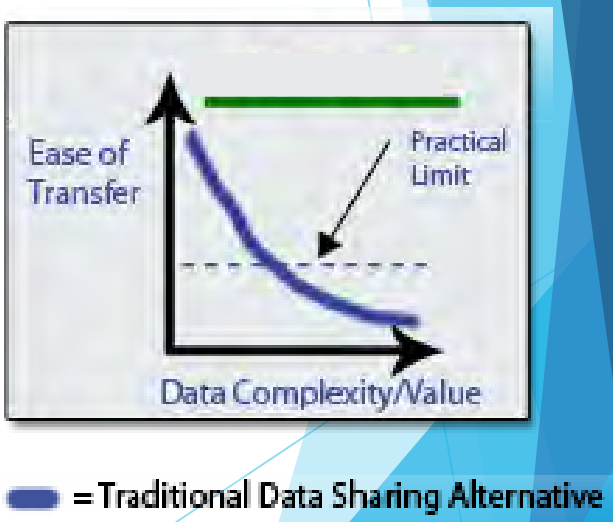
Are our systems efficient and effective for NDOT, operators, developers, and third parties?

Issues Related to ITS Data Sharing

Consider the future of "how" you intend to share your data:

Traditional Database Data Transfer Over the Web

***Direct* Database Transfer Over the Web**



Reference: http://dataportaltech.com/advantages-of-database-transfer/

Issues Related to ITS Data Sharing with Flat Files

The benefit and the problems with data sharing with flat files

Issues Related to ITS Data Sharing

Data is traditionally shared in two forms:

- Flat Files
  - Comma-Separated Values (CSV)
  - Extensible Markup Language (XML)
  - Microsoft Excel
- Databases
  - Microsoft Access
  - SQL (NDEX)
  - Oracle

Issues Related to ITS Data Sharing

The Benefits with data sharing with a CSV or Flat files:

- Each line of text is a single row
- Fields are separated by a delimiter a “comma” or “tab”
- The lines are just the data itself
- No need for special software
- All spreadsheet software applications (flat file apps) can read or write CSV files or vice versa

```
D1012,150513,10:06,9,119,119,14,124,,,,2,,0,,6562,,,,,,,,,,,,,,,32,,,,,,,
D3[illegible],150513,10:08,4,344,344,7,359,50,28,18,2,,0,,,,,,,,,,,,80,62,60,3,,32,8
D310,150513,10:07,4,20,20,7,40,50,29,19,2,,0,,,,,,,,,,,,79,62,60,3,,32,80,
D311,150513,10:07,6,140,140,9,143,54,26,20,2,,0,,6562,,,,,,,,,,84,63,58,5,
```

Issues Related to ITS Data Sharing

Inherit problems with data sharing with a traditional file (flat file):

- Text files do not guard against data redundancy and inconsistency
- Operating Systems (OS) want to lock files for exclusive input/output (I/O)
- This limits access to a file to one client at a time that can view and/or change data

Issues Related to ITS Data Sharing

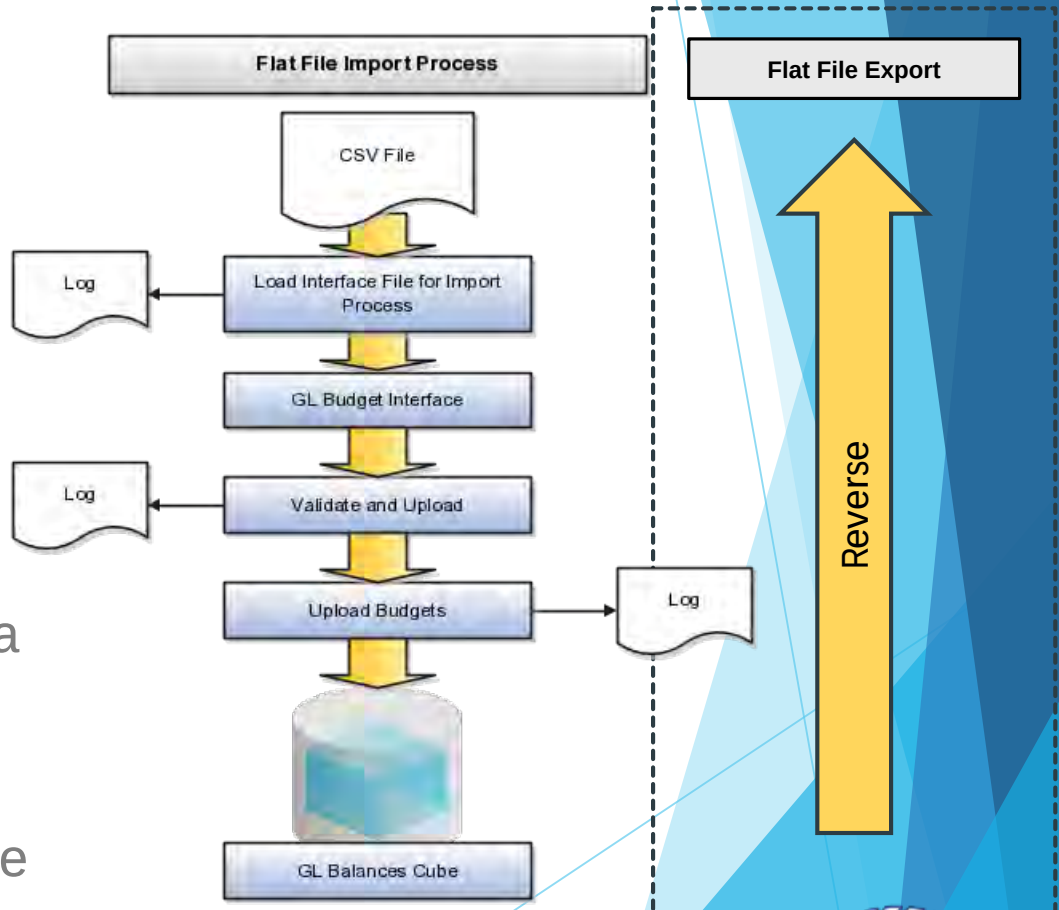
Inherit problems with data sharing with a traditional file (flat file)(continued)

- No programmatic independence between applications and text fields
- Every text file is formatted in a specific way and must be used by the program that knows how to read it
- Or developers must coordinate how to access the information

Issues Related to ITS Data Sharing

Flat File Process (Integration)

- CSV Flat File (locked 1:1)
- Data Import is limited
- Data Validation is limited
- Requires conversion of data
- Application is limited
- To generate a flat file is the reverse of this process

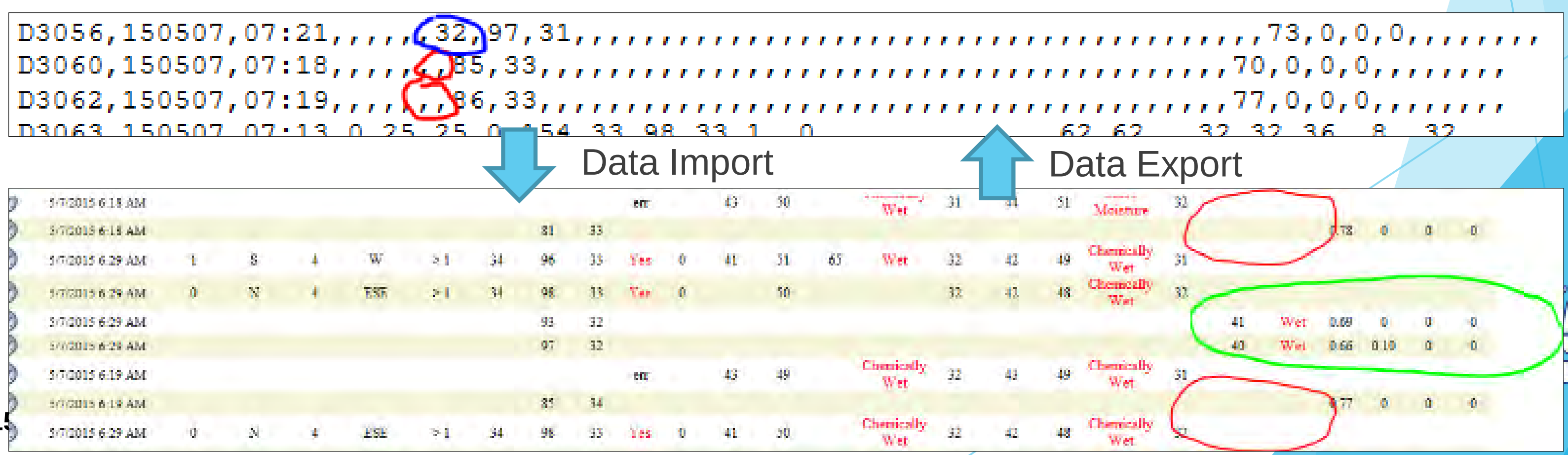


Reference: https://docs.oracle.com/cd/E51367_01/financialsop_gs/FAIGL/F1453214AN389F2.htm#F798499AN38CB9

Issues Related to ITS Data Sharing

Comma Separated Values (CSV)

- Each comma represents a potential dataset that needs to be identified and used
- Simple human error or a slight change in structure can cause errors



Issues Related to ITS Data Sharing

The Benefits of Data Sharing with XML (flat file):

- Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable
- XML is easy to read and understand
- XML is a W3C standards endorsed by the industry
- No fixed set of tags

Issues Related to ITS Data Sharing

The Benefits of Data Sharing with XML (flat file) (continued):

- Tags can be created as needed
- XML is well defined and can be stored without schemas
- XML was designed to describe data with focus on what data is
- Tags, attributes and elements allow for efficient data searching and mining

Issues Related to ITS Data Sharing

Inherit problems with data sharing with a traditional file (flat file):

- Very verbose relative to other text based formats
- No intrinsic data type support of “integer”, “string”, “Boolean”, and “date”, and so on.
- XML repeats every element and attribute name for every element and attribute instance

```
2    <user>
3        <firstName>John</firstName>
4        <lastName>Smith</lastName>
5    </user>
```

Issues Related to ITS Data Sharing

If “essSurfaceTemperature.0” reports “420” there is not an efficient method to validate if this information is correct or not with this XML schema.

```
</ntcipMessage>
- <ntcipMessage deviceID="D3060" dataTime="20150507T063839" source="I-
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNames
    <value name="essAirTemperature.0"/>
    <value name="essRelativeHumidity.0">85</value>
    <value name="essDewpointTemp.0">34.2</value>
    <value name="essSurfaceTemperature.0">42.0</value>
    <value name="essSurfaceStatus.0">5</value>
    <value name="levelOfGrip.0">76</value>
    <value name="amountOfWater.0">0.0</value>
    <value name="amountOfIce.0">0.0</value>
    <value name="amountOfSnow.0">0.0</value>
</ntcipMessage>
```

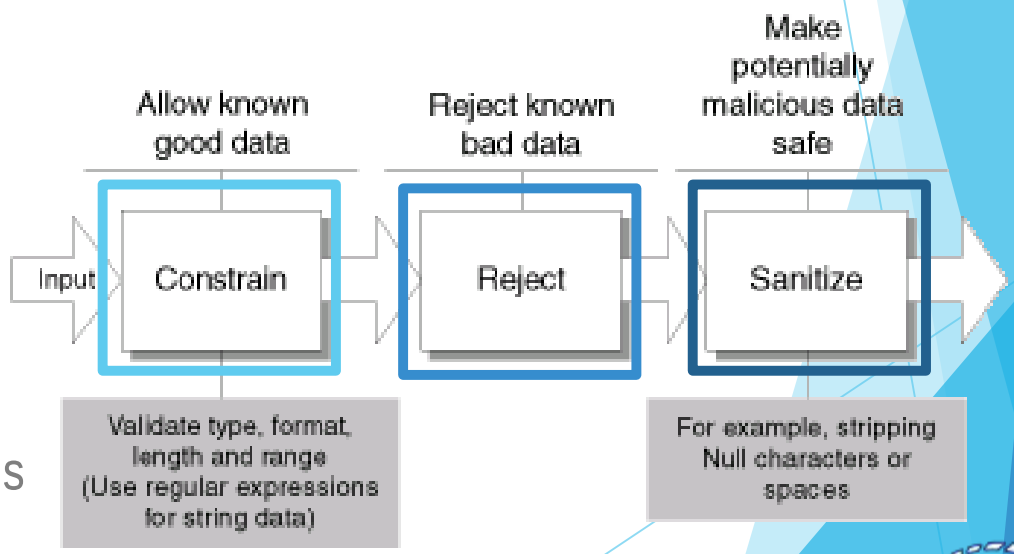

Reference: ftp://ftp.its.nv.gov/external/ File: D3rwis_devices.xml

Issues Related to ITS Data Sharing

A common practice is to constrain, reject, and sanitize Input Data

Data Input

- Allow known good data is constrained
- Reject known bad data
- Make potentially malicious data safe



Reference: https://msdn.microsoft.com/en-us/library/ff648647.aspx

Issues Related to ITS Data Sharing

My Opinion: Accessing and exchanging information in a traditional file system can be very restrictive

Easy to deploy but difficult to maintain schema against several various flat files and lacks data validation and authentication

Overview of Issues Related to ITS Data Sharing

The benefit and problems with data sharing with databases

Issues Related to ITS Data Sharing

The Benefits of Using a Relational Database:

- Represents data in tables
- Includes multilevel integrity to guard against data duplication
- Assigns unique keys to each record to guarantee accuracy and consistency

Issues Related to ITS Data Sharing

The Benefits of Using a Relational Database:

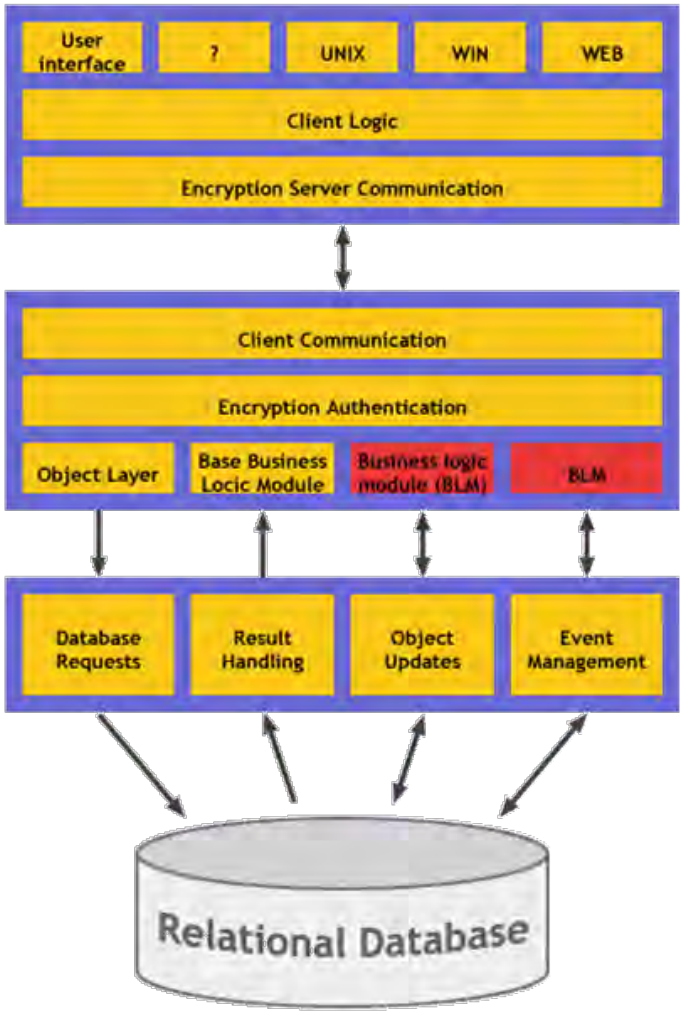
- Relational databases are simple and powerful
- The de facto standard for most Enterprise and Commercial environments
- Self describing
- Rule based

Issues Related to ITS Data Sharing

The Benefits of Using a Relational Database:

- Compatible with other applications that know how to use a relational database (Excel, Access, other DBs)
- Secure – Permissions set in Active Directory, local permissions set on standalone server, or Database Management System (DBMS) applications

Issues Related to ITS Data Sharing



Relational Database Process

- Database (open M:M)
- Dynamic Data Import / Export
- Bidirectional Data Sharing
- Business Rule Validation
- Data Validation
- Encryption
- Multiple Application Uses

Reference: https://www.python.org/about/success/strakt/

Issues Related to ITS Data Sharing

Inherit problems with data sharing with a database:

- Databases are Complex hardware and software systems
- Databases require significant upfront and ongoing financial resources
- Organizations need to ensure that their databases systems can securely store data
- Database management systems might not be compatible with operational requirements

Reference: https://www.python.org/about/success/strakt/

Issues Related to ITS Data Sharing

In my opinion: Databases are easy to maintain and are the most common way to store information in Enterprise and Commercial environments.

Enterprise (technology) processes should be leveraged to ease management of ITS Systems.

