NextGen Network-Enabled Weather Overview

AIXM/WXXM Conference

Oliver Newell, MIT Lincoln Laboratory
Aaron Braeckel, NCAR
Chris MacDermaid, NOAA/ESRL

14 May 2009

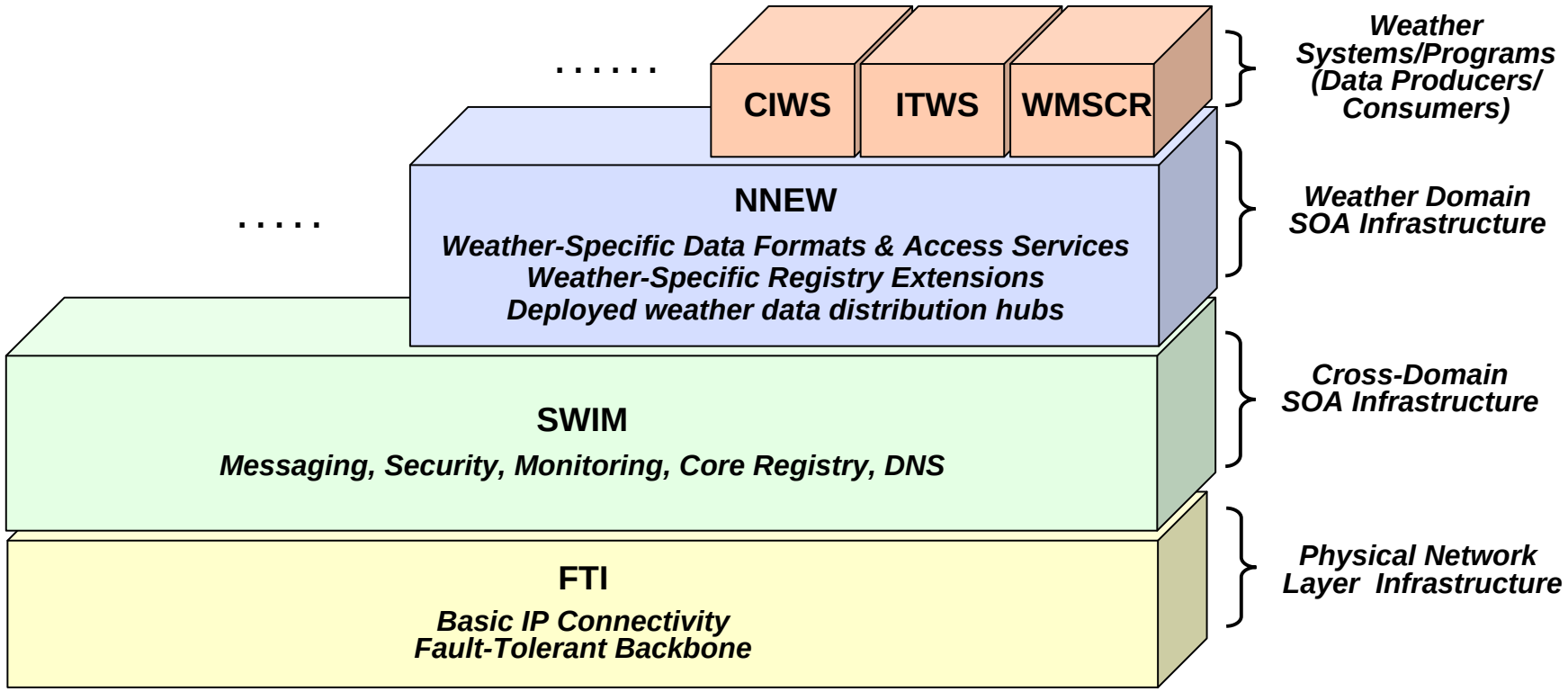
Next Generation Air Transportation System (NextGen)

Joint Planning and Development Office

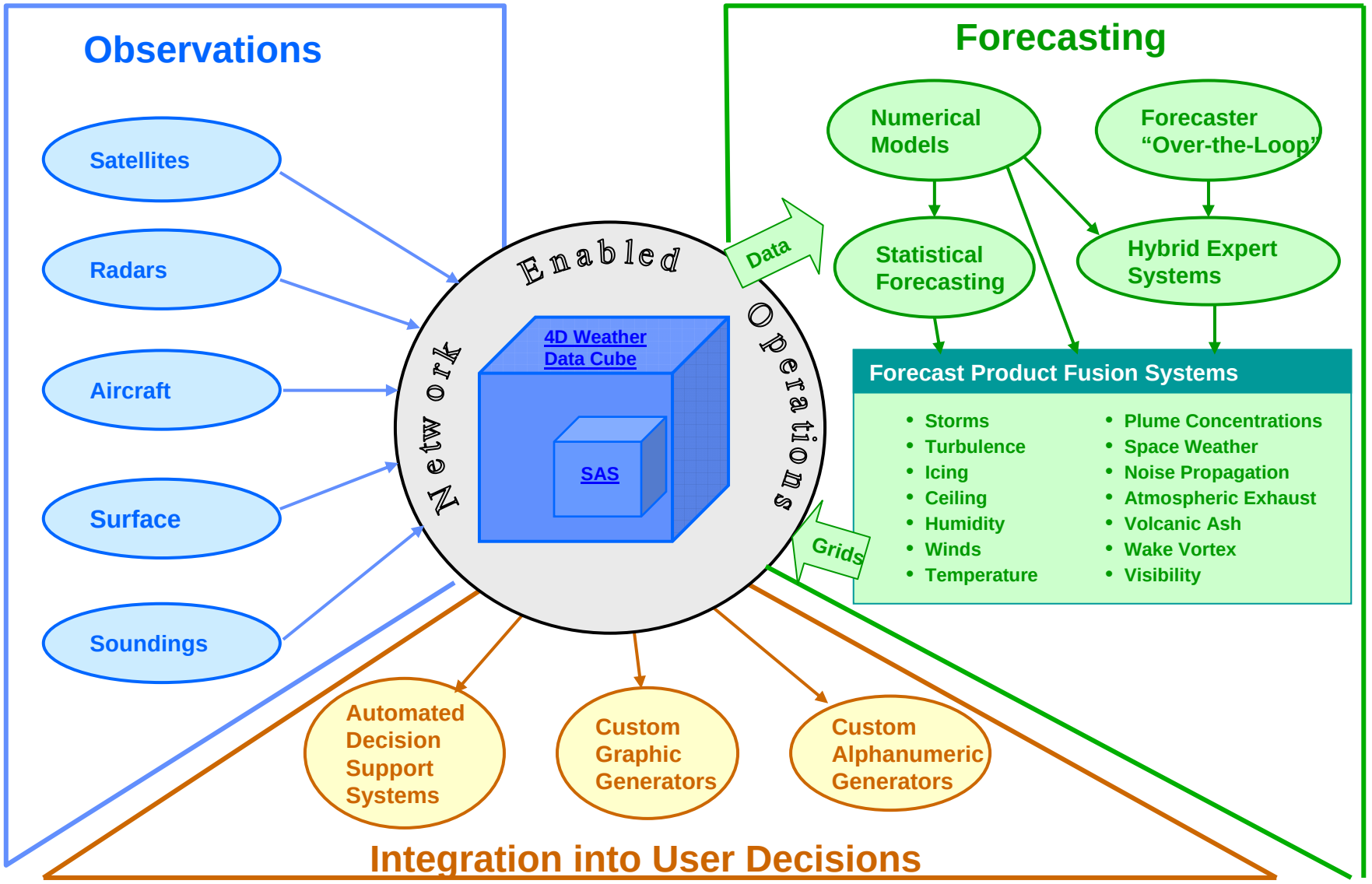
Operational Evolution Partnership

Goals	Operational Concepts	Development Programs
• Increase capacity • Maintain safety • Minimize environmental impacts • Support economic growth • Maintain U.S. leadership • Assure airspace security	• Trajectory-based operations • Performance-based operations and services • Weather-assimilated decision support • Network-enabled information access • Equivalent Visual Operations in IMC	• ADS-B • System-Wide Information Management (SWIM) • NextGen Network-Enabled Weather • NextGen Data Comm • NextGen Demonstrations

