Common Support Services
Information Management

Kajal Claypool

11 December 2012
Outline

- Motivation
- CSS-Wx Deep Dive
- Summary & Future Steps
Interactions between FAA Facilities and Airlines for Newark Congestion Problems

Evans, J. Ducot, E., "Corridor Integrated Weather System, Lincoln Laboratory Journal, Volume 16, Number 1, 2006
Next Generation Air Transportation System
Operational Concept
Information Management Session

- Common Support Services – Weather
  - Kajal Claypool, MIT LL

- System-Wide Information Management National Airspace: System Enterprise Messaging Service
  - Stephen Link, Harris

- Corridor Integrated Weather System Data Distribution Service
  - Carol Kelly, MIT LL

- Aviation Safety Information Analysis and Sharing
  - Alex Alshtein, MITRE
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Weather Along A Route

- CSS-Wx targeted for providing flight plan specific weather data
- Data will be filtered by:
  - Route, Time and Wx parameters requested by user

![Diagram showing weather data along a route with various weather conditions and time frames](image)

- Thunderstorms, Lightning, Crosswinds, Wind Shear, Freezing/Frozen Precipitation, Low Ceiling & Visibility, Surface Icing
- Thunderstorms, Jet Stream, Volcanic Ash, Turbulence, In-Flight Icing, Winds, Mountain Waves
- Thunderstorms, Lightning, Crosswinds, Wind Shear, Freezing/Frozen Precipitation, Low Ceiling & Visibility, Surface Icing

**Post-flight observed weather archives**
CSS-Wx Objectives

JPDO ConOps and Requirements Documents

Functional Requirements
- Common operational weather picture
- Support observation, forecast and archived weather data
- Single authoritative source for weather
- Weather content delivery network

Non-Functional Requirements
- Scalable
- Secure
- Agile
- Reliable
- Affordable
Key Technology Thrusts

Standardization & Interoperability

Data Standards

Data Access Standards

Open Geospatial Consortium
Web Feature Service/ Web Coverage Service

Performance

Dissemination Architecture

Semantic Technologies

Quality of Service
Data and Service Standards

Standardization is key to Interoperability

Corridor Integrated Weather System

Traffic Flow Mgmt System

Community/National Standards Bodies

Tier 2 International Standards Bodies (~2-4 year adoption time constant)

Tier 1 International Standards Bodies (~3-6 year adoption time constant)

JPDO (FAA/NWS/DoD)

OFCM (FAA/NWS/DoD)

Open Geospatial Consortium

Other Agencies (International)

ISO

WMO/ICAO

W3C

No standards – custom point to point integration

Diverse Interfaces & Models based on common standards, can be transformed/mapped.

Separate Interfaces But Common Data Model

Plug ‘n’ play Interoperability

Common Model + Interfaces

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W3C
• WXXM Ad-Hoc Working Group Membership: Eurocontrol, FAA, NWS, DoD, NOAA, British Atmospheric Data Center

• Composable, extensible data model balances standardization with the need for individual communities to innovate
• WXXM builds upon many concepts (e.g., ‘Core + extensions model’) gleaned from Standards Community participation
Adoption of WXXM

Luciad Demonstration OGC/OWS 8

Use of WXXM to provide Volcanic Ash and Turbulence SIGMETs at OGC/OWS 8

CIWS Data Distribution Service (CDDS)

Use of WXXM to provide CIWS Weather Products for Operational Use to Internal/External FAA Users
Air Transportation Exchange Models

- WXXM (weather)
- AIXM (aero)
- **XM (enviro)
- **XM (flight)
- **XM (surface)
- **XM (etc.)

Common Concepts
CSS-Wx Message Exchange Patterns

Message Exchange Pattern: Request/Response

5.1.3.3 Retrieve icing forecast product for Colorado
Retrieve (via pull mechanism) icing potential forecast product for the geometry of Colorado for 2007-10-12 12:00Z (future time, 12 hours from the time the request is made), from 5000 ft to 35000 ft

1) Request icing product in the Colorado area
2) Response: icing data

Message Exchange Pattern: Notification

5.1.3.8 Subscribe to volcanic ash alerts for a specified flight path
Retrieve (via pull mechanism) icing potential forecast product for the geometry of Colorado for 2007-10-12 12:00Z (future time, 12 hours from the time the request is made), from 5000 ft to 35000 ft

1) Subscribe for notifications of new volcanic ash alerts
2) Notify: volcanic ash alert A arrived
3) Request: volcanic ash alert A
4) Notify: volcanic ash alert B arrives
5) Request: volcanic ash alert B
6) New (matching) volcanic ash alert A arrives
7) New (matching) volcanic ash alert B arrives

Message Exchange Pattern: Persistent Query

5.1.3.9 Monitor hazard in the terminal approach airway
A TRACON air-traffic controller needs to monitor adverse weather conditions that exist, or are forecasted to exist, within the approach airway. The approach airway is defined as a volume around an airport, defined by a set of XYZ vertices, within which departing and landing flights must fly.