The only real Return on Investment (ROI) you will receive is accessibility to your data

Things to Note about NDOT Infrastructure

- All NDOT ITS servers, databases, and workstations are patched, updated, and imaged statewide
- Most of the NDOT ITS servers and 1/3 of ITS workstations are virtualized (100% virtualization of servers within 1 year)
- All NDOT ITS routers, switches, firewalls, and field hardened Ethernet switches are patched, updated, and *configs backed up statewide

* This metric should be met within 9 months after FY2016 begins

FHWA Initiatives that Drive the Use of a Data Warehouse

A list of things we need to account for as ITS grows

Real-Time System Management Information Program (RTSMIP)

FHWA Initiatives that Drive the use of a Data Warehouse

Real-Time System Management Information Program (RTSMIP)

- Section 1201 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEA-LU)(23 CFR 511)
- Provide the capability to monitor in real-time the travel conditions of major highways
- Share data with state and local governments
- Share data with the traveling public

Reference: http://www.ops.fhwa.dot.gov/1201/factsheet/index.htm

FHWA Initiatives that Drive the use of a Data Warehouse

Real-Time System Management Information Program (RTSMIP)

- A Final Rule in Nov 8, 2010 established the provision for Real Time monitoring on all Interstates by Nov, 2014
- All other significant roadways within 4 years (Nov, 2016) as identified by State and Local Agencies
- Any urban area with a population of > 1M requires monitoring on arterials as well as freeways

FHWA Initiatives that Drive the use of a Data Warehouse

Real-Time System Management Information Program (RTSMIP)

- The RTSMIP requires to provide a foundation of basic traffic and travel conditions

- Construction
- Roadway or Lane Blocking Incidents
- Road Weather Observations
- Travel Time Information
- Information Accuracy
- Information Availability

Data Exchange Format Specification (DXFS)

FHWA Initiatives that Drive the use of a Data Warehouse

RTSMIP – Data Exchange Format Specification (DXFS)

- In Aug, 2013 the Data Exchange Format Specification (DXFS) was developed
- The DXFS document is a companion to RTSMIP
- DXFS is intended to establish standards-based specifications for RTSMIP interfaces
- Used to specify the implementation of a RTSMIP at a state or regional level

Reference: http://www.ops.fhwa.dot.gov/publications/fhwahop13047/index.htm

FHWA Initiatives that Drive the use of a Data Warehouse

RTSMIP – Data Exchange Format Specification (DXFS)

- DXFS is a set of interfaces used to send traffic, transit, transportation-related weather, and traveler information from one agency to another
- DXFS is a specification of existing ITS standards
- AASHTO and ITE TMDD Version 3.03a
- CEN/TC 278 (Road Transport and Traffic Telematics)

FHWA Initiatives that Drive the use of a Data Warehouse

RTSMIP – Data Exchange Format Specification (DXFS)

- APTA TCIP-S-001 3.0.6 APTA Draft Standard for Transit Communications Interface Profiles
- OASIS Common Alerting Protocol v1.1
- National Weather Service using CAP and ATOM based formats
- NTCIP 2306 v01 - NTCIP Application Profile for XML Message Encoding and Transport in ITS C2C Communications
- SAE-J2266 Location Referencing Message Specification

FHWA Initiatives that Drive the use …

The Future of ITS – Data Archives, Warehouses, and Exchanges

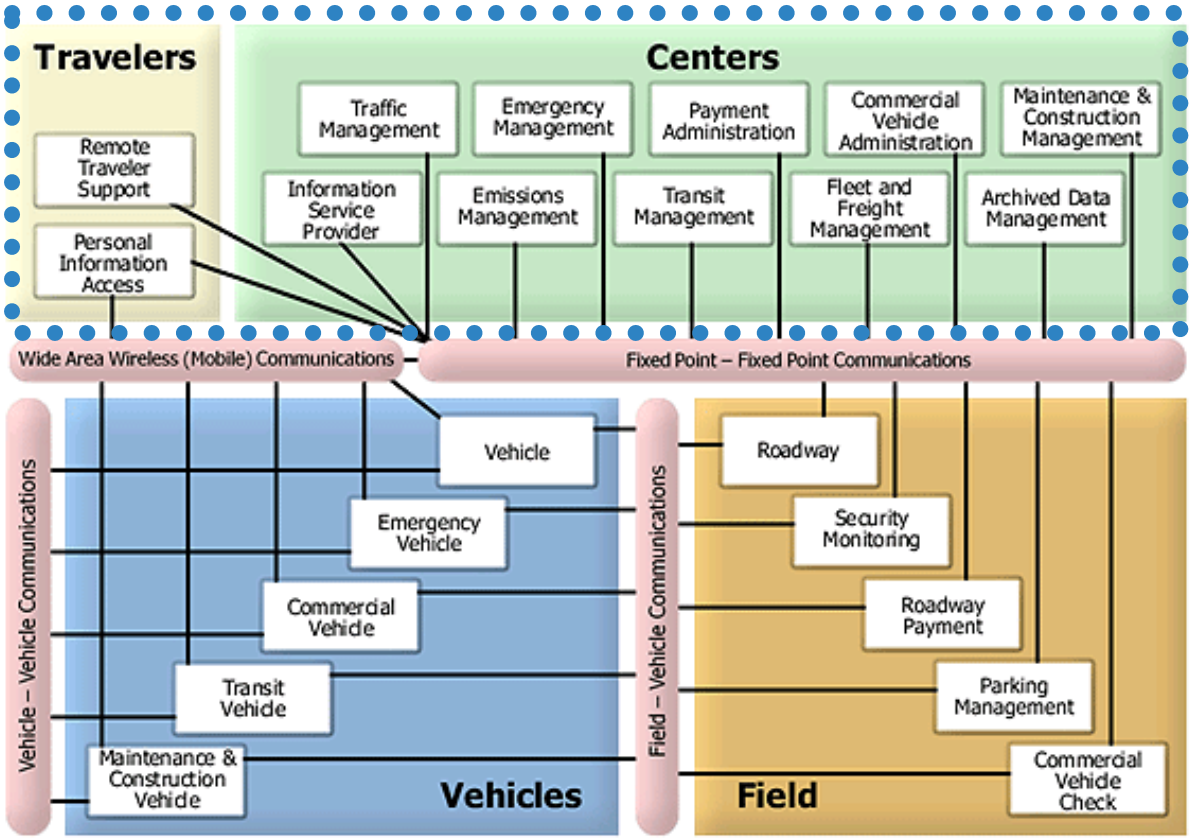
Again, a data warehouse is key across different transportation verticals

Image Source: http://www.iteris.com/itsarch/html/appareas/ifclass1apparea12.htm

User Services Defined within the National ITS Architecture

FHWA Initiatives that Drive the use …

Interconnected applications polling or receiving similar forms of data



Reference: http://www.its.dot.gov/arch/arch_longdesc.htm

FHWA Initiatives that Drive the use of a Data Warehouse

Examples of disparate systems and information strung across multiple platform types either controlled by the Traffic Management Center, other Divisions, Departments, or third parties (33 User Sub Services defined)

- Traffic Management
- Emergency Management
- Payment Administration
- Commercial Vehicle Administration
- Maintenance & Construction Management
- Information Service Provider
- Emission Management
- Transit Management
- Fleet & Freight Management
- Archived Data Management

Reference (Please Read, page 2): http://www.iteris.com/itsarch/documents/keyconcepts/keyconcepts.pdf

FHWA Initiatives that Drive the use of a Data Warehouse

- I purposely do not want to address the 33 Sub Services due to the fact that the National ITS Architecture can be a whole class upon itself.
- It is my opinion that other departments do not have the infrastructure or funding needed to perform these functions and it is likely that these end-point devices, at some point, will become part of the ITS network. (SmartDrive, Connected Vehicles, Connected Vehicles for First Responders and Transit)

Reference (Please Read, page 2): http://www.iteris.com/itsarch/documents/keyconcepts/keyconcepts.pdf

Crowd Sourced Data Project Related to Data Sharing

A Crowd Sourced Data Project

- Florida DOT uses crowd sourced data from Waze starting in March 2014
- Waze has access to the FDOT database (likely through a web service) "… and allows Waze to tap into the FDOT databases to enhance their offering to the public"
- Waze can login into FDOT 511 to get additional information

Image Source: http://www.dot.state.fl.us/trafficoperations/Newsletters/2014/2014-Aug.pdf

Video Source: http://wlrn.org/post/blazing-waze-fdot-traffic-app-s-first-us-partner

A Crowd Sourced Data Project

FDOT is not unique and there are several WAZE deployments in the following cities called “W10”:

- Rio De Janeiro
- Barcelona
- Jakarta
- Tel Aviv
- San Jose
- Florida
- Costa Rica
- Boston
- Los Angeles
- New York
- Utah

New Deployments:

- Iowa
- Kentucky
- Oregon
- Washington D.C.

Source: https://wiki.waze.com/wiki/Connected_Citizens_Program

Video Sources: http://justinchendesign.com/118490/5004825/works/one-day-on-waze

Determining a Course of Action

FHWA Initiatives that Drive the use of a Data Warehouse

Determining a Course of Action based on Future FHWA requirements:

- NDOT is forced to address traveler information for all Interstates
- NDOT is forced to address traveler information for all arterials with a urban population => than 1 Million
- NDOT has limited resources (3 personnel for statewide data distribution, video distribution, and backbone core infrastructure deployment)

Nevada Data Exchange (NDEX) Data Subscribers

Our key stakeholders

NDEX Key Stakeholders (Users)

- Traffic Management Centers (D2 Reno, D3 Elko, & D1 / FAST / Las Vegas)
- External Centers (UNR, UNLV, UC Davis, & DRI)
- Information Service Providers (Google, Traffic.com)
- Event Promoter (NASCAR, Sporting Events, etc.,)

NDEX Key Stakeholders (Users)

- Other County and City TMCs (RTC North, RTC Washoe County representing the cities)
- Maintenance and Operations Centers
- Surface Transportation Weather Service (RWIS/NOAA/Schneider Electric)
- Emergency Management (Police and Fire – Regional)
- Archive Data Management (All / Business Intelligence)

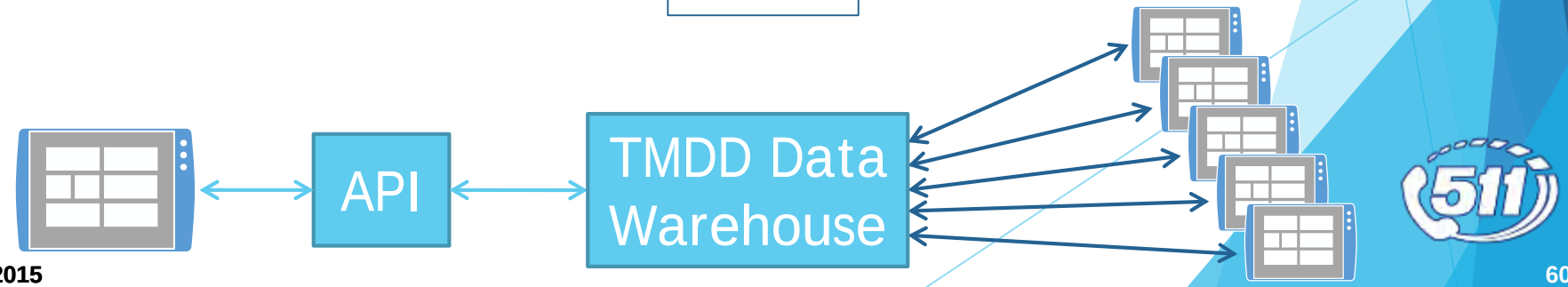
Nevada Data Exchange (NDEX) Technical Needs and Requirements

IT Key Stakeholder Needs that Drove the Project

Technical Needs & Requirements

- Standards based
- Support seamless bidirectional communications between ITS management platforms for inventory, history, and status
- Provide a central repository for information and long term storage (30+ years)

SAN Storage Area Network



Technical Needs & Requirements

- Provide a dedicated Storage Area Network (SAN)
- Provide a data exchange point using web services (next page)
- Use a three tier security architecture to allow external partners access to the system

- A SAN can replace the existing direct storage if the virtual machine is configured in this manner or configured to use shared storage on a host server

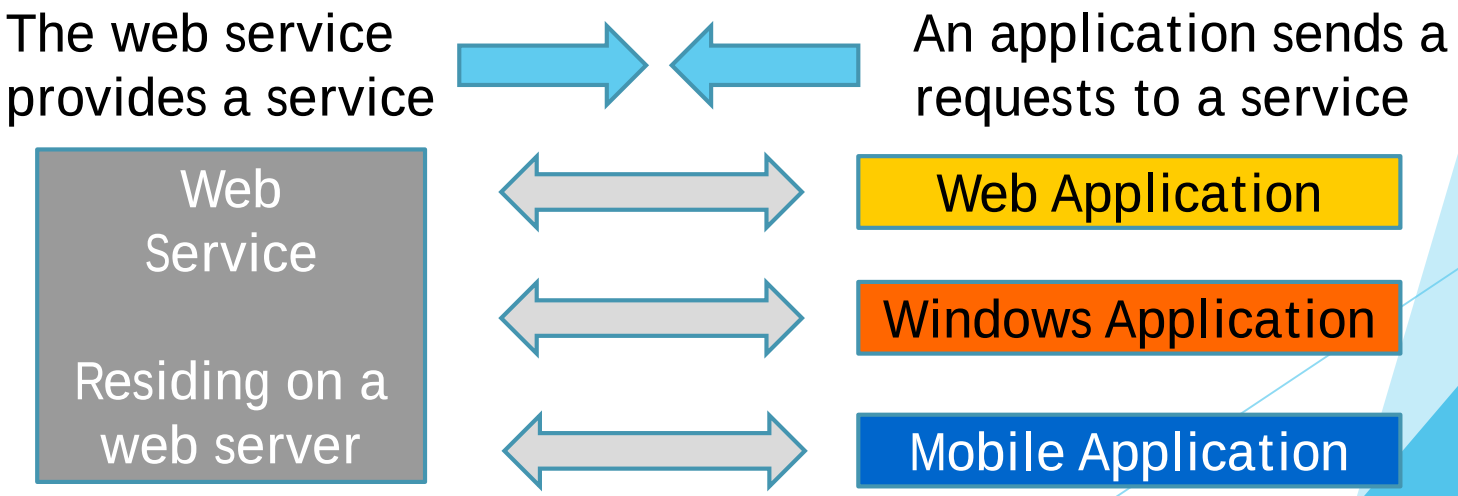
SAN Source: http://www.infoworld.com/article/2871290/cloud-computing/understanding-cloud-storage-models.html

Technical Needs & Requirements

Web Services and Service Based Architectures

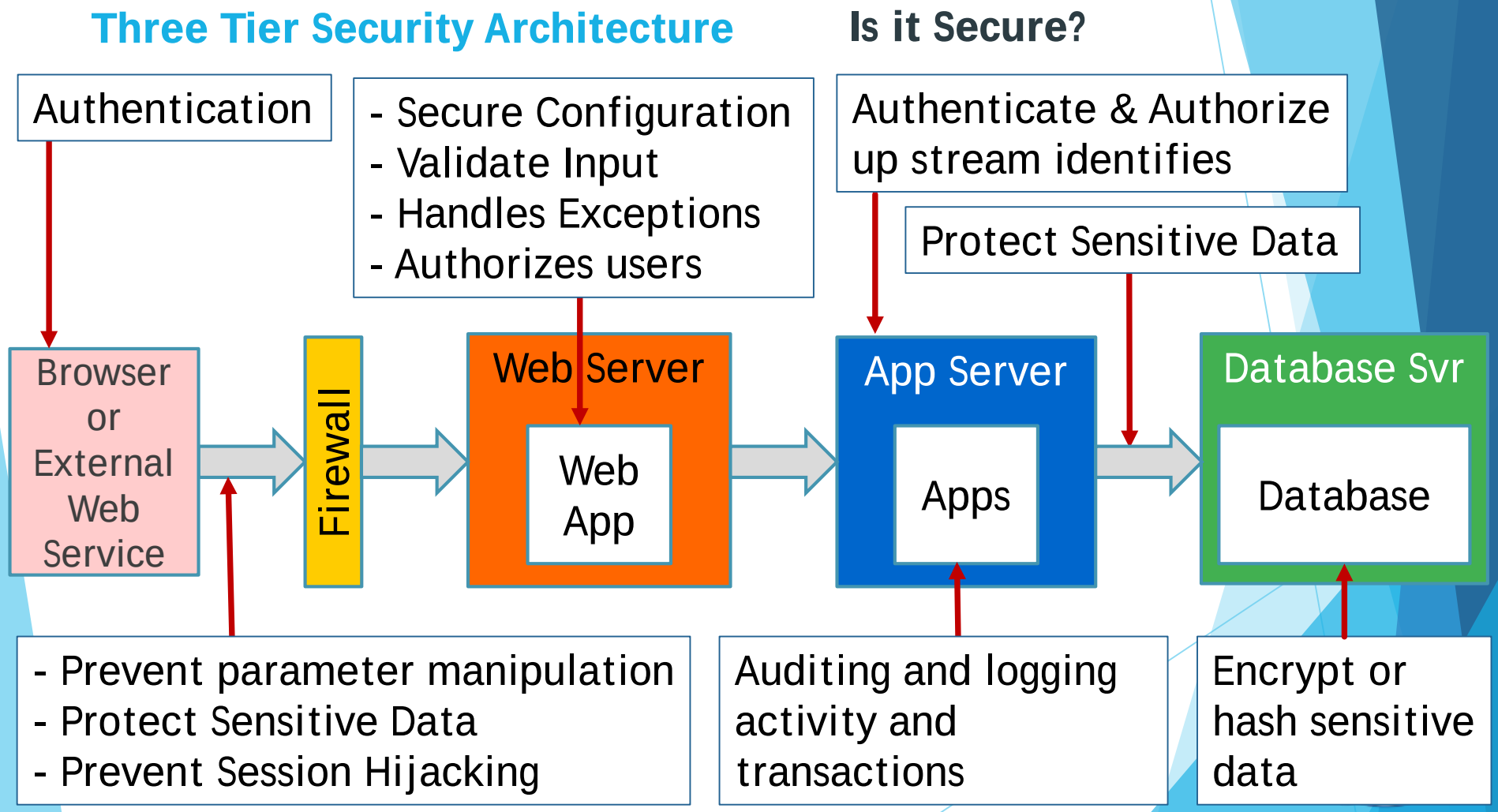
What is a web service and what does it do?