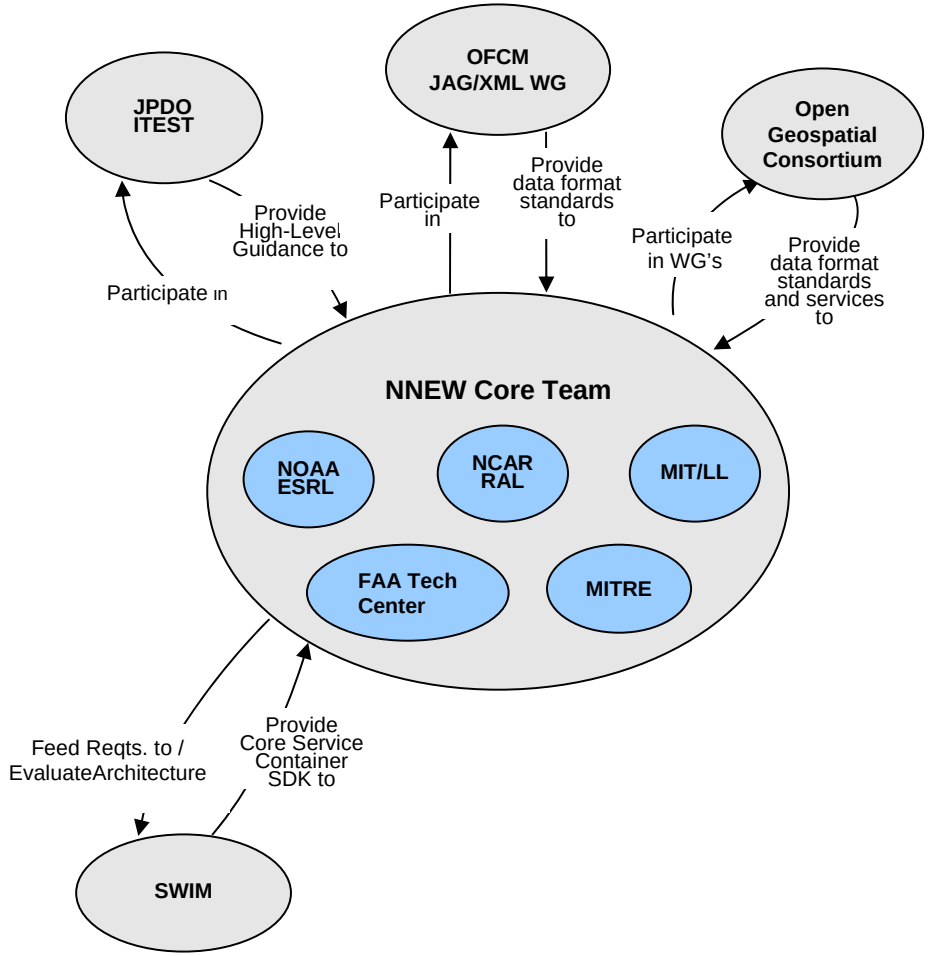
NextGen Weather Domain Programs



NextGen Network-Enabled Weather
Working Towards the '4-D Weather Data Cube'



NNEW Organizational Relationships

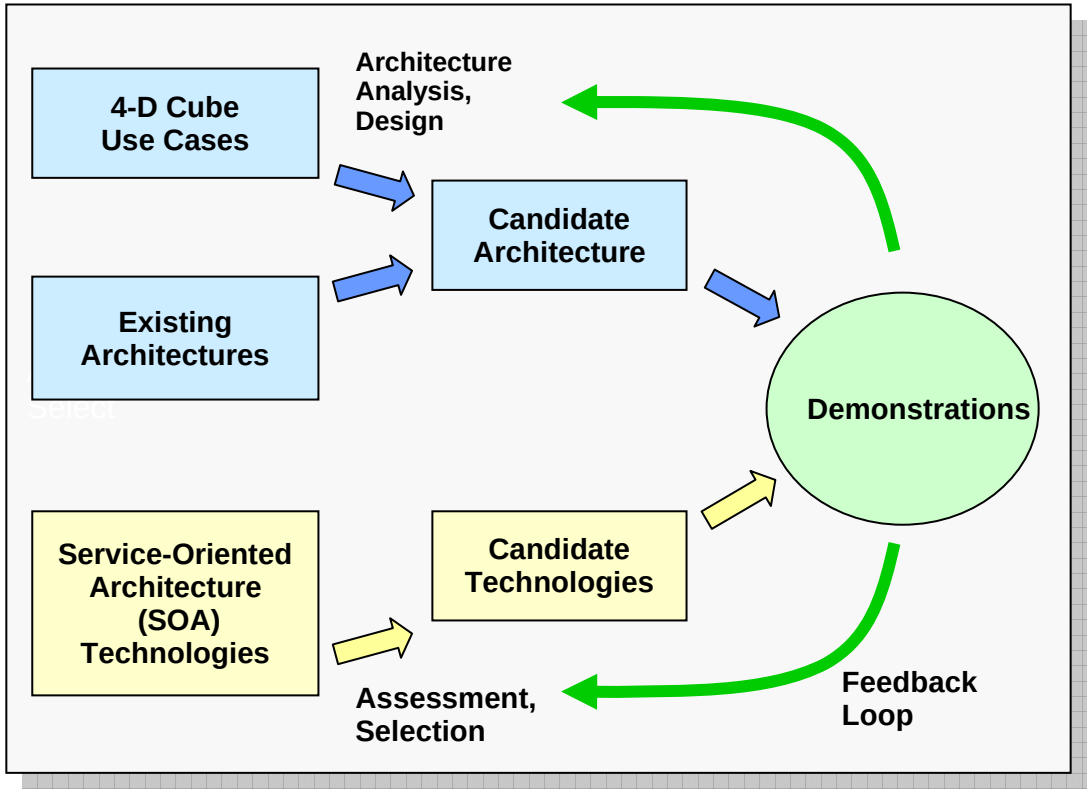


NNEW Activities, Methodology, and Timeline

Activities

- Service-Oriented Architecture (SOA) for the 4-D Weather Cube
- SOA Foundational Standards
  - Establish best practices for weather
- Standard Weather Data Formats
  - Gridded data
  - Non-gridded data
- Data Dissemination Services
  - Request data by weather product type, geographical region, time

Design Methodology
Top-Down + Bottom-Up



NNEW Segment 1 Timeline

Prototyping	Standards Development, Reference Implementations	Handoff to FAA / Industry	Initial Operating Capability
2007-2008	2009-2010	2011-2012	2013-2016