1) Subscribe for hazards within approach airway
2) New (matching) hazard arrives
3) Topic
4) Publish: hazard data
5) New (matching) hazard arrives
6) Publish: hazard data
7) New (matching) hazard arrives
8) New (matching) hazard arrives
9) New (matching) hazard arrives
CSS-Wx Net-Centric Service Standardization

‘Conventional’ SOA design is not scalable!
• N-squared problem as more users and service providers connect
• Semantic divergence as service providers provide variations on the same theme (e.g. pub/sub)

Standards-based Information Management Architecture scales well as users and services are added
• Filtered data access interface makes it easy for users to ask for the data they need
• Producers logically decoupled from consumers

Filtered Data Access Service
getInfo(Info Type, filter):
getInfo(Flight,, "flt=AA123 and info=departureTime")
getInfo(SurfaceMgt,, "airport=LGA and info=congestion")

Data standardization provides foundation for service interface standardization
Standards Development
Open Geospatial Consortium

- OGC - Geospatial standards body
  - Data models & schemas
  - Services Reference Architecture
  - Service Standards
    *What, When, Where data access*
  - Strong coupling to ISO

- Founded in 1994. 350+ members - national, international, government, commercial
- MIT/LL, NCAR, NOAA members at Technical Committee level or higher (NOAA)

Current CSS-Wx Involvement
Web Feature Service

- Filtered access to non-gridded data formatted as XML
  - Query model is based on OGC Filter 2.0 specification, which can be (loosely) thought of as a set of spatial and temporal operators that extend the core Xpath filter specification

- Version 4.0 released July 1, 2012:
  - Enabled with 2 of the 3 message exchange patterns
  - Full Spatial and Temporal filtering
  - Request delegation to another WFSRI
  - Client request limitations
  - Self-test diagnostics following installation
  - Monitoring of performance metrics
  - XML Schema validation
  - Support for different underlying data stores
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  - Standardization & Interoperability
  - Semantic Technologies
  - Architecture & QoS

- Summary & Future Steps
Semantic Search

Registry/Repository

National Weather Service

CF
Ontology

NextGen
Weather
Ontology

Department of Defense

JMBL
Ontology

Keyword Search

Complex Query

Registry/Repository

Web service

Web service

Web service

Web service

Satellite Imagery

Radar Imagery

Future system

Satellite Imagery

Radar Imagery

air_temperature

{Air, Temperature}

TemperatureAir

Department of Defense

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Future system

Satellite Imagery

Radar Imagery

air_temperature

{Air, Temperature}

TemperatureAir
Application: Semantic Search

Term used for searching

Results returned

Semantic search turned off
Application: Semantic Search

Term used for searching

Semantic search turned on

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Quality of Service

- FAA CSS-Wx moving towards a centralized cloud architecture
  - Eliminates the Top-Tier Distribution servers
- Quality of Service a higher priority
  - Different CSS-Wx applications have different needs for
    - Timeliness and Jitter
    - Data rate
    - Data loss
- Different data-types with varying ranges of size, and rate of production and consumption

Transmit Queue

Critical Priority traffic stuck behind large number or large size of traffic of lower priorities at a constrained site (queues, or hardware interfaces, e.g.)
Potential QoS Bottlenecks Across the Different Layers

**Application Layer** - Contention for
- Middleware
- OS (CPU/memory/file IO)
- HW interfaces

**Middleware Layer** - Contention for
- Messaging Queues
- OS (CPU/memory/file IO)
- HW interfaces
- Other Services, such as Persistence, Transaction, & Security

**Network Layer** - Contention for
- Switch and Router Queues
- Bandwidth to FTI core
- Bandwidth Cost and Latency of the core network
- Other Services, e.g., Persistence, Transaction, & Security
Summary and Future Work

- Standardization efforts crucial for the success of NextGen
  - Standards tend to be vetted by broad community
  - Facilitate development and adoption of common data access and support services
  - Provide fundamental basis of situational awareness and interoperability among FAA, DoD and international partners
    - FAA Towers, TRACONs, ARTCC, ATCSCC, etc
    - Airlines, DoD and NWS
    - ICAO, Eurocontrol, SESAR partners
  - Reduce time, cost, and complexity of new data integration, for both producers and consumers

- Other ongoing efforts
  - Aeronautical Information Management, Flight object