You need both to make a system



Source: http://www.infoworld.com/article/2871290/cloud-computing/understanding-cloud-storage-models.html

Technical Needs & Requirements



Source: https://msdn.microsoft.com/en-us/library/ff648647.aspx

Technical Needs & Requirements

- Provide an up time of 99.99% (< 52 minutes, 35.7s a year)
- Create a test and production environment
- All Central System Software (CSS) servers and the 511 systems must have the ability to cache any information for one (1) hour

Technical Needs & Requirements

- Use a firewall to restrict visibility on the NDEX
- Use NDOT self-signed certificates to secure communications
- Have a third party to validate the output of the NDEX

Technical Needs & Requirements

- Use a fixed price cost contract with a detailed SOW for any development
- Use a third party to maintain the NDEX (10% to 20% of original cost)
- Use a third party to assist others with integration into the NDEX (yearly fixed sum)

SAN Source: http://www.infoworld.com/article/2871290/cloud-computing/understanding-cloud-storage-models.html

Technical Needs & Requirements

Provide Future Support for FHWA initiatives:

1. Traffic Management
2. Emergency Management
3. Payment Administration
4. Commercial Vehicle Administration
5. Maintenance & Construction Mgmt.
6. Information Service Providers
7. Emissions Management
8. Transit Management
9. Fleet and Freight Management
10. Archived Data Management
11. DSRC / Connected Vehicles (Future)
12. Crowd Sourced Data (Future)

12+

Different Types of Systems

Image Source: http://www.ops.fhwa.dot.gov/weather/resources/publications/fhwa/itssimcv2/index.htm

What is the Traffic Management Data Dictionary (TMDD)?

Key Stakeholder Needs that **Drive** the Project

What is TMDD?

- The standard was published by American Association of State Highway and Transportation Officials (AASHTO) and the Institute of Transportation Engineers (ITE) under a cooperative agreement with the Federal Highway Administration (FHWA)
- TMDD was developed in coordination with FHWA, AASHTO, and ITE **public** and **private** partners

Reference: http://www.ite.org/standards/tmdd/3.01.asp

What is TMDD?

- The Traffic Management Data Dictionary (TMDD) Standards are used to support center-to-center (C2) communications
- Dialogs, message sets, data frames, and data elements are used to manage and share the use of these devices
- TMDD is used by centers to allow cooperative management of a corridor, arterial, incident mitigation, and event management

What is TMDD?

- TMDD has the ability to report status and inventory for devices (NDOT implementation)
- TMDD also has the ability to send control requests to other centers for devices (sent center-to-center (C2C))
- A control message is a request and an agency can approve or deny the control message based on business logic or rules

What is TMDD?

- At no time does TMDD talk directly to your devices
- Control messages are sent from FMS to FMS, FMS to TMS, TMS to FMS, or TMS to TMS
- Protocol-independent
- NDOT uses version 3.01
- NDOT uses XML version of TMDD (ASN.1 is an alternate)

What is the Nevada Data Exchange?

A simple description of a complex system

What is the NDEX?

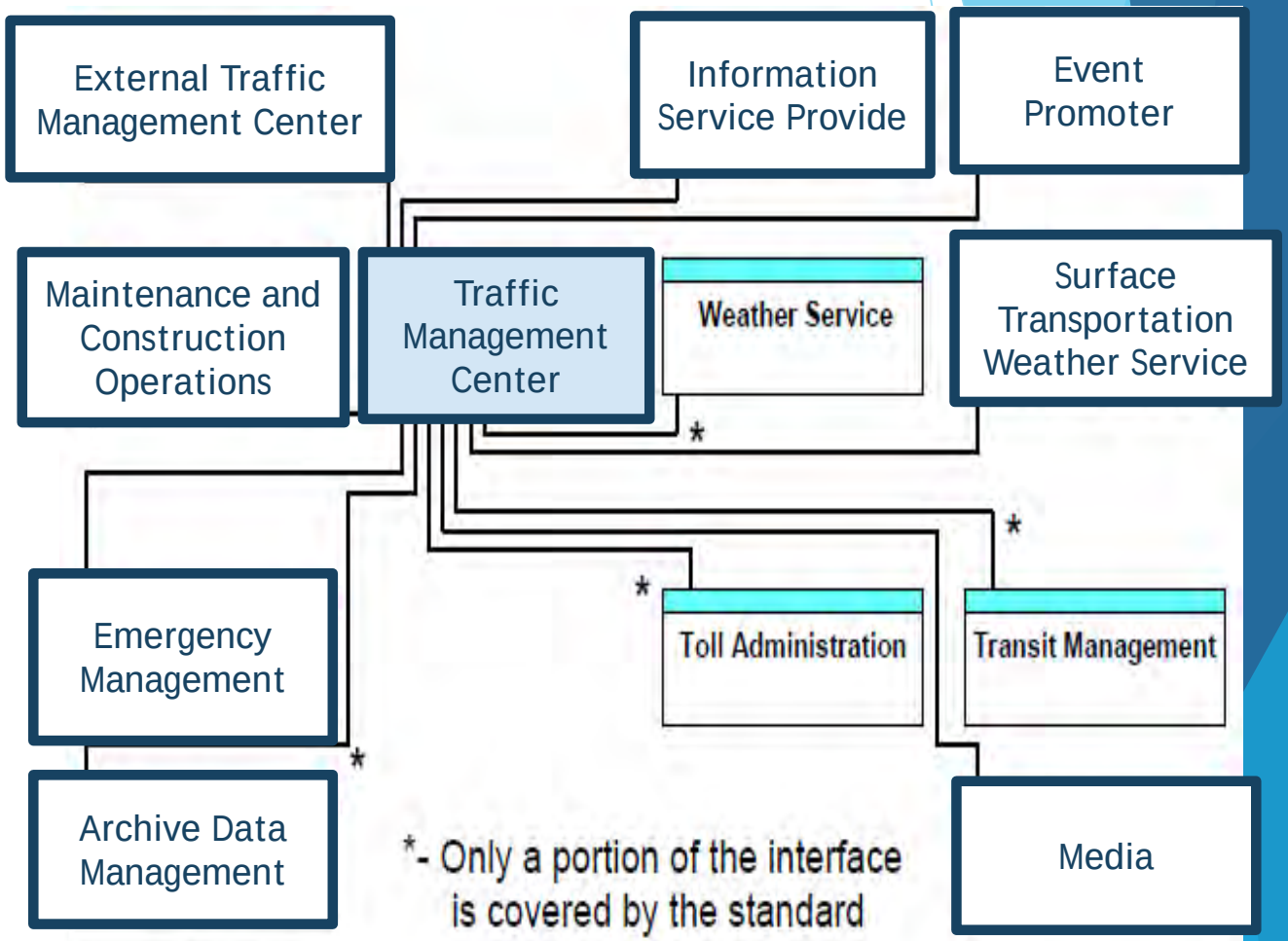
At its core the NDEX is the following:

- The NDEX is simply a set of services that provide a service running on a server
- Other services or applications running on other servers can request the data within the service
- Other services can publish their data to the NDEX services
- The NDEX was specifically designed to address FHWA User Needs (next page) related to sharing data

What is the NDEX?

The User Services that the NDEX supports

- **NDOT Supported Features**



TMDD v3.01 Vol. 1, page 13: http://library.ite.org/pub/e26acab9-2354-d714-5171-8bc8b57920cc

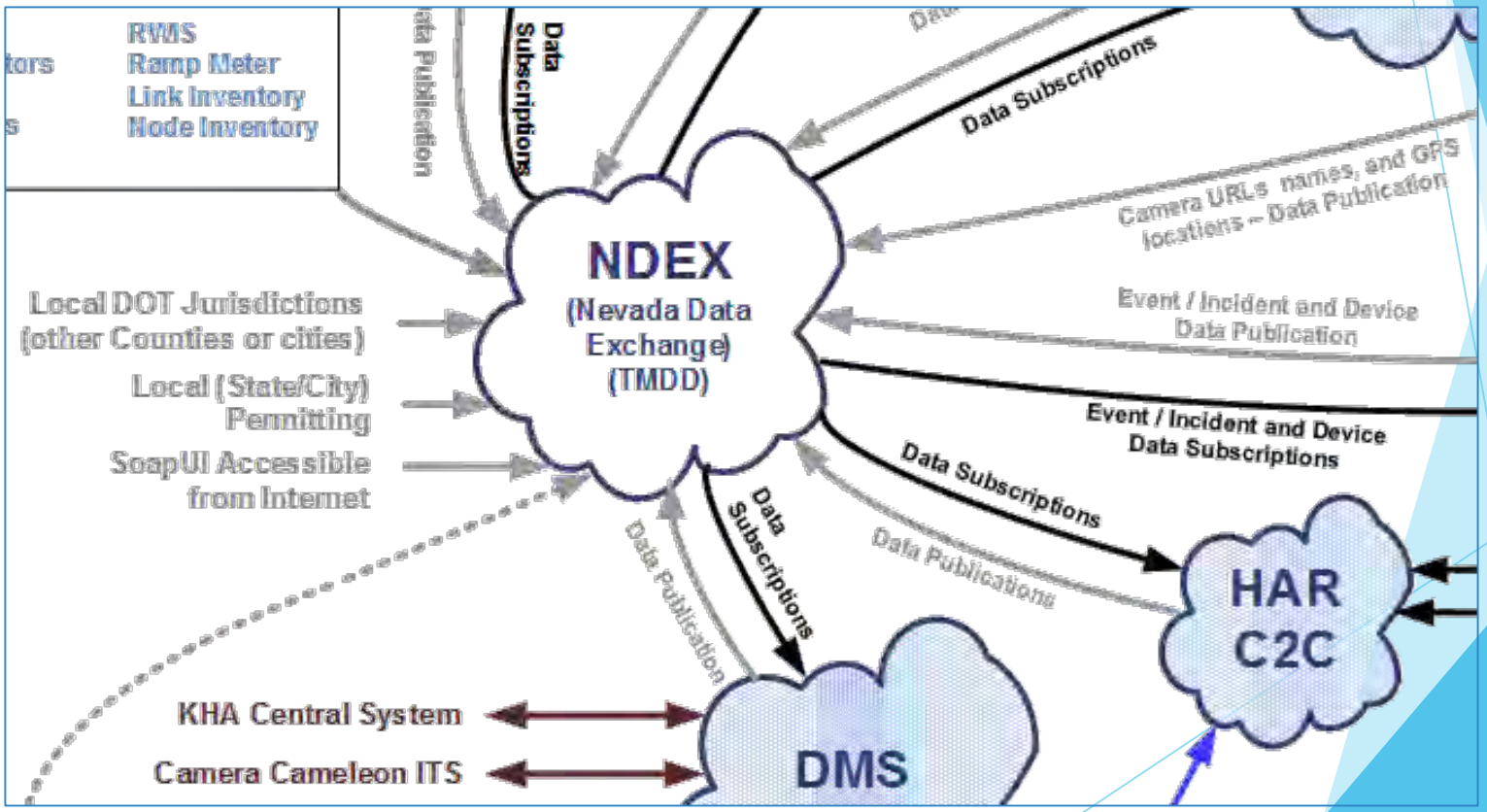
What is the NDEX?

- The NDEX is the heart of the system (see next page)
- Data warehouse = Data exchange = Data Archive (same)
- The NDEX provides a secure means to publish, subscribe, store, and report on information
- Data sharing is publication and subscription based
- Concept similar to Really Simple Syndication (RSS) feeds

Reference: http://www.consystec.com/nevada/xmlschema/

What is the NDEX?

- The Heart of NDOT ITS Data Distribution



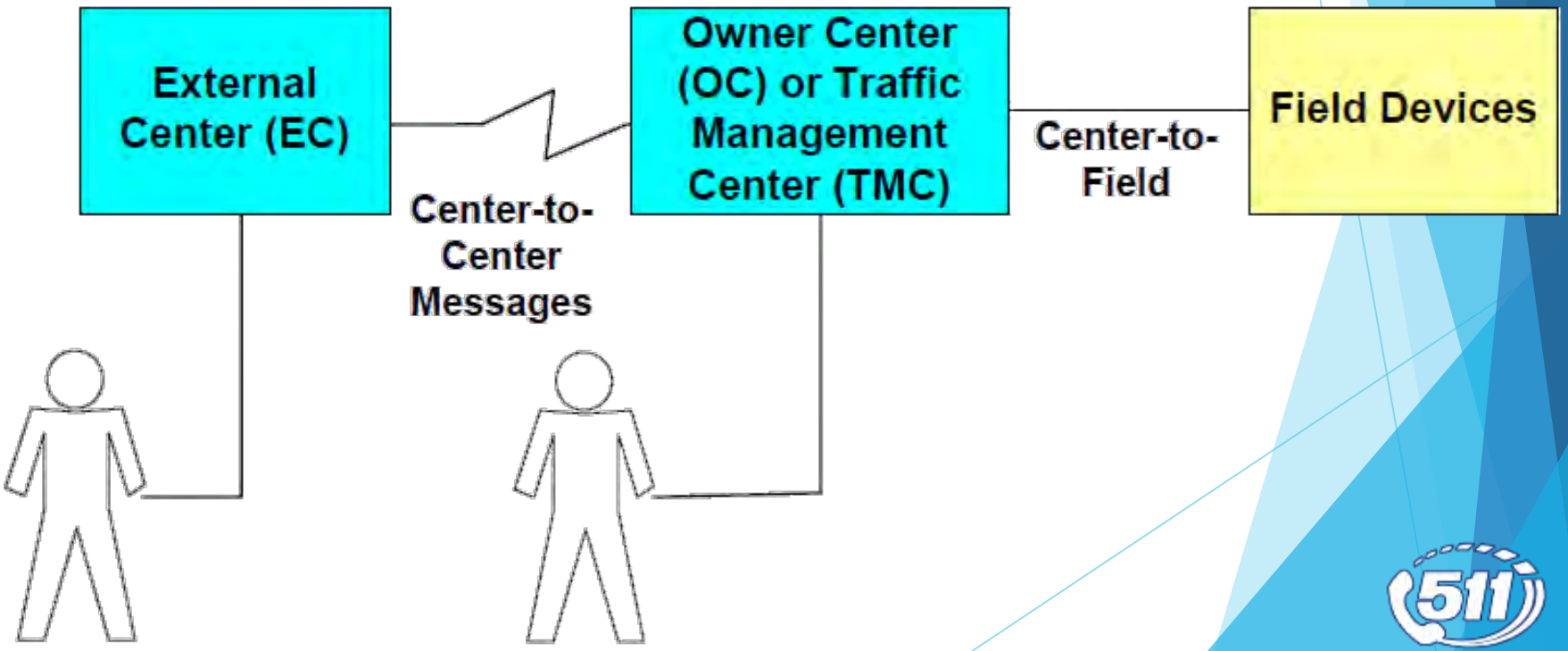
What is the NDEX?

- TMDD for C2C will allow ITS management platforms to share data autonomously (internally and externally)
- The NDEX uses secure web services to allow internal and external Centers to publish or subscribe to data
- Owning Centers (OC) publisher their data based on their need
- External Centers (EC) subscribe to OC data based on their need (Next Page)

Reference: http://www.consystec.com/nevada/xmlschema/

What is the NDEX?