Outline

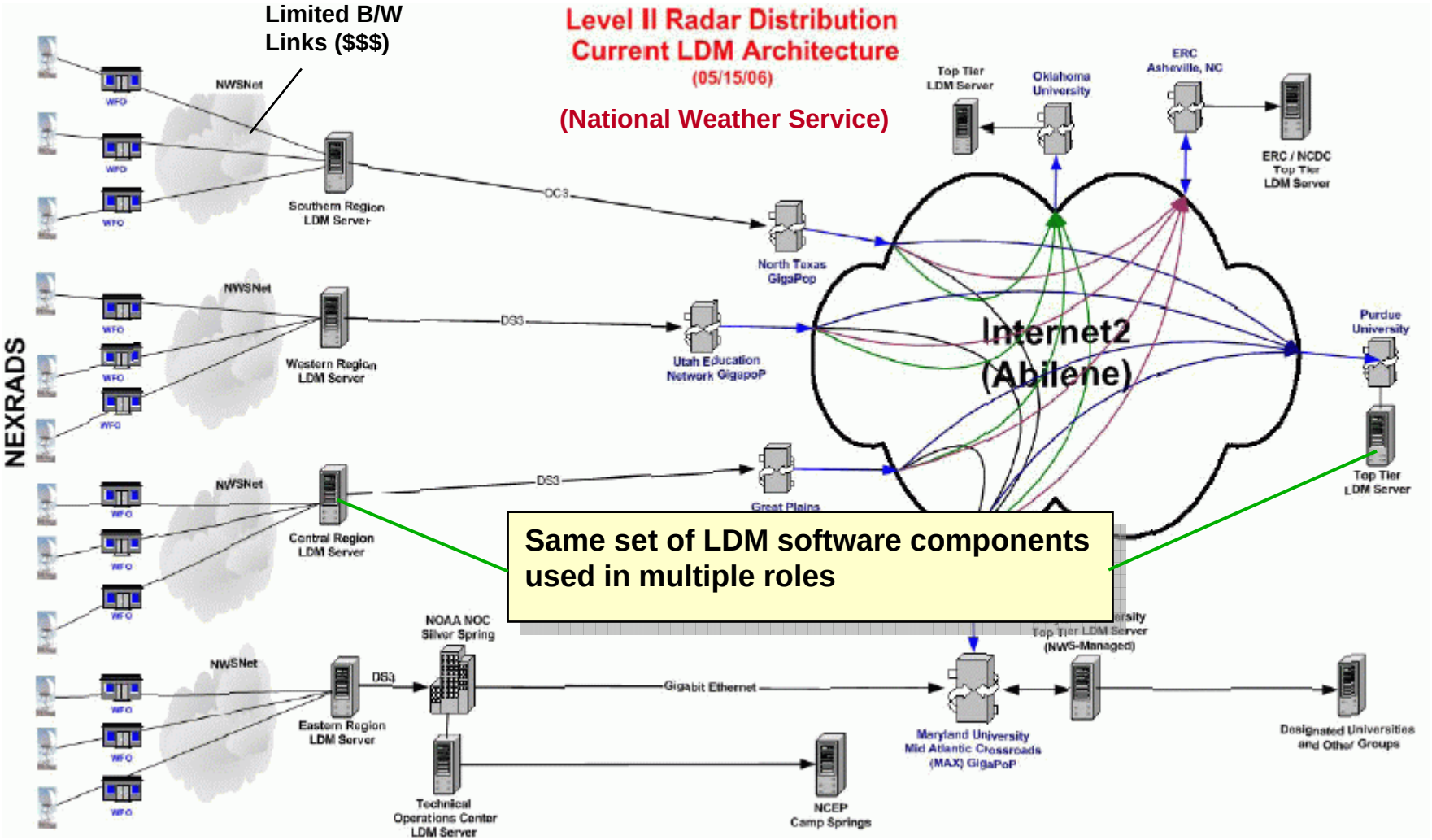
- NNEW architecture
  - Related systems
  - High-level architectural concept
- Foundational standards
- Data model standards
- Service standards
- Registry/repository
- Status of prototyping and demonstration efforts
- Summary

Related Data Distribution Systems

- Are there existing service-oriented systems we can learn from?
  - Yes - two examples of such systems are: LDM and Akamai
- LDM – Unidata Local Data Manager
  - In widespread use for large-scale weather data dissemination, highly scaleable
- Akamai – commercial content delivery provider
  - Optimization overlay for the Web
  - 20% of Web traffic handled by deployed Akamai servers
  - Caching provides scaleability, improves response time
- Other relevant systems
  - WARP Weather Information Network Server (WINS)
  - Aviation Digital Data Service (ADDS)
  - Integrated Terminal Weather System (ITWS)
  - Corridor Integrated Weather System (CIWS)

NEXRAD Weather Data Distribution

LDM: Scalable, Data Type Agnostic, Fault-Tolerant

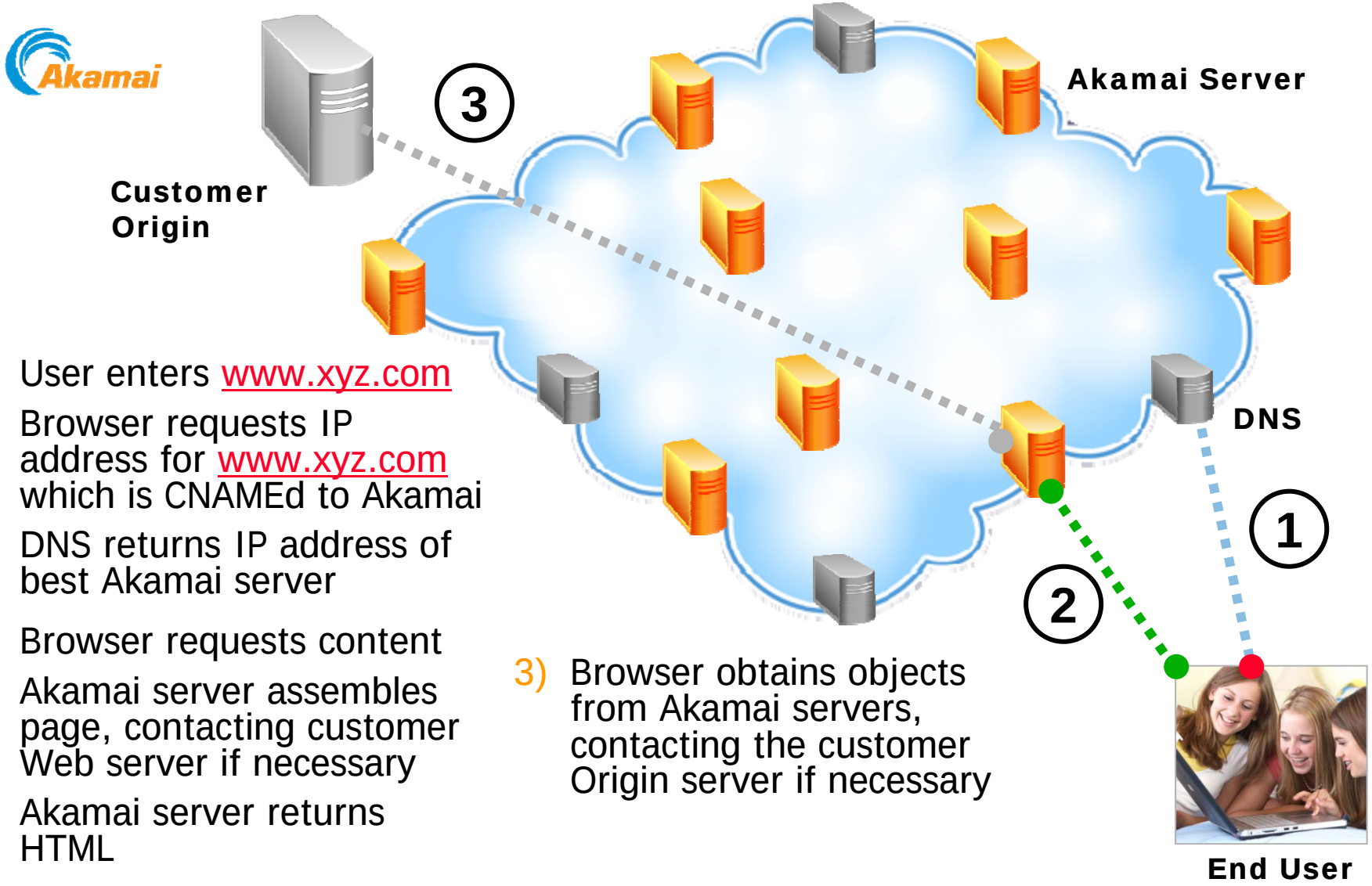


LDM Pros & Cons

- **Pros**
  - **Data-agnostic – can handle most data types (possible exception being streaming video)**
  - **Flexible – LDM 'nodes' can act as data origin servers, data aggregators, or data repeaters. Numerous topologies possible to meet a variety of requirements.**
  - **Fault tolerant – support for redundant nodes and automatic fail-over included in LDM software package**
- **Cons**
  - **No automatic data discovery capability**
  - **Limited data filtering (filtering by product type only, not space/time)**
  - **No support for archived data access**
  - **Static hub & spoke topology configurations**
  - **Not leveraging XML-based technologies & tooling**

Leveraging Separation of Data/Services

Network Overlay – Content Delivery Network (CDN)



1) User enters www.xyz.com

   Browser requests IP address for www.xyz.com which is CNAMEd to Akamai

   DNS returns IP address of best Akamai server

2) Browser requests content

   Akamai server assembles page, contacting customer Web server if necessary

   Akamai server returns HTML

3) Browser obtains objects from Akamai servers, contacting the customer Origin server if necessary

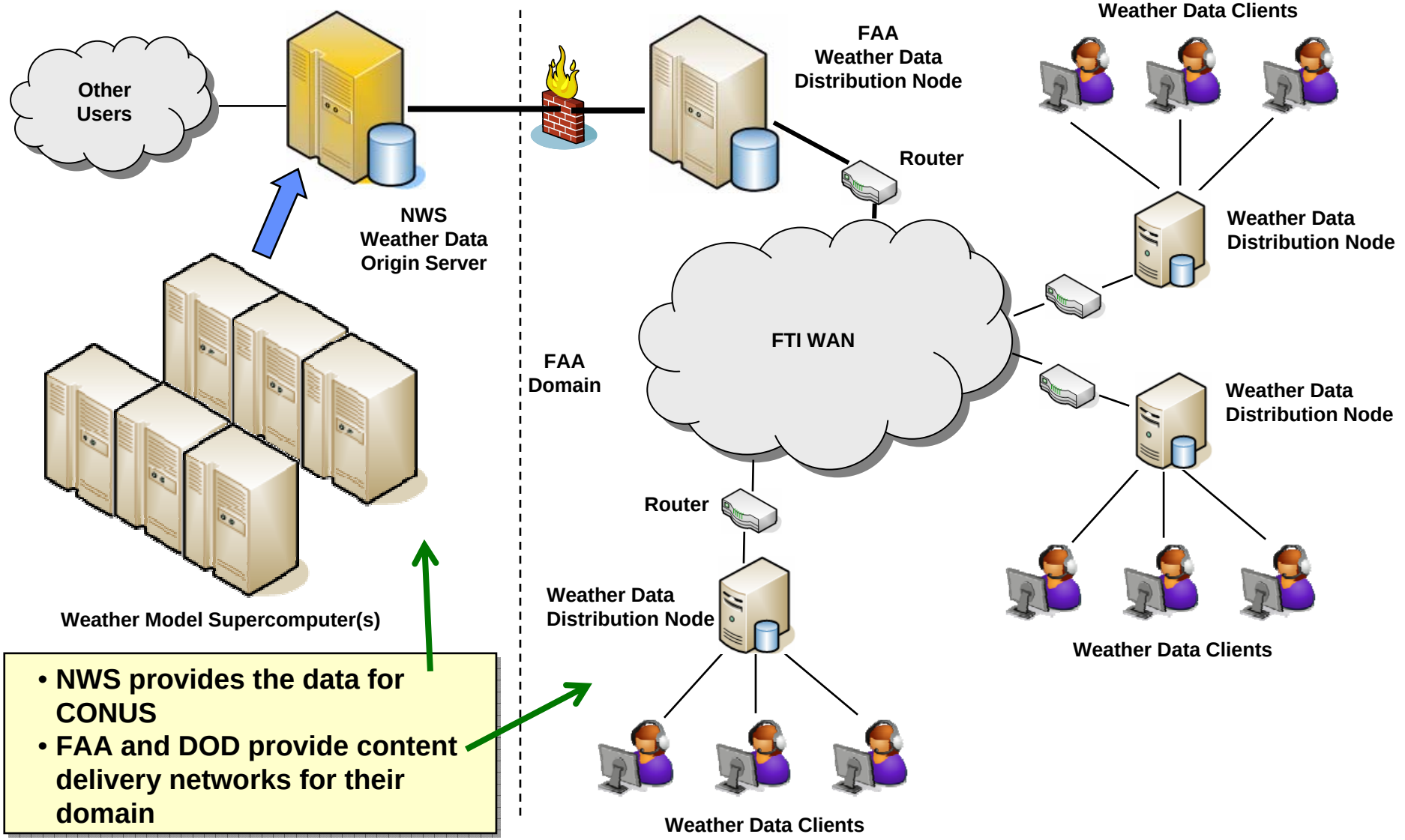
Akamai Pros & Cons

- **Pros**
  - **Network overlay that is largely transparent to application layer (Google-based discovery still works)**
  - **Dynamically optimizes routes based on real-time network latency measurements**
  - **Fault-tolerant**
  - **Dynamic caching of static content at the edge (Web pages and page fragments)**
  - **Strategies to minimize TCP connection overhead**
- **Cons**
  - **Caching strategy depends on content being relatively static**
  - **No filtering of data (temporally or spatially)**