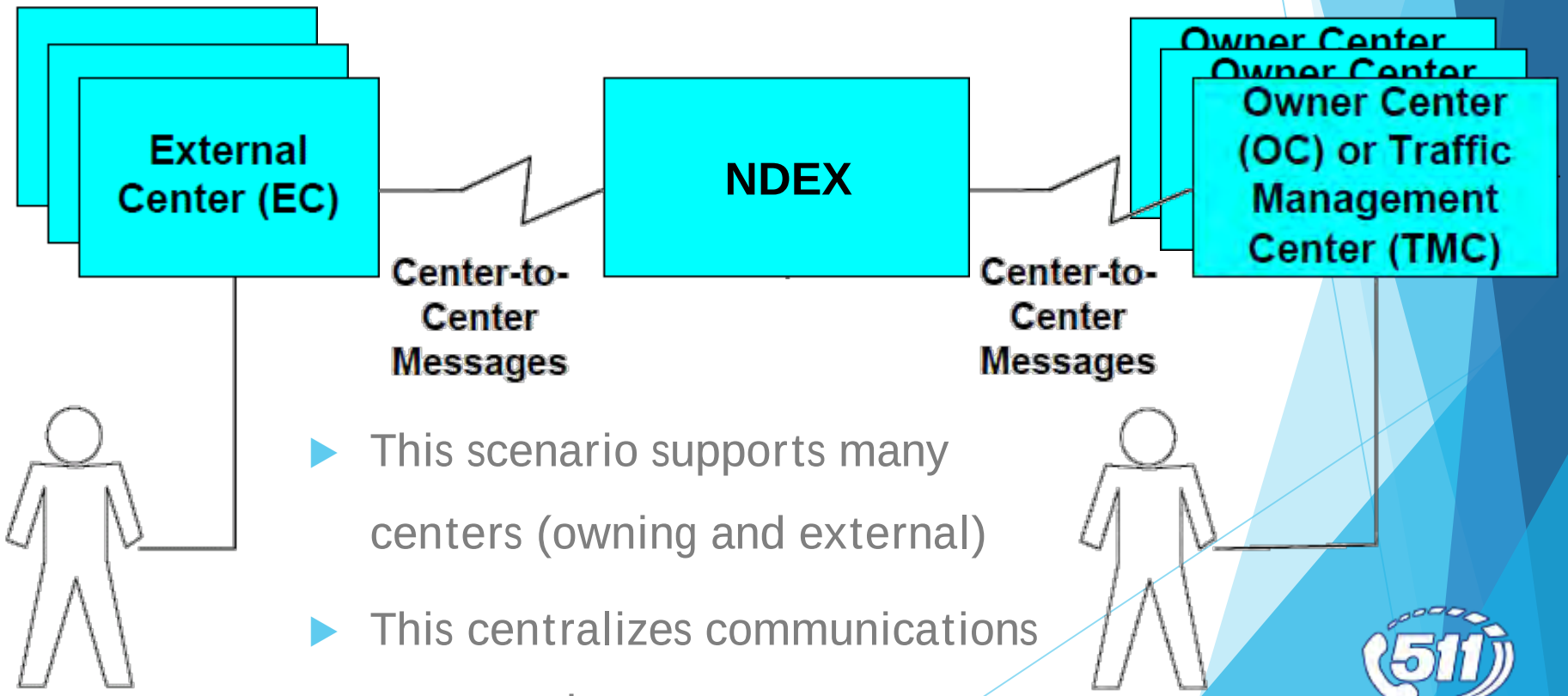
- TMDD inventory, status, and control messages can be direct
- In this scenario, a data exchange is not necessary



TMDD v3.01 Vol. 1, page 13: http://library.ite.org/pub/e26acab9-2354-d714-5171-8bc8b57920cc

What is the NDEX?

- The NDEX is the intermediary for communications between centers



- This scenario supports many centers (owning and external)
- This centralizes communications to one point

What is the NDEX?

- There is a distinction between direct communications to/from a center and storing information in an exchange
- In direct or Center-to-Center (C2C) communications , all information is sent directly between centers
- Archive information may or may not be stored or archived beyond a set period and is private between centers
- In a data exchange, data is sent to a single point for distribution and the data is archived

What is the NDEX?

- The NDEX was officially released in December 2014
- The data visualization portion is due to be released on June 2015
- We are in the process of migrating our 511 system to the NDEX
- UC Davis is the closet to being fully integrated with the NDEX

What is the NDEX?

- A Wiki will be built to provide general information on the NDEX and detailed information for strategic partners
- An NDOT initiative is to upgrade the various TMS and FMS systems that NDOT uses to TMDD v3.01
- TransCore TransSuite and KHA CSS / KITS have been upgraded to meet NDOT requirements
- This upgrade benefits all DOT's who are aware of the module

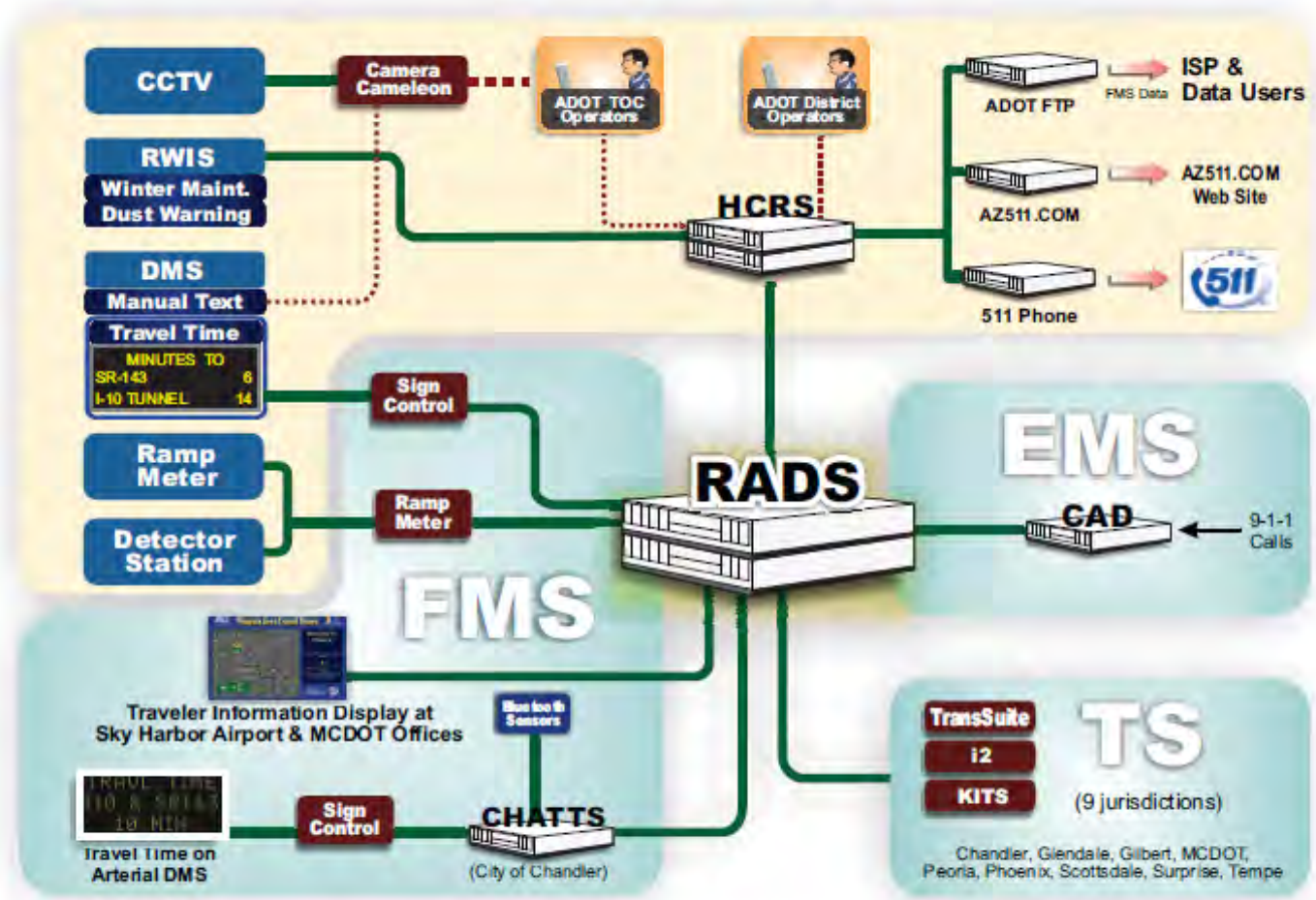
What is the NDEX?

- The NDEX was built on the framework from the Regional Archive Database Server (RADS) completed in 2006
- Arizona Technology (AZTech), a regional partnership of ADOT, MCDOT and Phoenix Metropolitan regional, sponsored the project
- The implementation uses TMDD v2.0
- The system is active and is still working today

Reference: http://www.aztech.org/trafmgmt/C2CStandards.aspx

What is the NDEX?

- AZTech RADS - 2012



Reference: http://www.aztech.org/trafmgmt/RADSReport.pdf

The NDOT Network

A simple description of what the NDOT network looks like statewide. It all starts here.

The NDOT network

The NDOT network consist of fiber and leased lines:

- California Stateline on US-395 to Carson City (Praxis / 25 miles)
- Carson City to Reno (Leased line upgrade from 300 Mbps to 10 Gbps)
  - Carson City to Reno fiber going in this year (NDOT project)
- Fiber along I-80 from Reno, NV to Utah State line (Level 3 / 397 miles)

The NDOT network

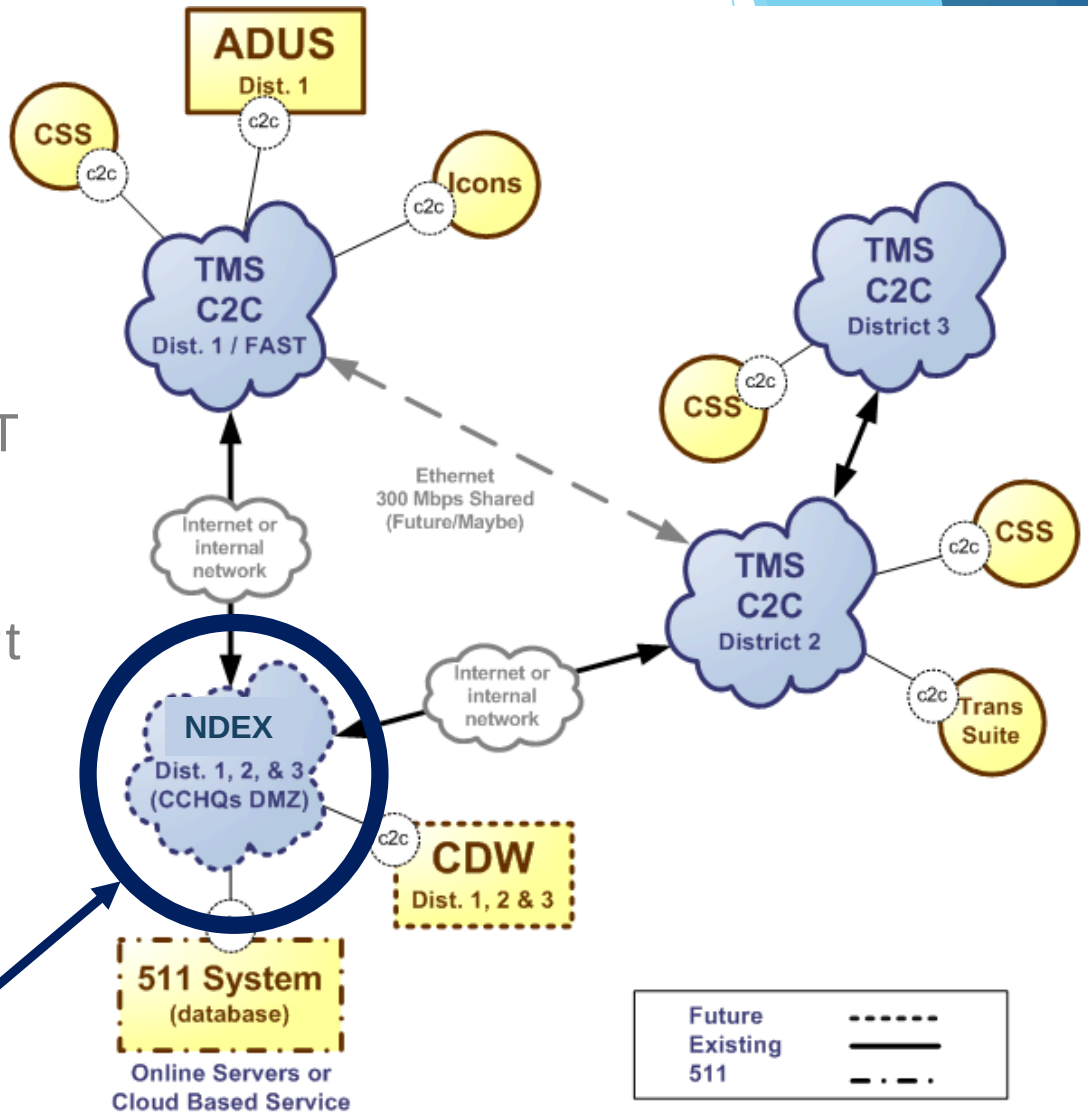
The NDOT network consist of fiber and leased lines:

- A leased line 1 Gbps connection from Elko to Las Vegas
- A leased line 1 Gbps connection from Las Vegas to Carson City
- Fiber from Las Vegas to Reno, NV (Switch / 448 Miles) (Future)(Dark Fiber)
- This creates a statewide ring
- The next page shows a very simplified version of our network

Reference: http://www.rgj.com/story/news/2015/01/15/sandoval-major-data-center-project-coming-reno-area/21836041/

The NDOT network

- Allows any DOT to Bi-directionally share data
- FAST is outside the NDOT Network
- A 300 Mbps circuit is part of the SPB upgrade



Any DOT

The NDOT network

Shortest Path Bridging Upgrade:

- The Core and Backbone is designed for carrier grade service level of 99.999% (Less than 5m 15.6s yearly)
- Shortest Path Bridging / 802.1aq (SPB) will support NDOT's virtualized environment and multitenant scenarios
- SPB is somewhat similar to MPLS but without the complexity of building the tunnels
- This project should be complete in December 2015

Reference: http://www.networkworld.com/article/2222372/cisco-subnet/cisco-s-not-on-board--but-is-shortest-path-bridging-winning-.html

The NDOT network

- NDOT has many strategic partners (tenants / three amigos):
- Traffic Operations (NDOT)
  - We build and provide the infrastructure and equipment
  - We still place our equipment for ITS devices (hand off)
  - Only three personnel to manage the infra. statewide
- Nevada System of Higher Education (NSHE)
  - NSHE manages the network using SONET
  - They install their backbone equipment at key facilities

The NDOT network

NDOT has many strategic partners (tenants / three amigos):

- EITS (State - Enterprise Information Technology Services)
  - EITS participates and connects other state entities
  - One point of contact for state entities
- NDOT IT (Information Technology Group)
  - Connects to traditional services such email and other enterprise services
  - Manages our network switches and servers

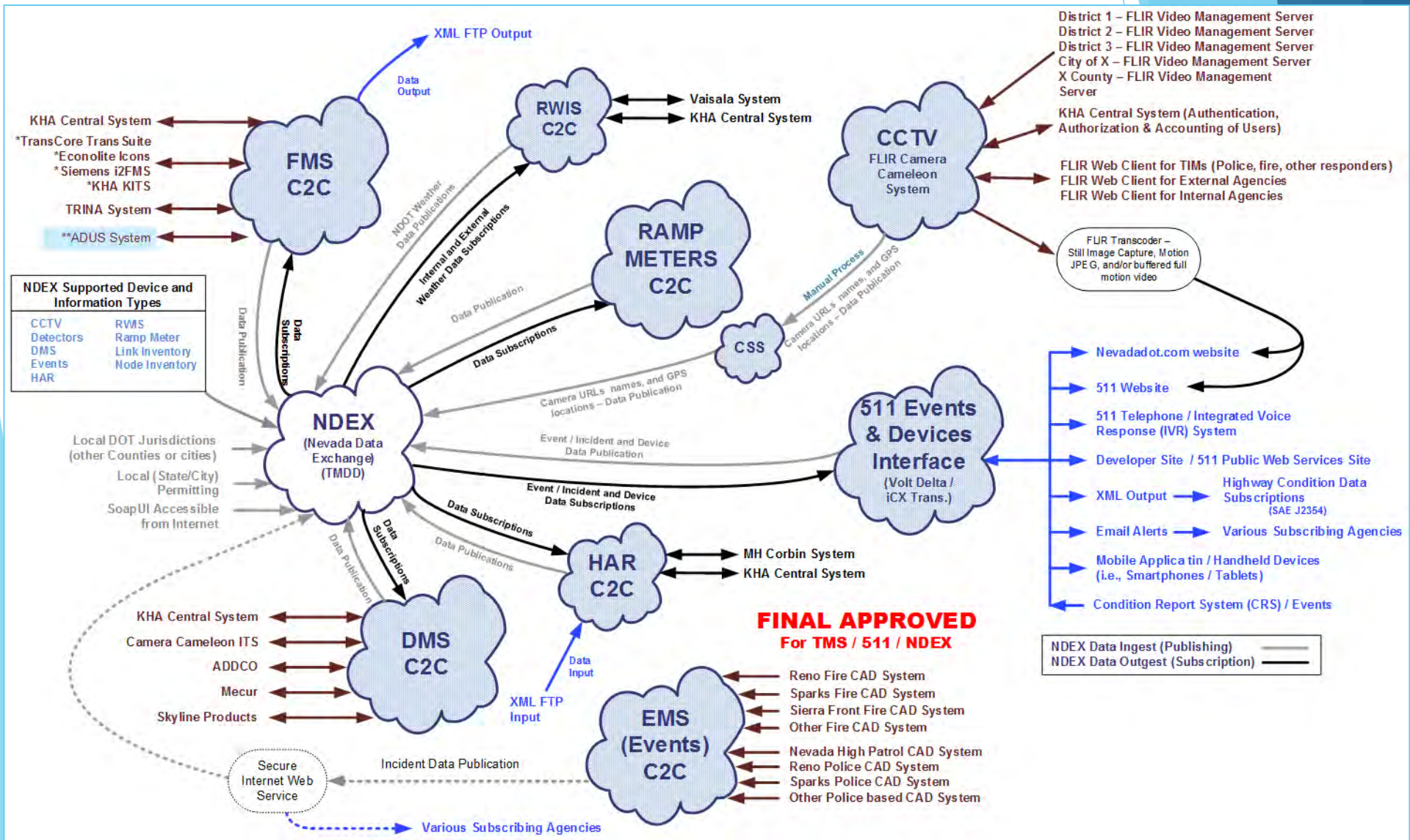
What does the NDEX do?