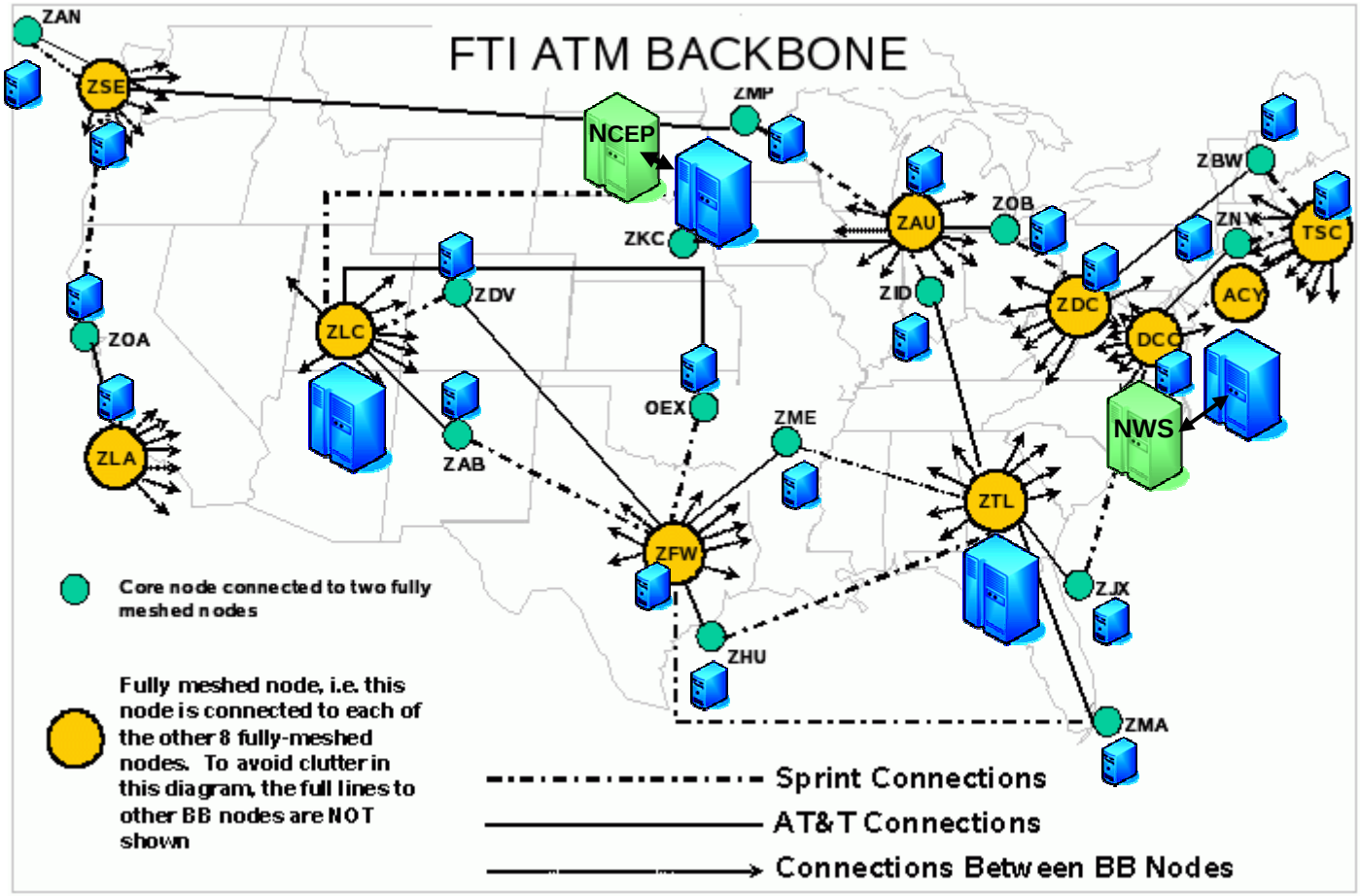
What are we after with respect to the NNEW architecture ?

- A combination of the features incorporated in LDM and Akamai, plus:
  - Dynamic discovery
  - Support for XML-based technologies
  - Flexible filtering of data based on spatial/temporal properties
  - Support for intelligent caching of weather data (much more dynamic than typical Web content)
  - Improved support for scaleability of any single hub in a NNEW node topology
  - QOS support for virtual priority-based communications channels
- Implementation of the architecture using technologies associated with the SWIM container, and registry/repository
- Software modules organized as composable services
- *Flexibilty/agilty with respect to system topology*
  - *Change is guaranteed over time*

Distributed Hub & Spoke Topology for 4-D Weather Cube (Notional 'Slice')



Sample Instantiation of NNEW Hub & Spoke Architecture



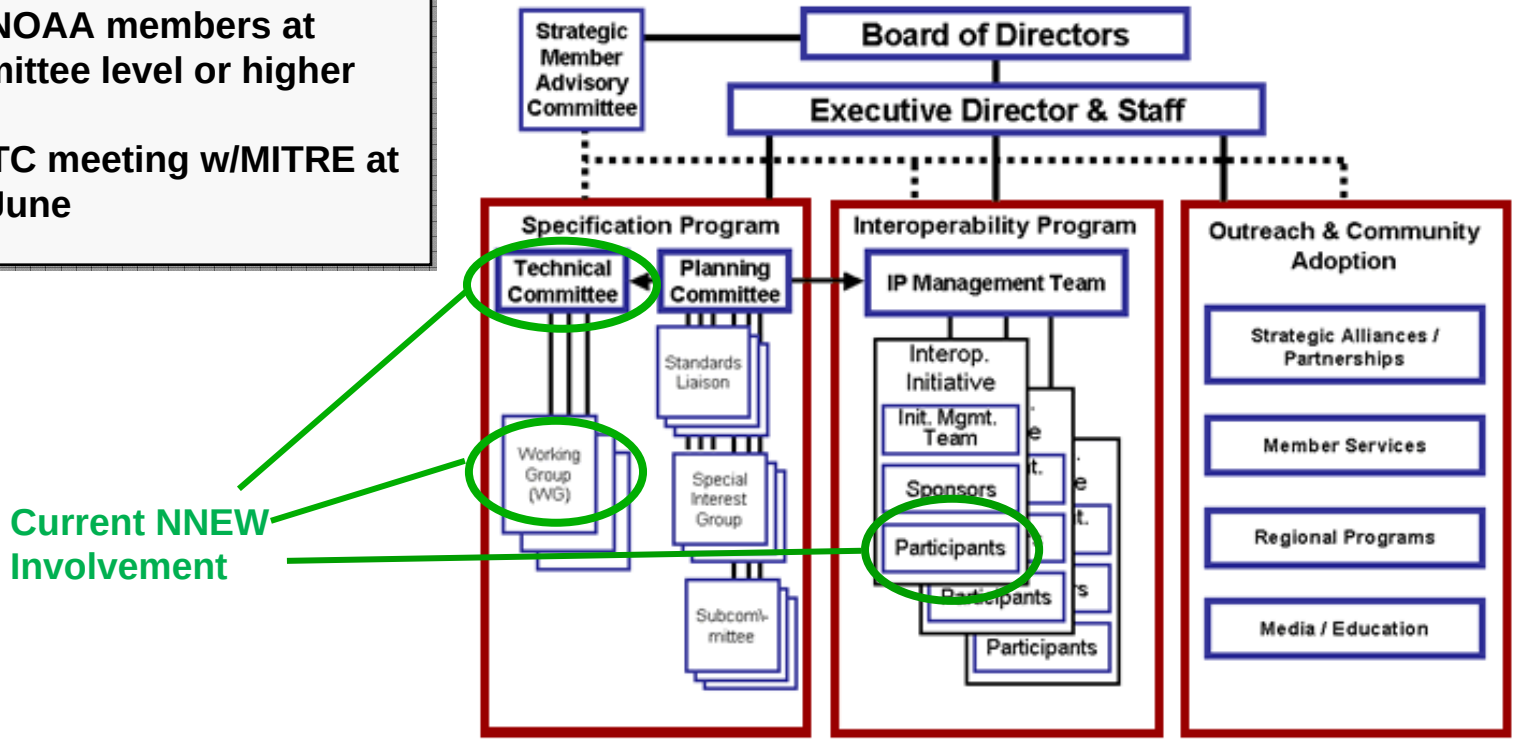
- One deployed instance of the NNEW SOA would co-locate hubs with FTI backbone hubs.
- Many other deployment options possible with general architecture (cost/benefit driven decision)\
- Once size will not fit all (airborne network topology may differ from ground-base topology, for example)