A simple description of what the NDEX does to facilitate sharing of data

What does the NDEX do?

- The NDEX Supports TMDD Inventory and Status Messages for the following types (next slide):
- Connection Management (Organization Information)
- Detectors
- DMS
- RWIS
- Ramp Meter
- CCTV
- HAR
- Event Index
- Full Event Update
- Node Inventory
- Link

What does the NDEX do?



What is the NDEX?

- With the NDOT NDEX and AZTech RADS certain vendors support TMDD version 2.0 and/or 3.0 out of the box:
  - KHA CSS / KITS
  - TransCore TransSuite
  - Siemens
  - Econolite

What is the NDEX?

Legend (Next Slide)

- "X" = Version 2.0 Supported
- "O" = Version 3.01 Supported
- Central System publishes all device data to the NDEX
- Our 511 publishes all events into the NDEX
- TransCore TransSuite and other platform subscribe to the NDEX
- There is a variation with the interface when publishing versus subscribing

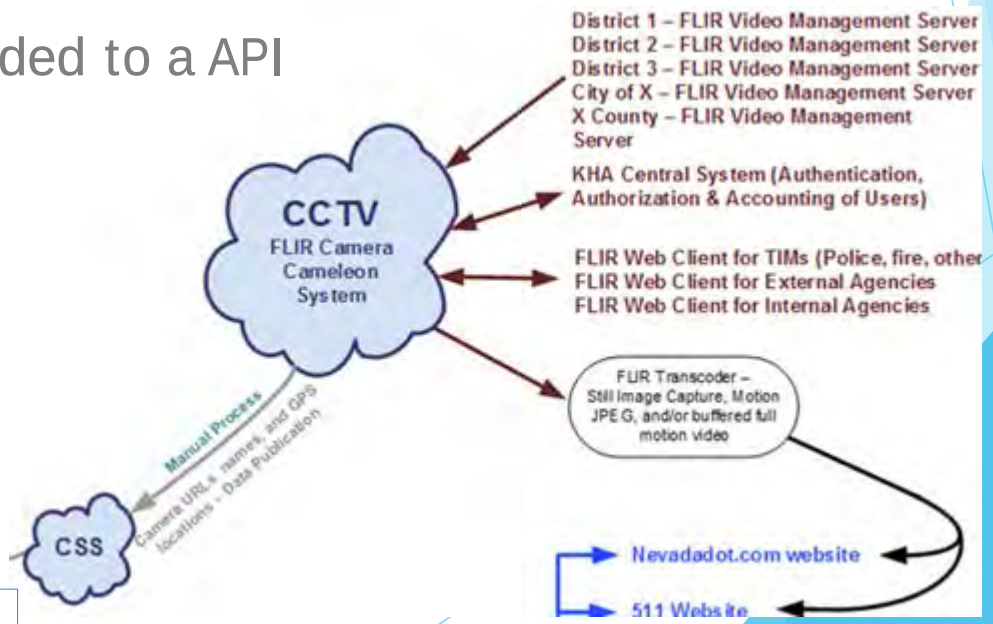
What is the NDEX?

TMDD Version Support	KHA		TransCore		Siemens		Econolite	
Description	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0
CCTV	-	O	-	O	-	-	-	-
Detectors	X	O	X	O	X	-	X	-
DMS	X	O	X	O	X	-	X	-
Event Index	-	-	-	O	-	-	-	-
Full Event Update	-	-	-	O	-	-	-	-
HAR	-	O	-	O	-	-	-	-
Ramp Meter	X	O	X	O	X	-	X	-
RWIS	X	O	X	O	-	-	-	-
Traffic Signals	X	-	X	-	X	-	X	-

What is the NDEX?

NDOT CCTV Cameras

- Central System receives a flat file from FLIR
- CSS publishes the CCTV camera info into the NDEX
- This is being upgraded to a API

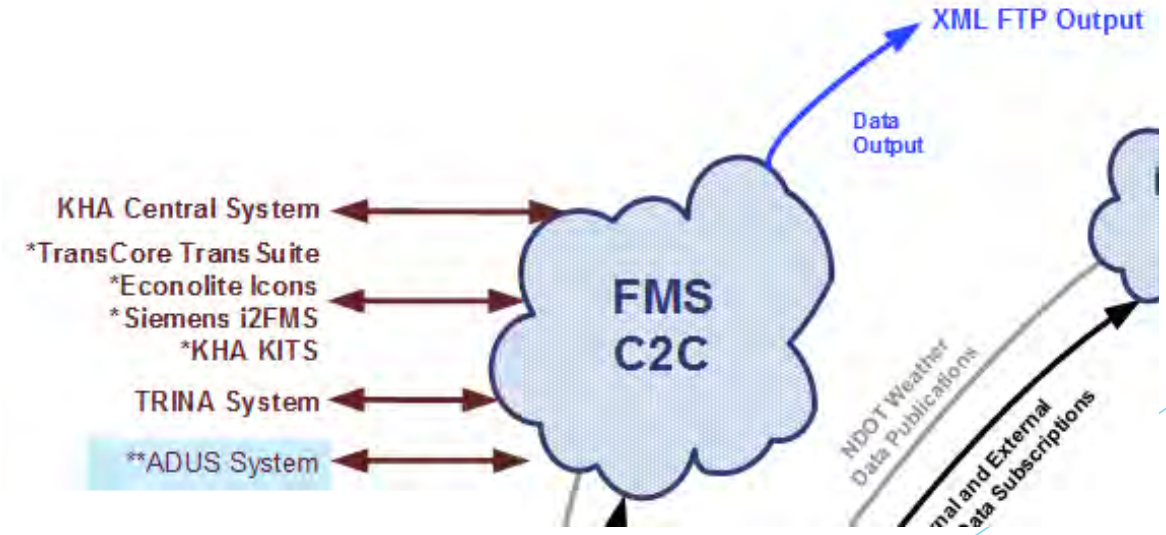


Reference: http://v2p.its.nv.gov:90

What is the NDEX?

Vehicle Detectors

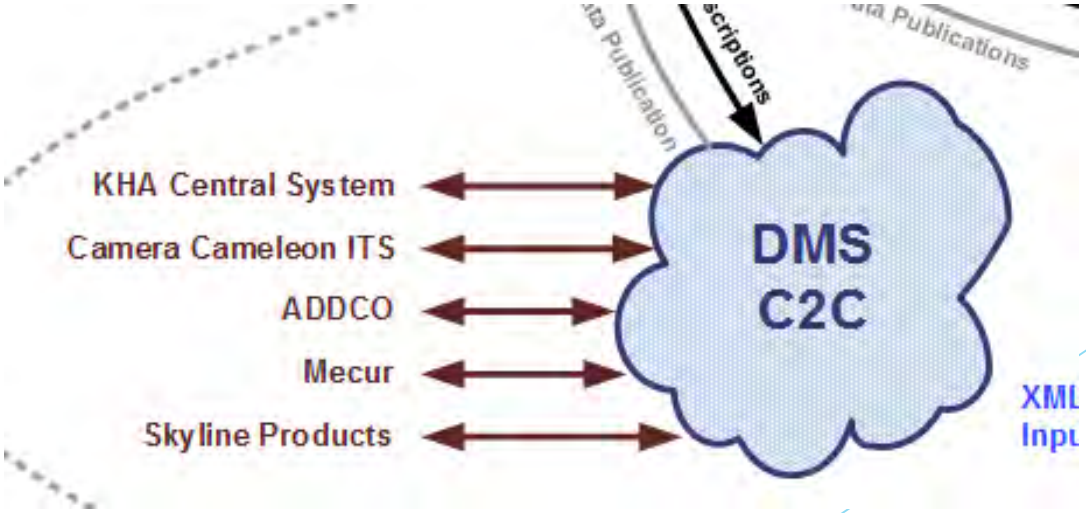
- Central System is used to poll all NDOT vehicle detectors
- CSS publishes the vehicle detector info to the NDEX



What is the NDEX?

Dynamic Message Signs (DMS)

- Central System is used to post to all NDOT DMS signs
- CSS publishes the DMS sign info to the NDEX



What is the NDEX?

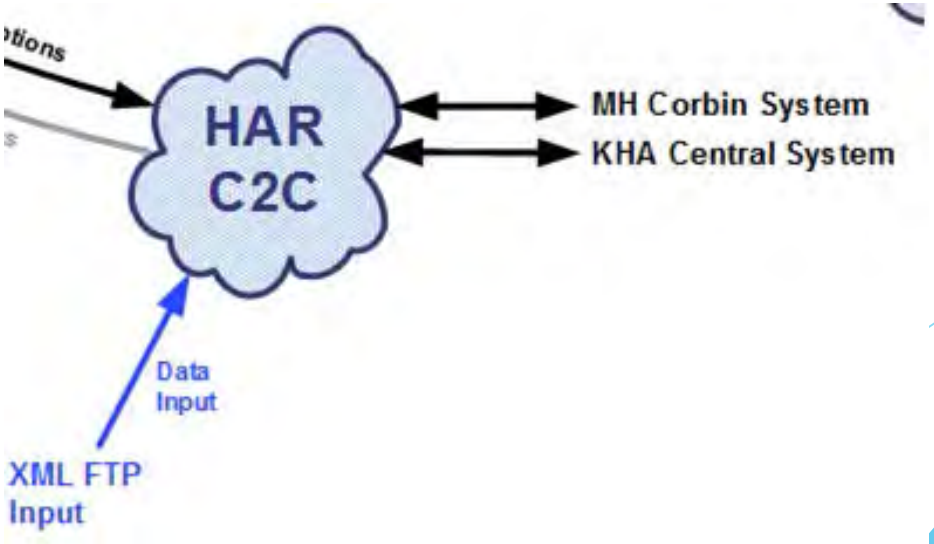
Events (Incidents / crashes)

- The Condition Reporting System (CRS) is used to report events into 511
- The 511 system publishes the event info to the NDEX

What is the NDEX?

Highway Advisory Radio (HAR)

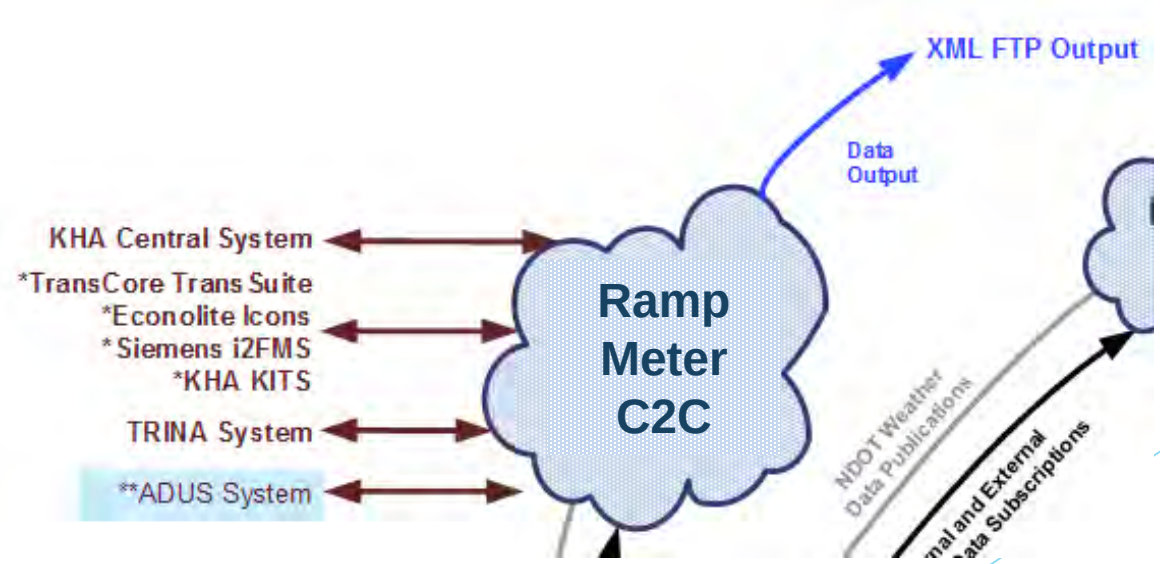
- Central System is used to post to all HAR locations
- CSS uses the MH Corbin API to post HAR messages
- CSS publishes the HAR message (text) into the NDEX



What is the NDEX?

Ramp Meters

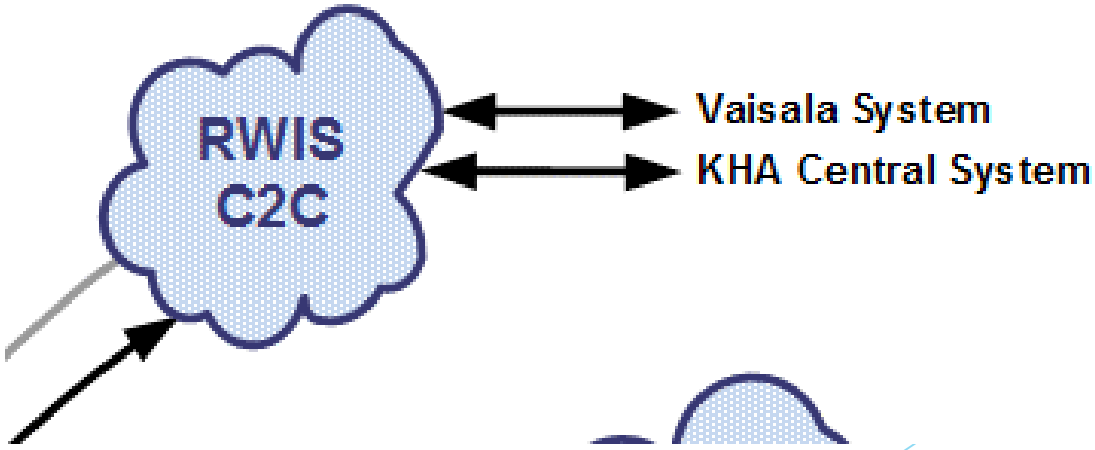
- Central System is used to poll all Ramp Meters
- CSS publishes the Ramp Meter info into the NDEX



What is the NDEX?

NDOT RWIS Weather Stations

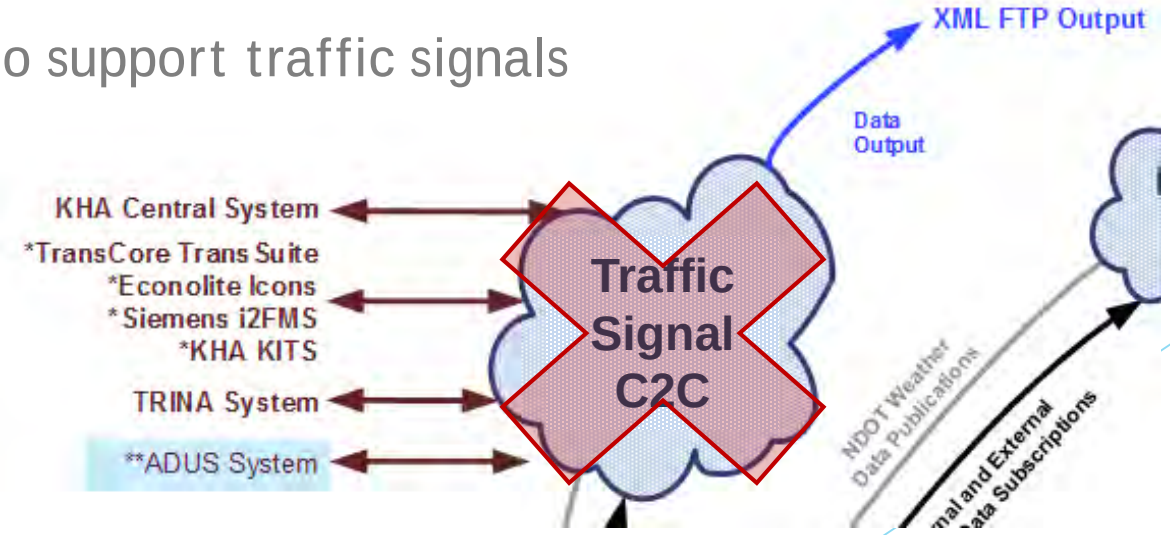
- Central System is used to poll all NDOT RWIS stations
- Central System publishes the RWIS info to the NDEX



What is the NDEX?

Traffic Signals

- NDOT's instance of Central System does not support traffic signals (A traffic signals module exists)
- An upgrade to the NDEX is scheduled to happen in FY016 to support traffic signals



How does the NDEX work?