Outline

- NNEW architecture
  - Related systems
  - High-level architectural concept
- Foundational standards
- Data model standards
- Service standards
- Registry/repository
- Status of prototyping and demonstration efforts
- Summary

NNEW is Leveraging Open Geospatial Consortium (OGC) & ISO Standards

- OGC - Geospatial standards body
  - Data models & schemas
  - Services Reference Architecture
  - Service Standards
  - 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)
- Quarterly OGC TC meeting w/MITRE at MIT campus in June



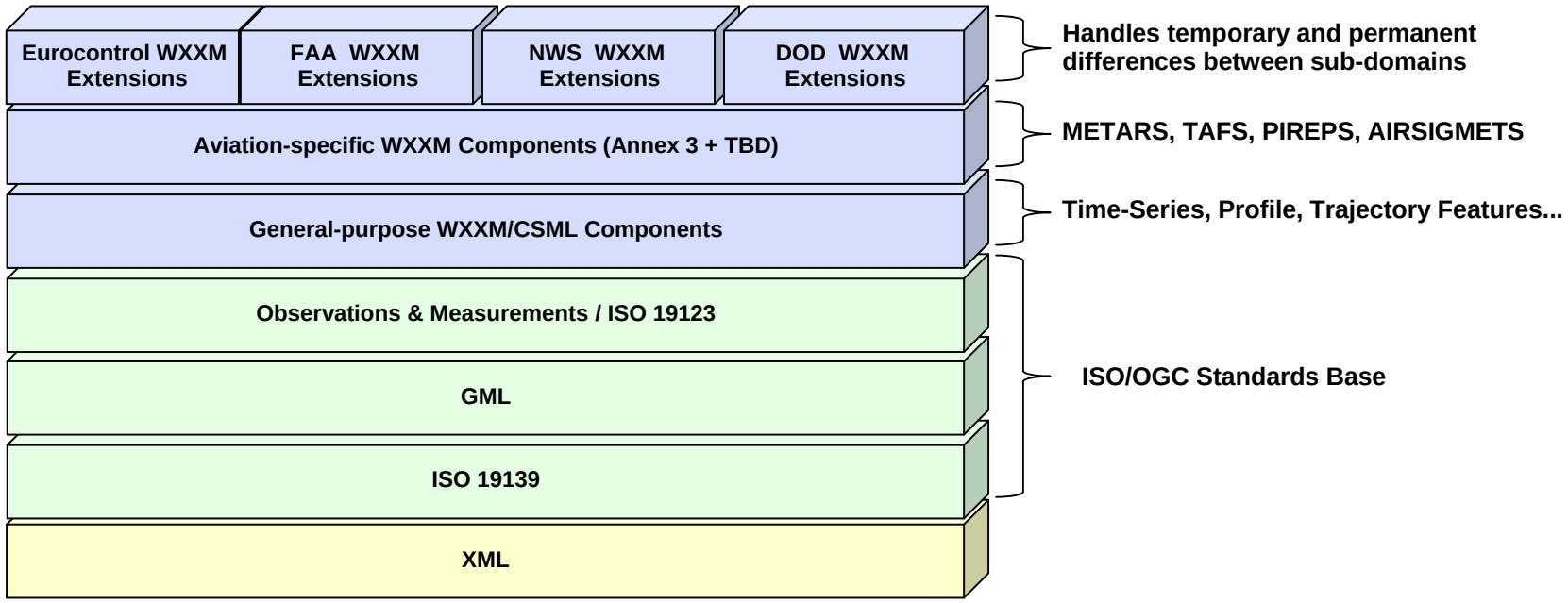
Relevant Standards

- **W3C Standards**
  - XML, XML Schema, SOAP, WSDL, RDF, OWL (Semantic Web)
- **OASIS**
  - ebXML registry/repository
  - Common Alerting Protocol (CAP)
- **ISO TC/211 Geographic information standards**
  - ISO 19101 Reference model
  - ISO 19103 Conceptual schema language
  - ISO 19107 Spatial schema
  - ISO 19108 Temporal schema
  - ISO 19109 Rules for application schema
  - ISO 19110 Methodology for feature cataloging
  - ISO 19115 Metadata
  - ISO 19118 Encoding
  - ISO 19119 Services
  - ISO 19123 Schema for coverage geometry and functions
  - ISO 19136 Geography markup language (GML) (Shared OGC standard)
  - ISO 19139 Metadata - XML schema implementation
  - ISO 8601 Time

Relevant Standards (continued)

- **Open Geospatial Consortium**
  - Geography Markup Language (GML)
  - Web Feature Service (WFS)
  - Web Coverage Service (WCS)
  - Web Map Service (WMS)
- **DOD**
  - JMBL
  - IC/ISM (security markup)
- **FAA/Eurocontrol**
  - Aeronautical Information Exchange Model (AIXM)
  - Weather Exchange Model (WXXM)
  - Models and notional data dissemination mechanisms based on ISO/OGC standards
- **World Meteorological Organization**
  - GRIB
  - BUFR
- **International Civil Aviation Organization**
  - ICAO Annex 3

NNEW Usage of ISO/OGC Standards WXXM Data Model 'Stack'

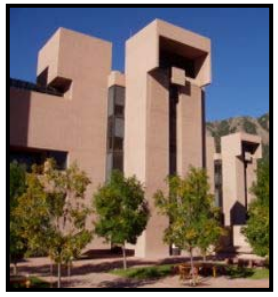


- Heavily leverages ISO/OGC standards stack
- Each component assigned its own XML namespace
- Top-level extensions shown are intended to provide extensibility within sub-domains
- *Goal is to minimize the number of these, but some level of independent customization typically needed during schema lifetime*

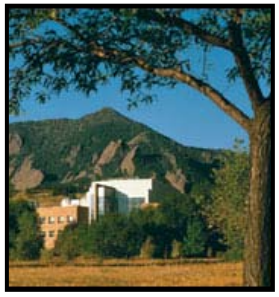
NNEW Data Access Service Requirements

- Ability to query for weather data using *what, where, when* semantics
  - *when* implies an inherent archival capability as well
- Access to gridded and non-gridded data types
  - 2-D precipitation maps, frontal boundaries, etc…
- Weather data is highly dynamic. Real-time subscriptions required
- OGC Web Feature Service (WFS) and Web Coverage Service (WCS) meet many of the requirements, but not all
  - Need access to gridded data products along a flight path
  - Extensions needed to fulfill pub/sub requirement

MIT LL



NCAR



NOAA

Participating in…

- Web Coverage Service (WCS) Working Group
- Web Feature Service (WFS) Working Group

Standards Development not without its Risks

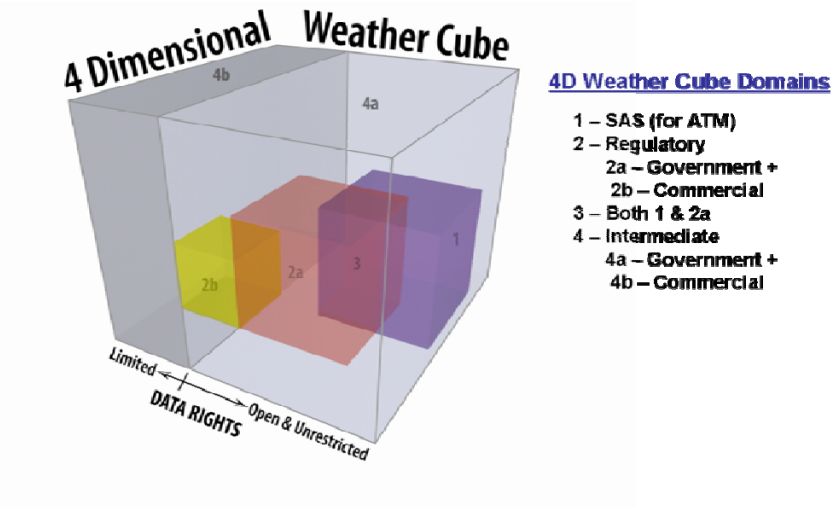
Outline

- NNEW architecture
  - Related systems
  - High-level architectural concept
- Foundational standards
- Data model standards
- Service standards
- Registry/repository
- Status of prototyping and demonstration efforts
- Summary