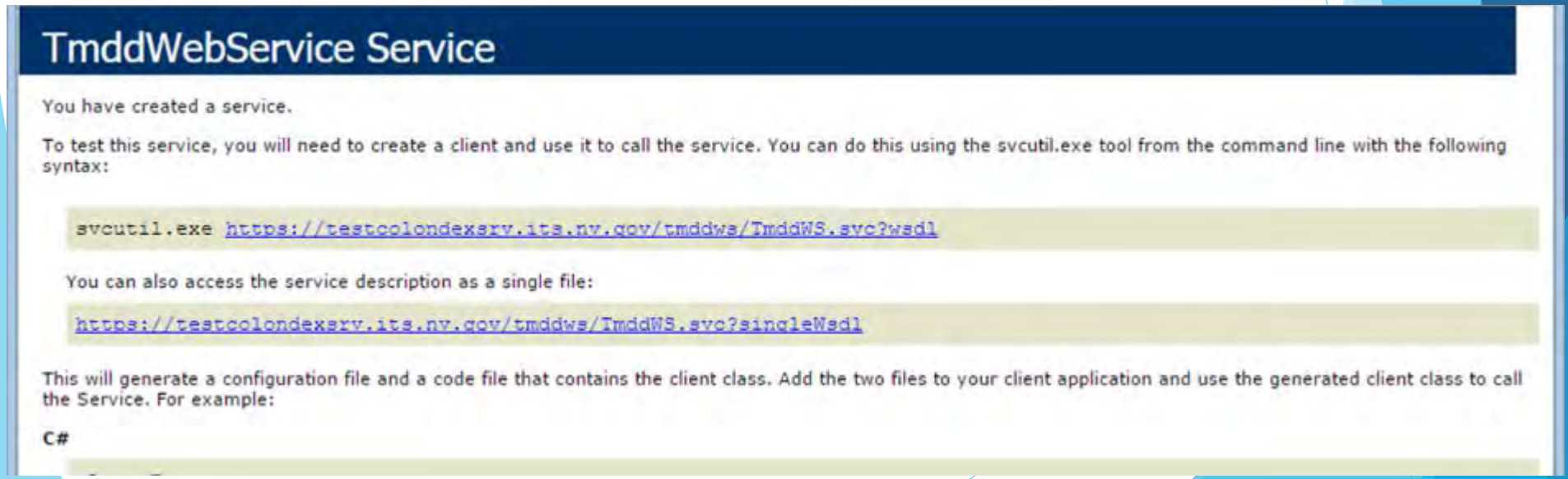
A simple description of how the NDEX is setup and works

Web Services Description Language

How does the NDEX work?

Web Services Description Language (WSDL)

- A language for describing web services and how to access those services electronically
- The Test and Productions NDEX have WSDLs



TmddWebService Service

You have created a service.

To test this service, you will need to create a client and use it to call the service. You can do this using the svcutil.exe tool from the command line with the following syntax:

```
svcutil.exe https://testcolondexsrv.its.nv.gov/tmddws/TmddWS.svc?wsdl
```

You can also access the service description as a single file:

```
https://testcolondexsrv.its.nv.gov/tmddws/TmddWS.svc?singleWsdl
```

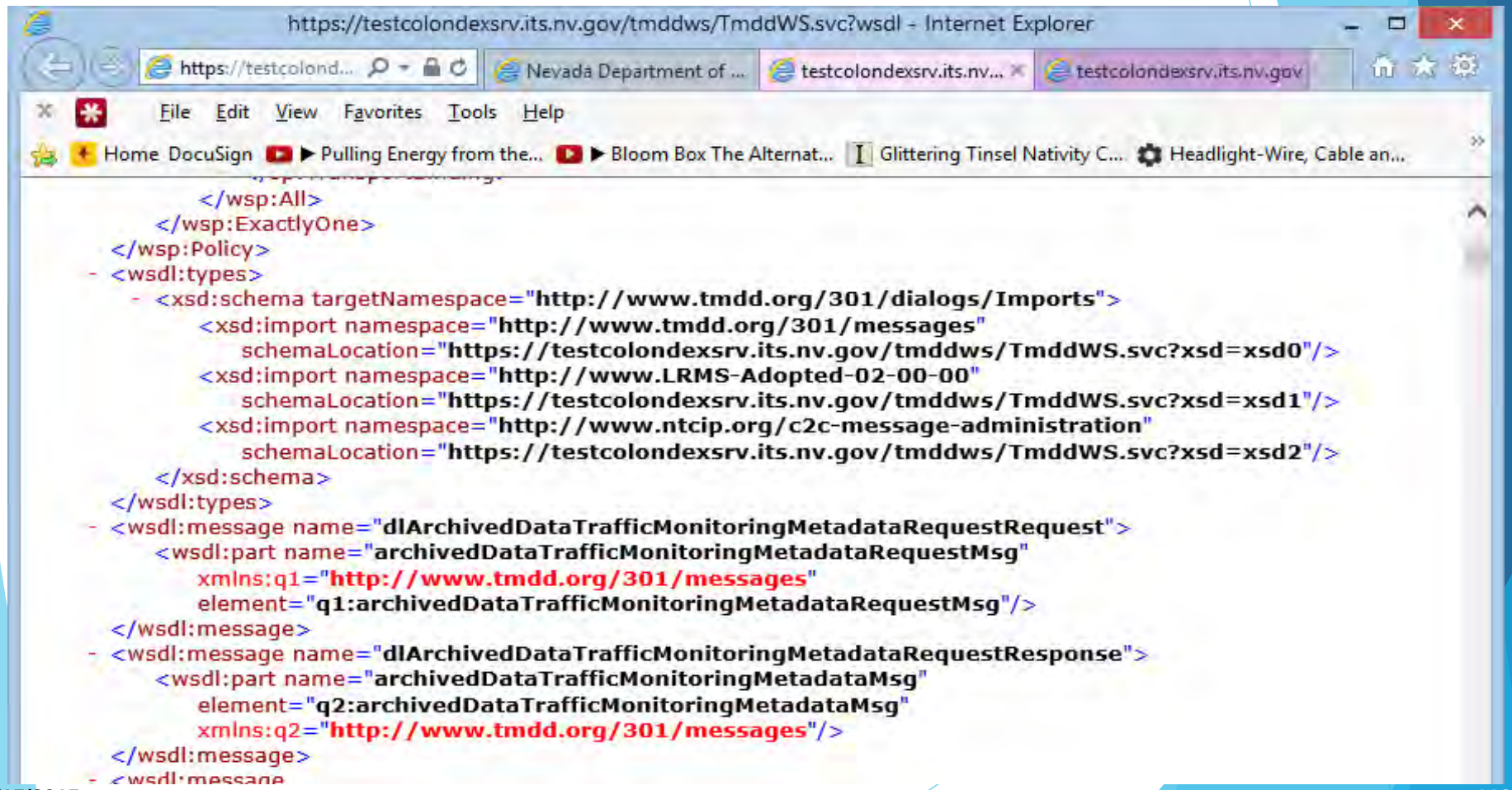
This will generate a configuration file and a code file that contains the client class. Add the two files to your client application and use the generated client class to call the Service. For example:

C#

Reference: http://testcoloNDEXsrv.its.nv.gov/tmddws/TmddWS.svc or https://coloNDEXsrv.its.nv.gov/tmddws/TmddWS.svc

How does the NDEX work?

Web Services Description Language (WSDL)



Reference: https://testcolondexsrv.its.nv.gov/tmddws/TmddWS.svc?wsdl or https://testcolondexsrv.its.nv.gov/tmddws/TmddWS.svc?singleWsdl

How does the NDEX work?

Web Services Description Language (WSDL)

- As you subscribe to this WSDL, the external center provides a location on where you want to send the subscription updates
- Web services and databases are virtually invisible to most people
- This is the case for the NDEX

How does the NDEX work?

Web Services Description Language (WSDL)

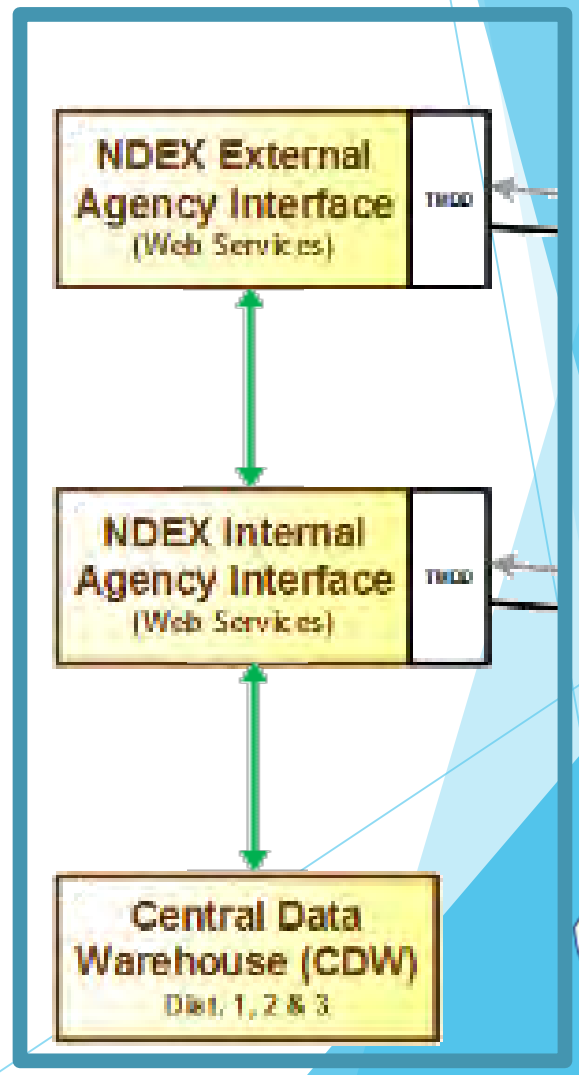
- When you bank you never think “Wow, that database server and those web services are rock 'in”
- The applications front end gets the credit
- Web services and databases are back end but nothing works if they don’t

Reference: http://testcoloNDEXsrv.its.nv.gov/tmddws/TmddWS.svc or https://coloNDEXsrv.its.nv.gov/tmddws/TmddWS.svc

IDEX and EDEX Web Services Architecture

How does the NDEX work?

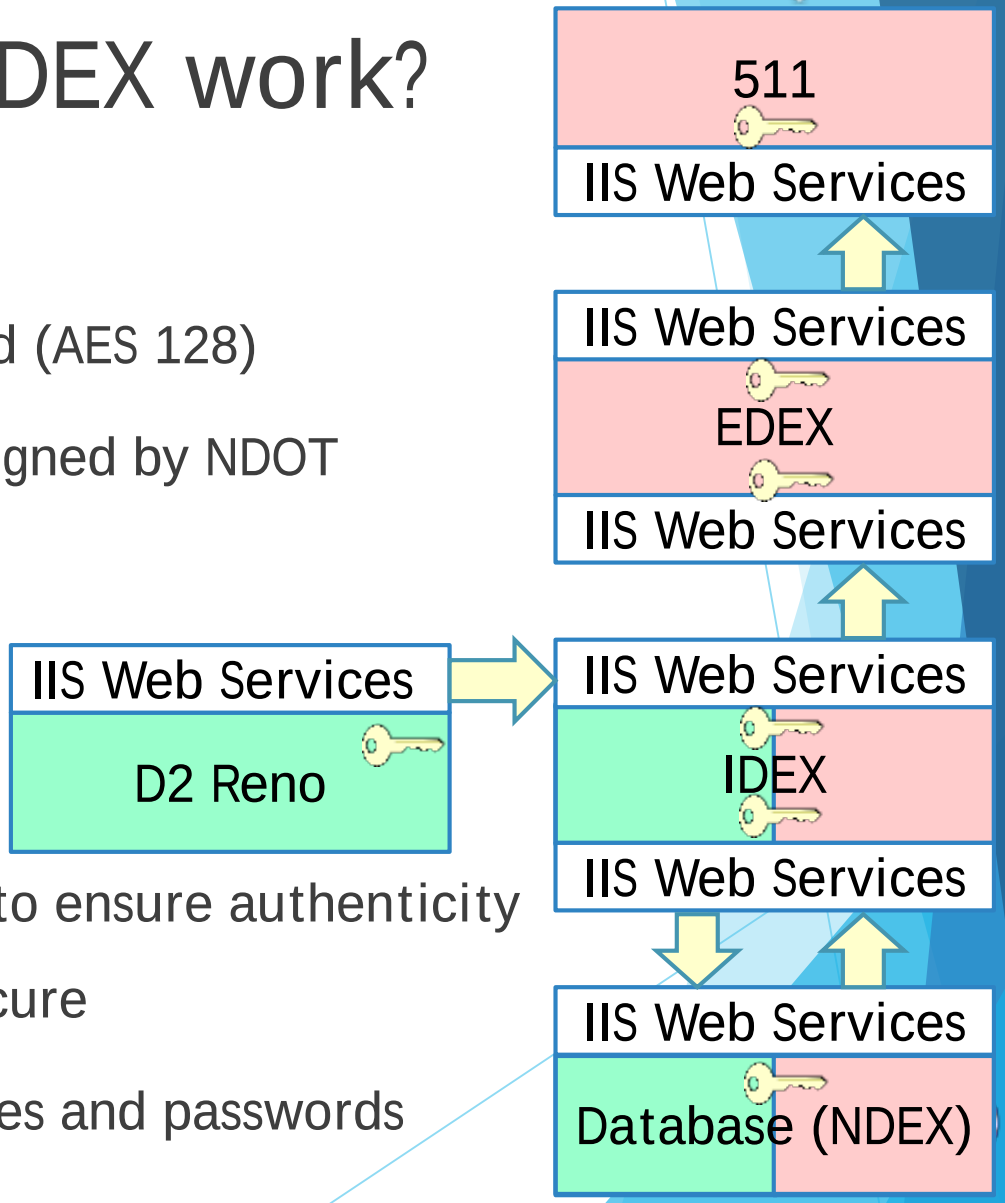
- The NDEX has two interfaces
- The External Data Exchange (EDEX)
- The Internal Data Exchange (IDEX)
- The EDEX is for **external** interfaces
- The IDEX is for **internal** interfaces
- The EDEX is located in the DMZ
- The IDEX is located on the LAN
- This addresses two specific needs
- This whole system is the NDEX



How does the NDEX work?

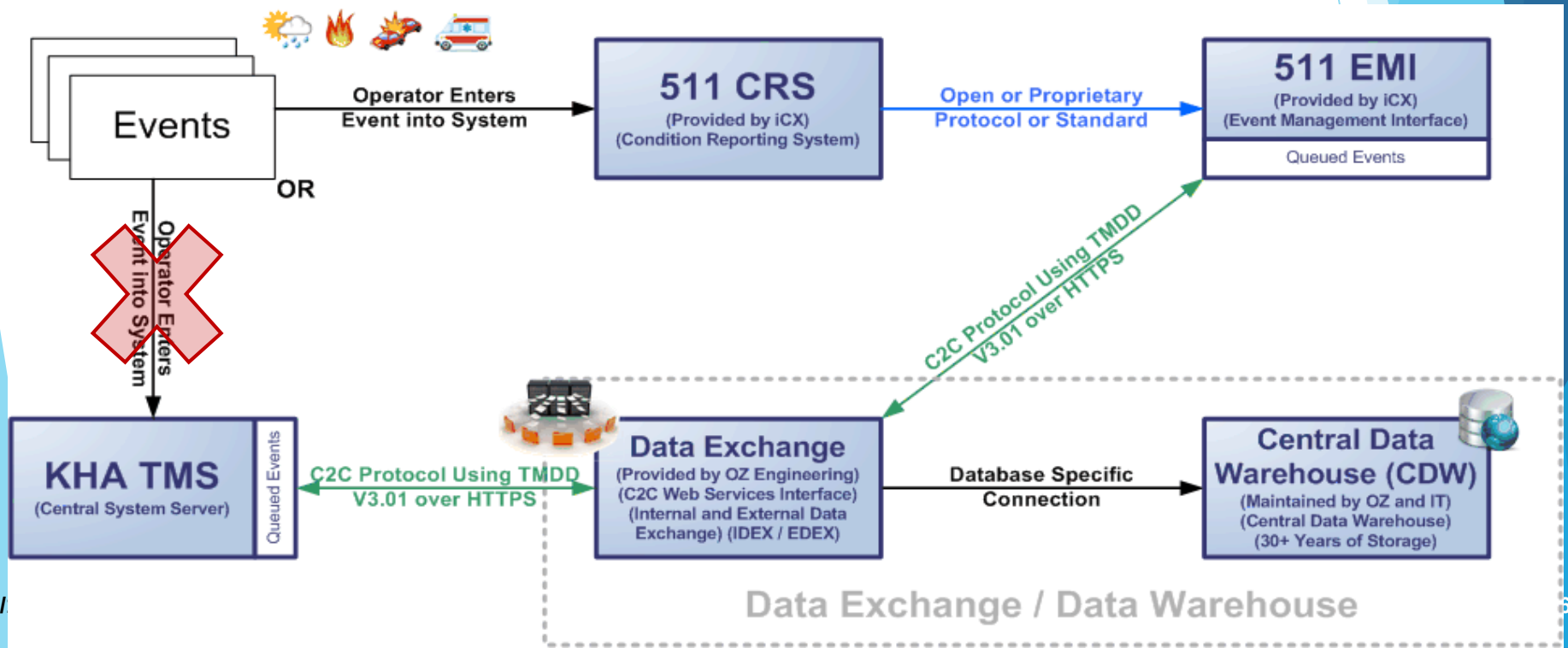
Three Tier Security Architecture

- X.509 certificates are used (AES 128)
- The certificates are self signed by NDOT
- X.509 certificates co terminate at the same time
- The certificates are used to ensure authenticity of the data source and secure
- This also secures usernames and passwords



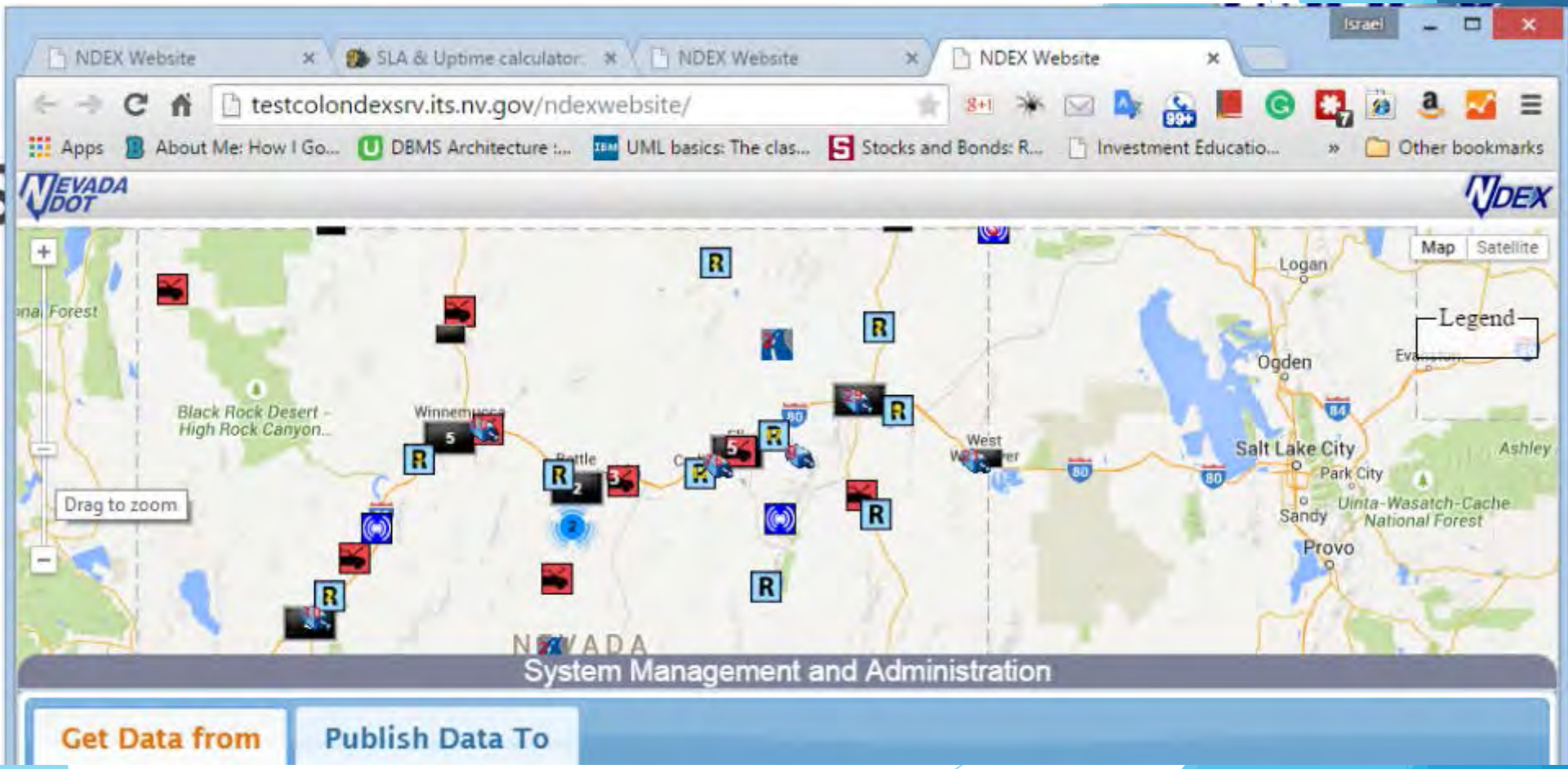
How does the NDEX work?

- Another Example – 511 Events
- CSS does not publish or subscribe to Events on the NDEX
- The NDEX supports events



How does the NDEX work?

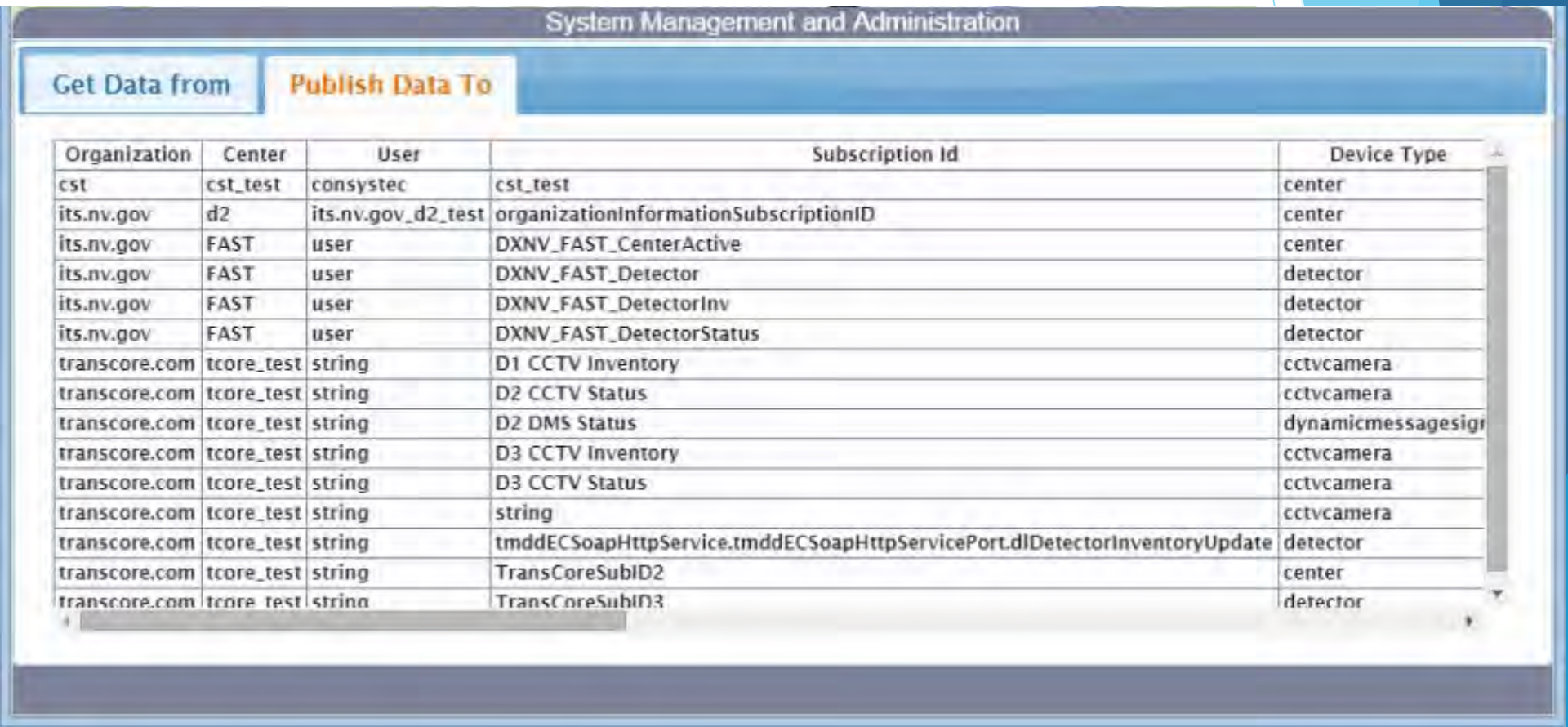
- NDEX Website to verify content is publishing



Reference: http://testcolondexsrv.its.nv.gov/ndexwebsite/ or http://colondexsrv.its.nv.gov/ndexwebsite/

How does the NDEX work?

- NDEX Website to verify content is publishing



Organization	Center	User	Subscription Id	Device Type
cst	cst_test	consystec	cst_test	center
its.nv.gov	d2	its.nv.gov_d2_test	organizationInformationSubscriptionID	center
its.nv.gov	FAST	user	DXNV_FAST_CenterActive	center
its.nv.gov	FAST	user	DXNV_FAST_Detector	detector
its.nv.gov	FAST	user	DXNV_FAST_DetectorInv	detector
its.nv.gov	FAST	user	DXNV_FAST_DetectorStatus	detector
transcore.com	tcore_test	string	D1 CCTV Inventory	cctvcamera
transcore.com	tcore_test	string	D2 CCTV Status	cctvcamera
transcore.com	tcore_test	string	D2 DMS Status	dynamicmessagesigr
transcore.com	tcore_test	string	D3 CCTV Inventory	cctvcamera
transcore.com	tcore_test	string	D3 CCTV Status	cctvcamera
transcore.com	tcore_test	string	string	cctvcamera
transcore.com	tcore_test	string	tmddECSoapHttpService.tmddECSoapHttpServicePort.dlDetectorInventoryUpdate	detector
transcore.com	tcore_test	string	TransCoreSubID2	center
transcore.com	tcore_test	string	TransCoreSubID3	detector

Reference: http://testcolondexsrv.its.nv.gov/ndexwebsite/ or http://colondexsrv.its.nv.gov/ndexwebsite/

Data Visualization Module – An upgrade to the NDEX

A simple description of how the data visualization module will be important

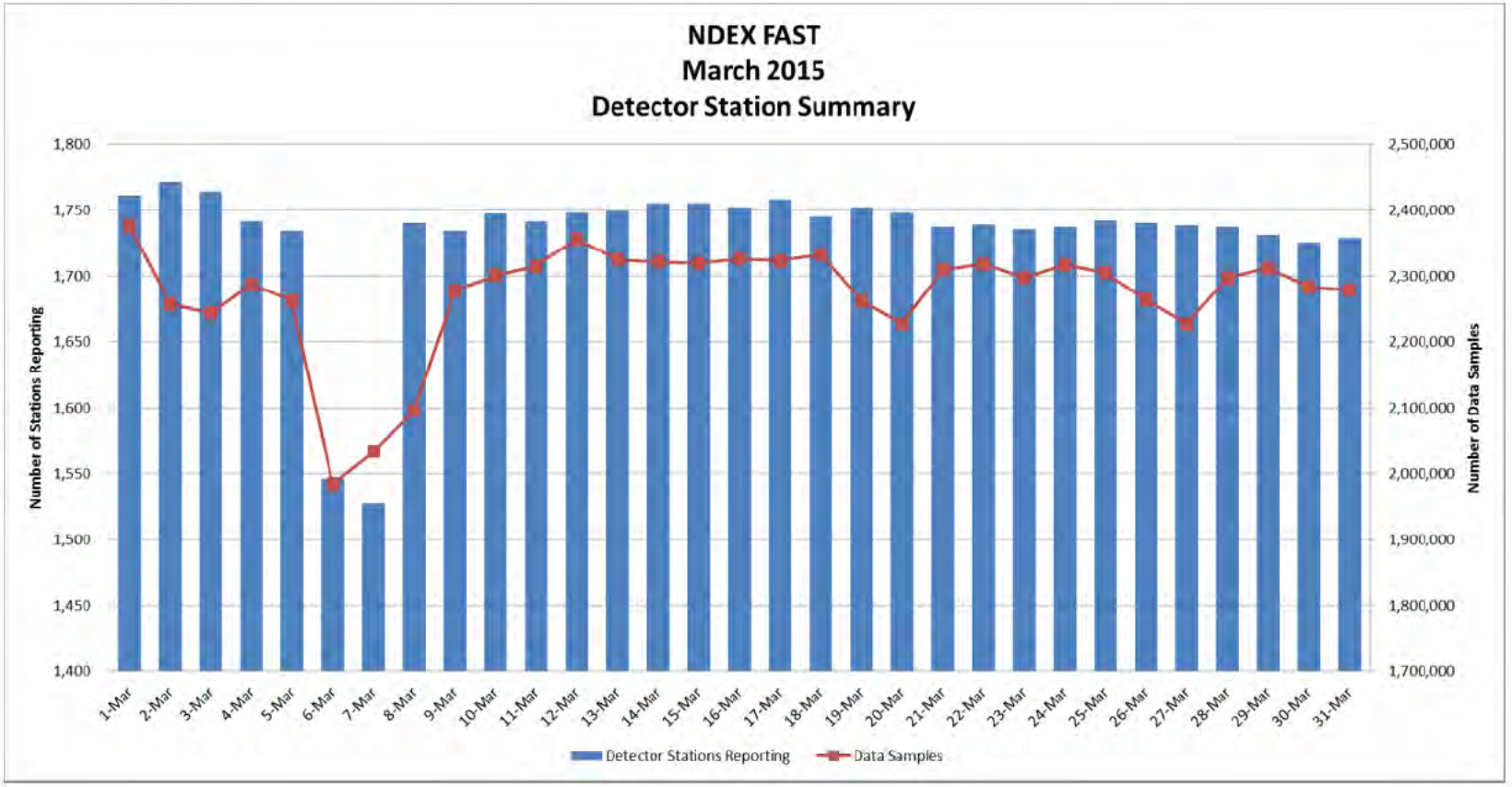
Data Visualization Module

- A data visualization module is due to be released at the end of June 2015
- The module will allow creating on the fly dashboards for most recent reported data and archived data over a period
- This project is still being implemented at the time of developing this presentation
- A few examples are provided (next slide)

Data Visualization Module

Detector Station Summary

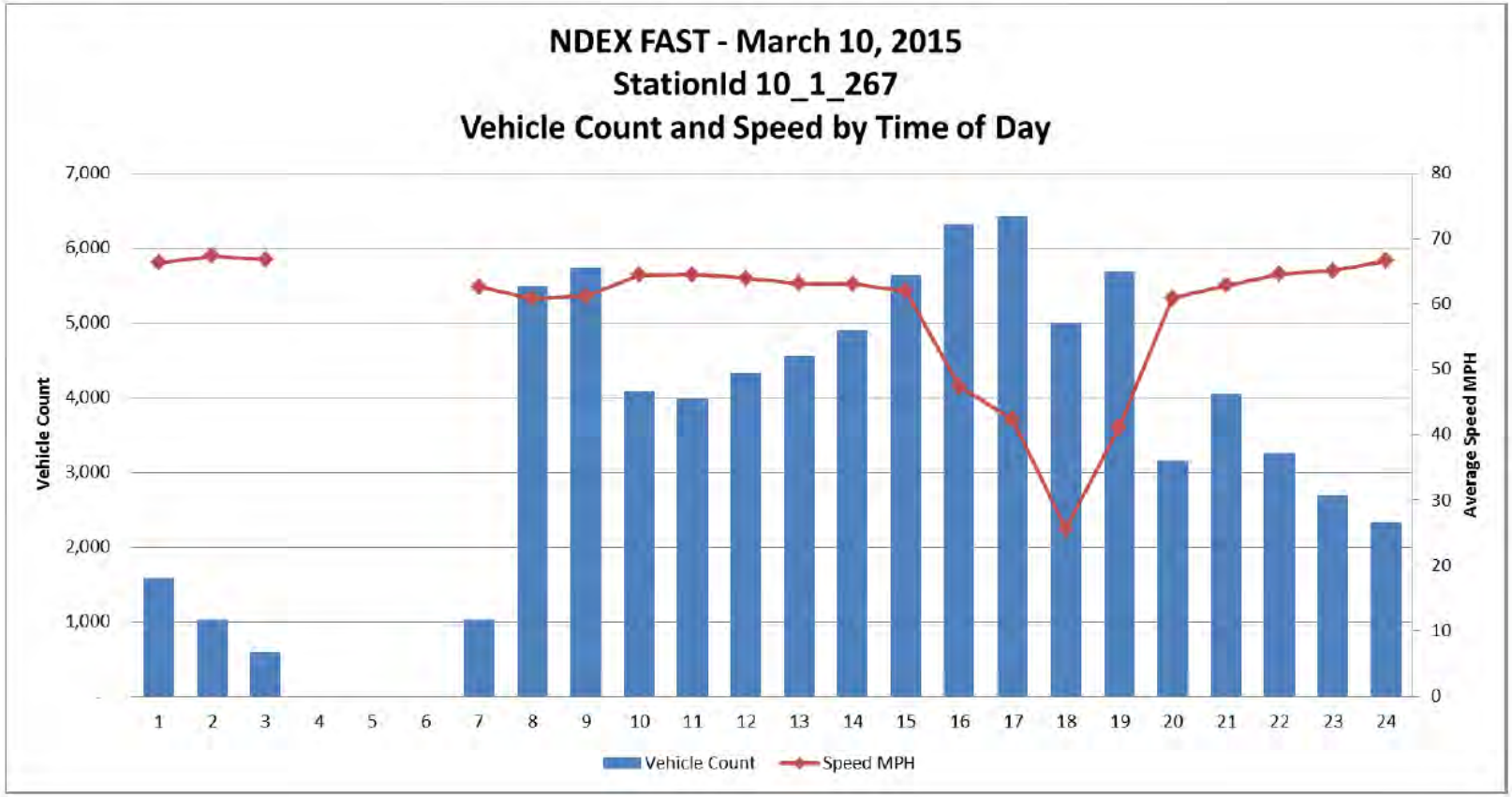
This chart indicates the total number of FAST detector stations reporting per day during the month of March 2015 (left axis). The right axis provides the number of data samples received per day.