Key Roles of the NNEW Registry/Repository

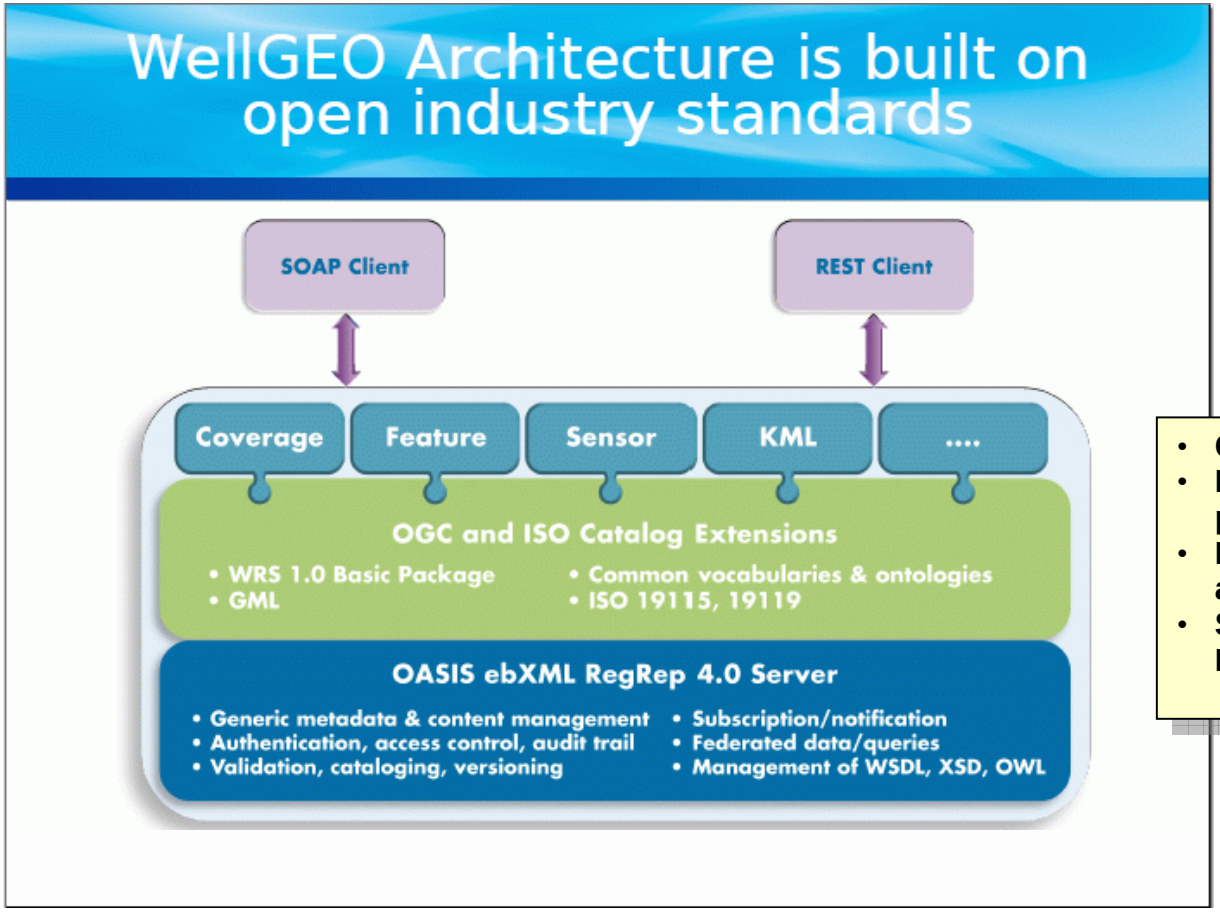
- **Build-time**
  - Storage/discovery of service interface descriptions (WSDL and associated schemas)
  - Storage of dictionary/vocabulary information (e.g. coordinate reference system dictionary, upper-level weather ontology)

- **Run-time**
  - Discovery of datasets and their associated data access services using high-level metadata
  - Dataset metadata within registry includes weather cube domain 'membership' (e.g. SAS)
  - Dataset can be a member of more than one domain



NNEW Registry-Repository

- **NNEW Using early release of ebXML RegRep 4.0 – compliant registry/repository**

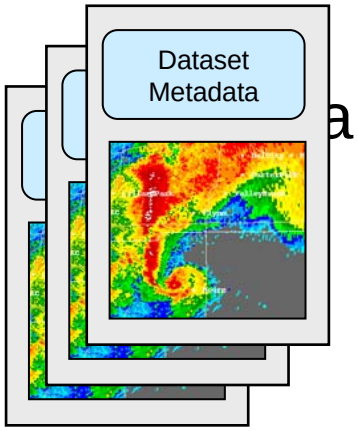


- **General purpose core**
- **Designed for extensibility using profiles**
- **Profiles exist for ISO Metadata and subset of GML**
- **Standardized OWL profile for RegRep 4.0 not yet available**

Registration of Datasets and Services

Dataset Series

e.g. Precip Data for most recent one year period



Operates On

Data Access Service

Data Access Service (e.g. OGC WCS, OGC WFS, JMBL)