Data Visualization Module

Vehicle Count and Speed

The vehicle count (left axis) and average speed (right axis) are shown for a specific detector station in the following chart.



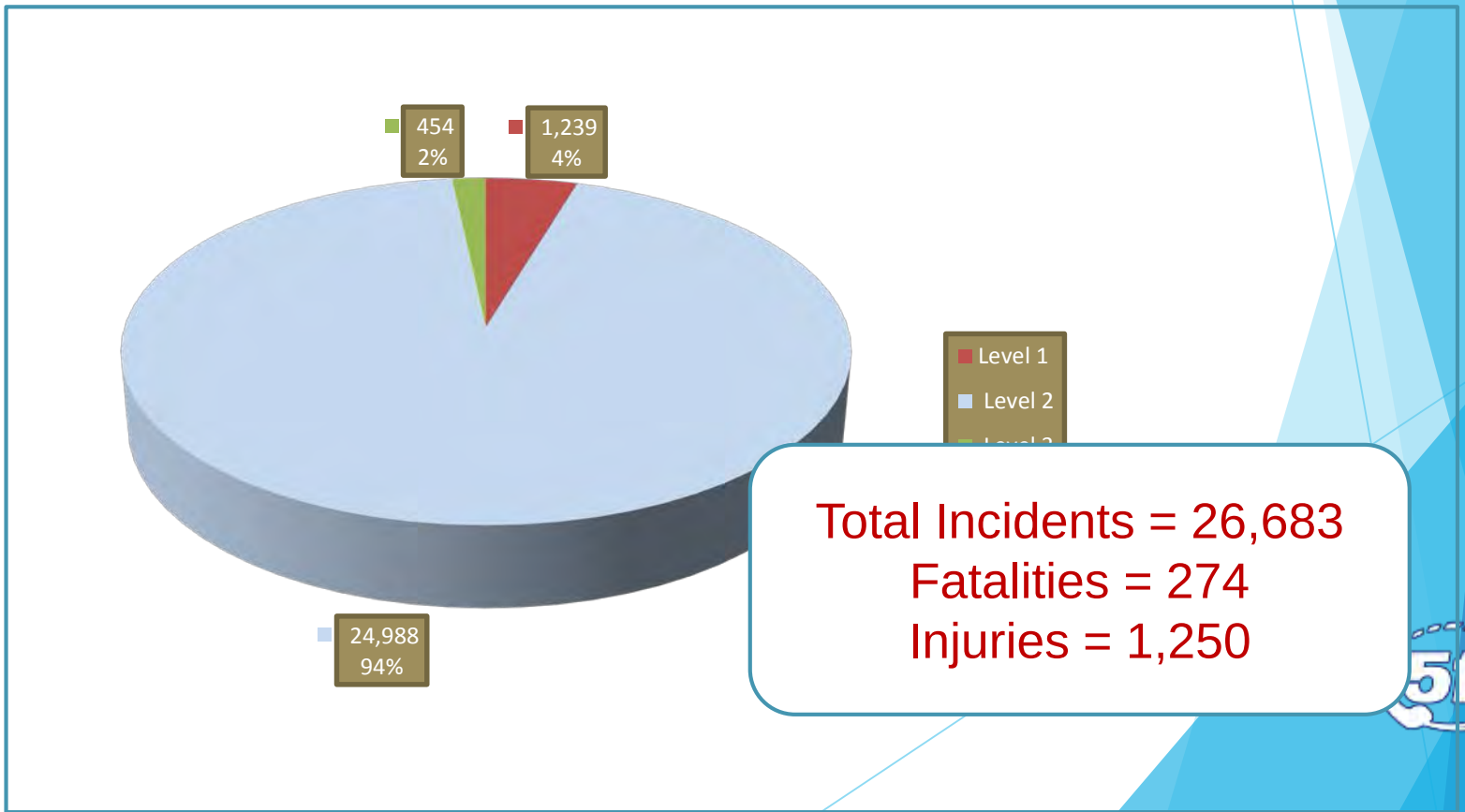
Data Visualization Module

ADOT - 2012/2011 Travel Times
Inbound AM Traffic

Corridor	length	Free Flow mins	2012 mins	2011 mins	% Change
Black Canyon SB	11.6	12.7	14.0	14.0	0.0%
Maricopa WB	16.1	15.7	20.0	19.9	1.0%
Piestewa SB	12.1	13.2	14.0	13.7	2.0%
Pima EB	13.6	12.6	15.0	15.5	-3.0%
Pima NB	15.7	14.5	16.6	16.2	2.0%
Price NB	9.0	8.3	10.5	10.2	3.0%
Red Mountain WB	9.1	8.4	10.4	10.2	2.0%
Superstition WB	20.5	19.1	20.6	20.7	0.0%
Papago EB	11.5	10.7	11.4	10.9	5.0%

Data Visualization Module

ADOT - 2012
Incidents/Accidents



Data Visualization Module

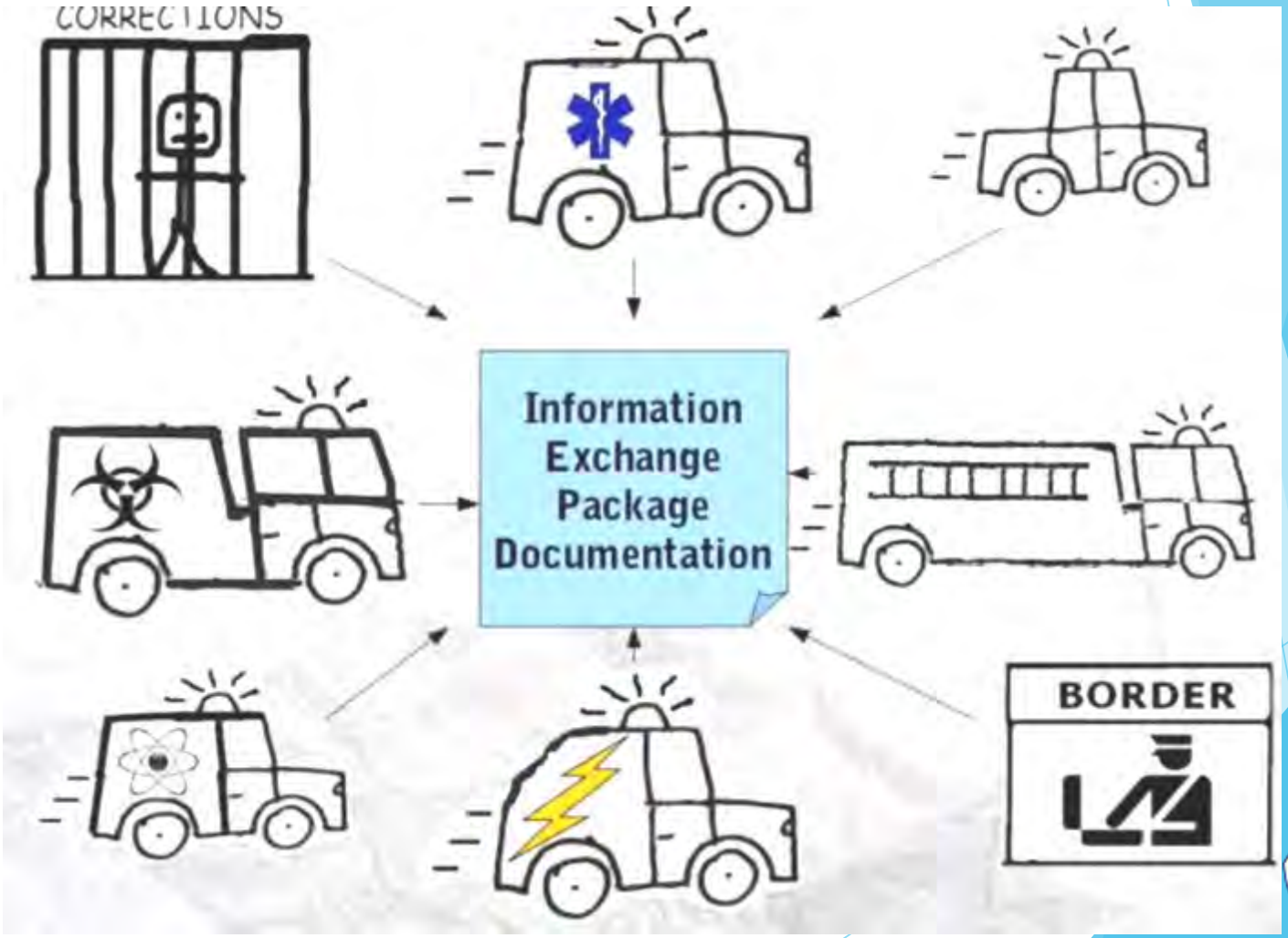
ADOT - 2012 Incidents by Highway

Highway	Total Incidents	% Statewide	In Phoenix	% Phoenix
I-10	6,804	25%	3,020	24%
I-17	3,334	12%	1,617	13%
US-60	2,751	10%	1,508	12%
I-40	1,405	5%		
L-202 Red Mountain Freeway East West	1,376	5%	1,376	11%
L-101 Pima Freeway North South	1,039	4%	1,039	8%
L-101 Price Freeway	1,001	4%	1,001	8%
SR-51	892	3%	892	7%
L-101 Pima Freeway East West	866	3%	866	7%
L-101 Agua Fria Freeway North South	657	2%	657	5%
SR-87	543	2%	76	1%
L-202 Santan Freeway East West	520	2%	520	4%
I-19	491	2		
SR-260	396	1%		
I-8	355	1%		

15 worst highways

Other Protocols for Sharing Data

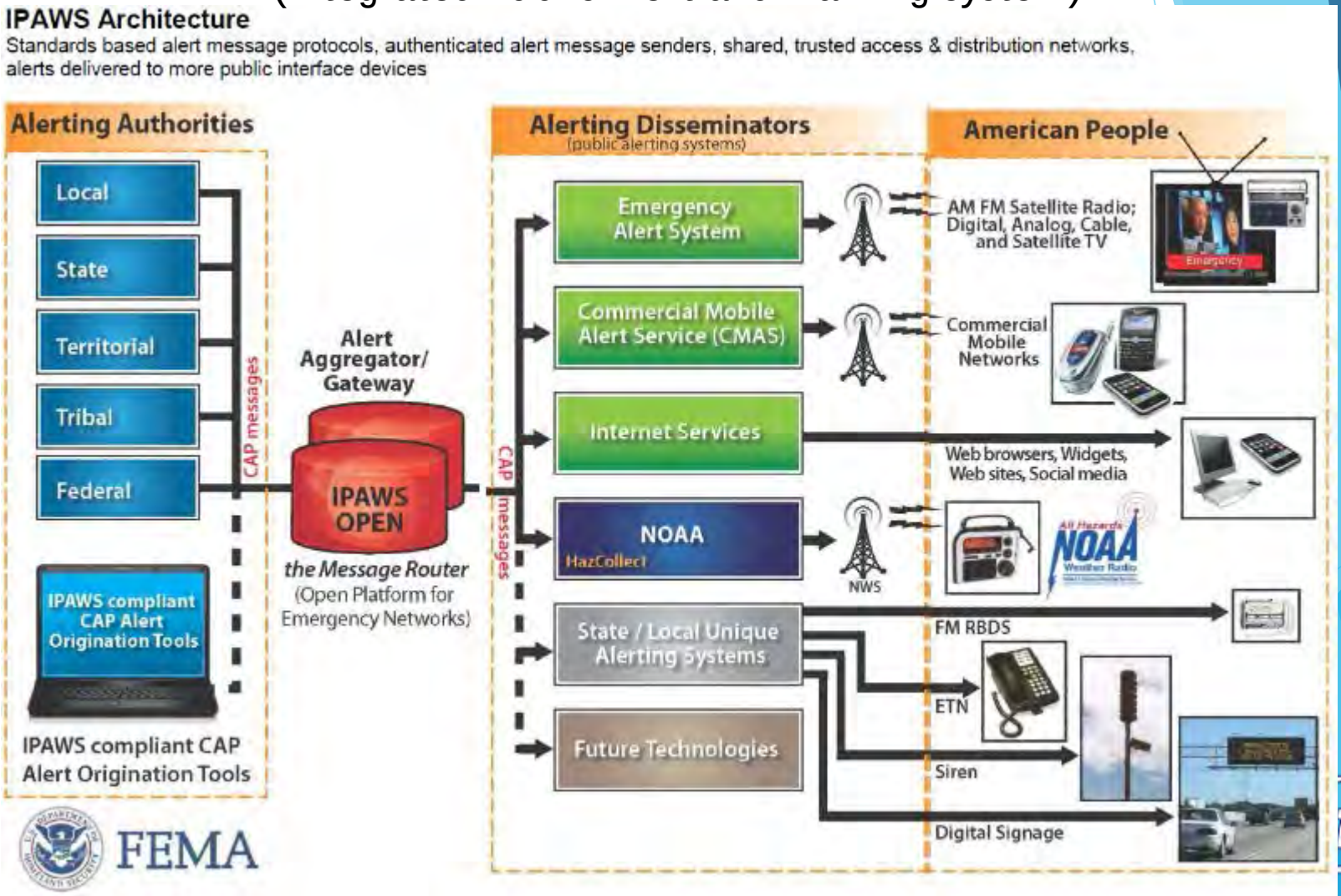
National Information Exchange Model (NIEM) Video



Reference: https://www.niem.gov/news/Pages/niem-simplified.aspx

FEMA Common Altering Protocol (CAP)

(Integrated Public Alert and Warning System)



Reference: https://www.youtube.com/watch?v=HAzRjEeqKhI

Lets re-cap!

The bad!

Let’s recap!

The bad!

- Third party validation of TMDD was an after thought
  - The Prime Contractor was running the validation on the Sub Contractor
- According TMDD version 3.01 there are no beacons on any HAR
- According TMDD v3.01 you can only have a message with 1024 characters

Let's recap!

The bad

- There is no provision to run C2C control request commands through the NDEX
- Some requirements are ambiguous and can been seen from a few different stand points
  - Have a very skilled Subject Matter Expert (SME) on staff to identify what the intent of the dialog at the time of developing the standard

Let’s recap!

The bad

- The RWIS data is encoded into a string and a decoder is needed
- Development took two times longer than anticipated
  - The NDOT Traffic Operations – Technology Section was responsible for the NDEX and TransCore development
  - NDOT Traffic Operations – ITS Section was responsible for CSS development

Let's recap!

The bad

- Development took two times longer than anticipated
  - NDOT Traffic Operations – Operations Section was responsible for 511 development
- Agreements for development of systems such as CSS and 511 took between six and nine months to complete before development could take place

The Benefits!

Let’s recap!

Benefits

- ITS management platforms are protected against unnecessary exposure to Public and NDOT partners
- This allows developers to focus on improvements of the system versus writing several different interfaces for many different data sharing uses
- The system can restrict information based on authentication

Let's recap!

Benefits

- Supports Connection Management, Authentication, and Restriction (security) requirements
- Supports bi-directional sharing of Roadway Network, Links and Route Status inventory, history, and status
- Allows bi-directional sharing of CCTV, DMS, and Vehicle Detection inventory, history, and status

Let's recap!

Benefits

- Allows bi-directional sharing of Events, Event History, and Event Status Information
- Allows bi-directional sharing of Weather Stations, other Environmental Sensors, and Highway Advisory Radio (HAR) Inventory, History, and Status
- Critical: Bi-directional sharing of Roadway Event and Route Status Information

Let's recap!

Benefits

- The system can be scaled as needed to match funding levels and more users (states, counties, or cities)
- All ITS related databases will be integrated into the data warehouse (e.g. ADUS, TRINA, GIS, etc.) in the future
- An extensive dashboard will have the ability to provide key stakeholders with the information they need to make key decisions at key times

Any Questions?

+ plus some additional information

TMDD Examples

- AZTech – Arizona and Maricopa County DOT (TMDD Version 2.1):
- RADS Website: http://www.aztechrads.org/monitor/monit.jsp
- Phoenix Fire : http://www.aztechrads.org/monitor/rob.jsp?logId=PhxFireEMS
- RCRS Retriever: http://www.aztechrads.org/monitor/rob.jsp?logId=RCRSLiteRetriever
- Arterial Travel Time: http://www.aztechrads.org/monitor/rob.jsp?logId=chandleraz.gov_bluetoothSegs