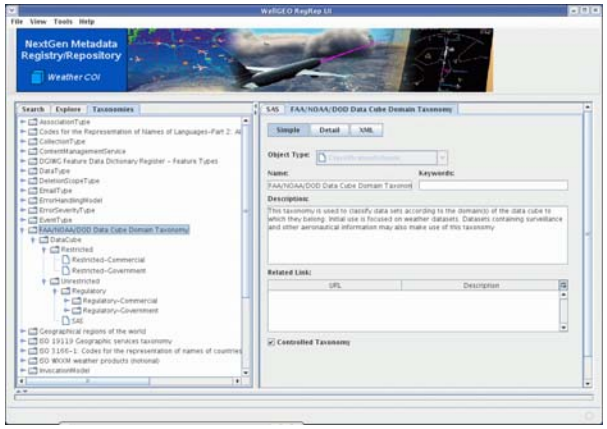
ISO 19115

Dataset Series Metadata

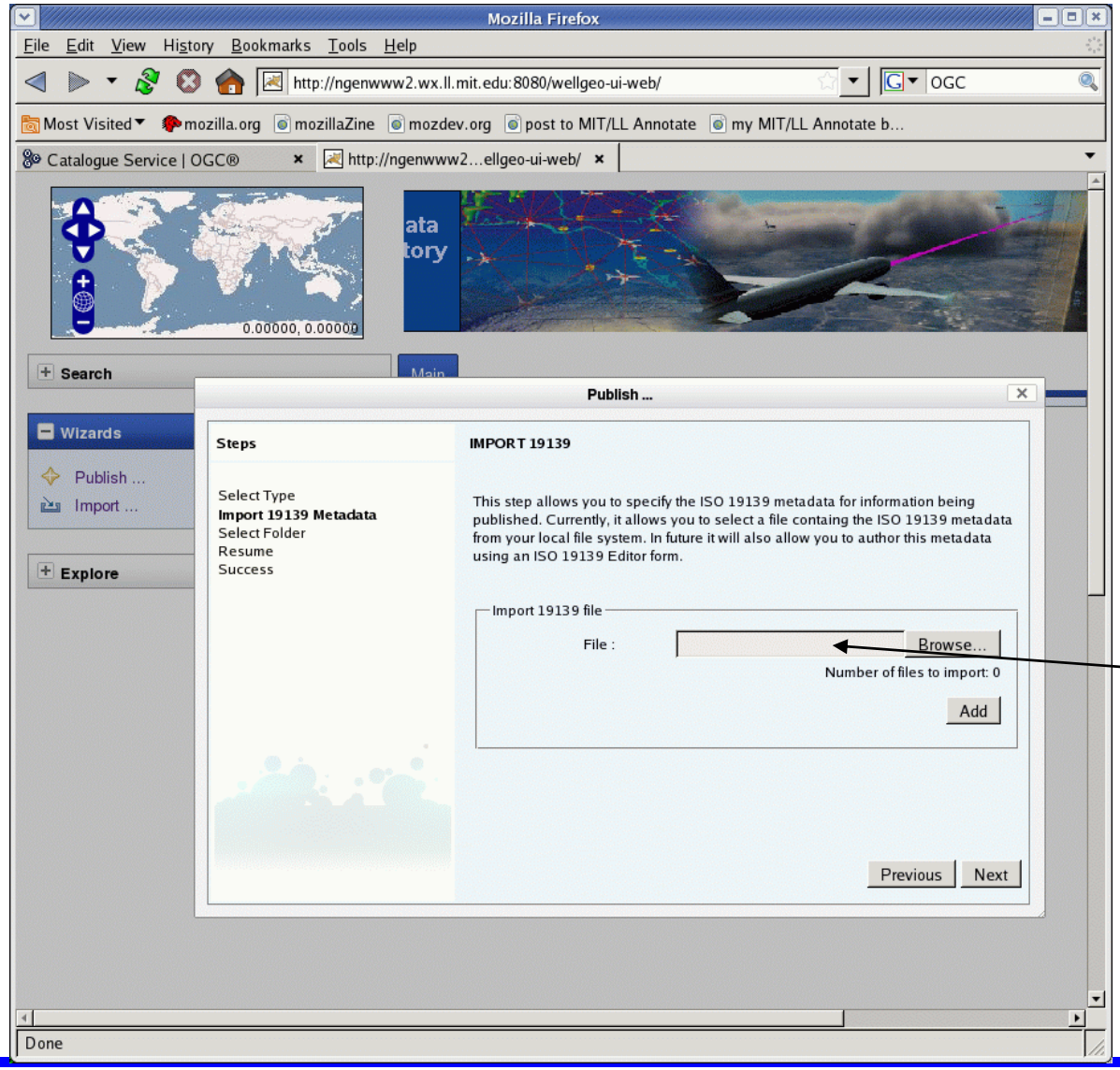
Service Metadata

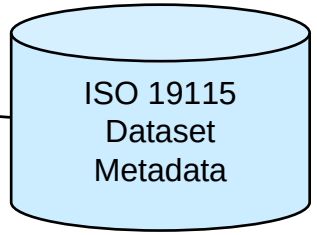
Combination of WSDL + ISO 19119

Registry/Repository

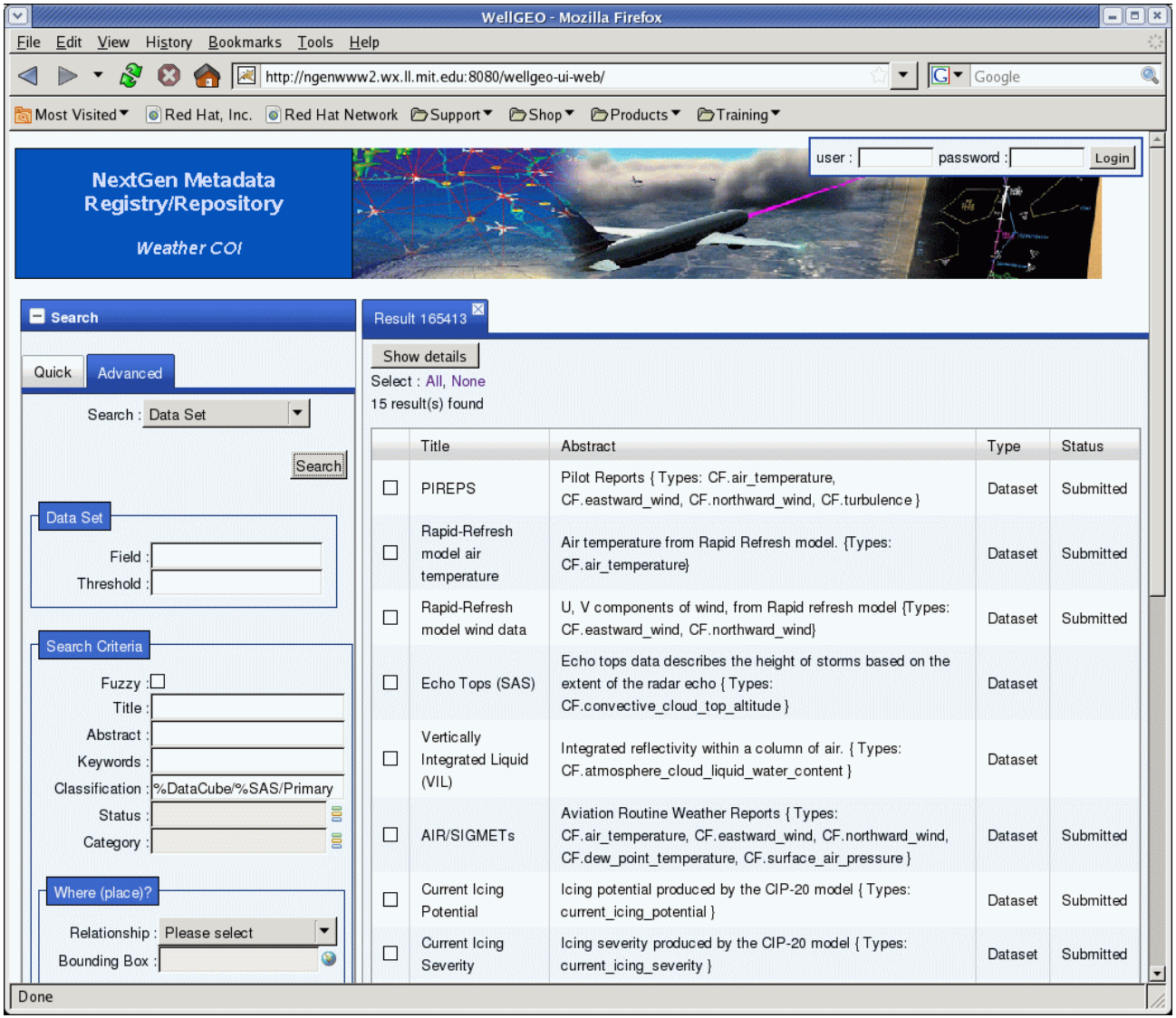


Dataset Publication via Web-Based UI (by WxCube Manager)



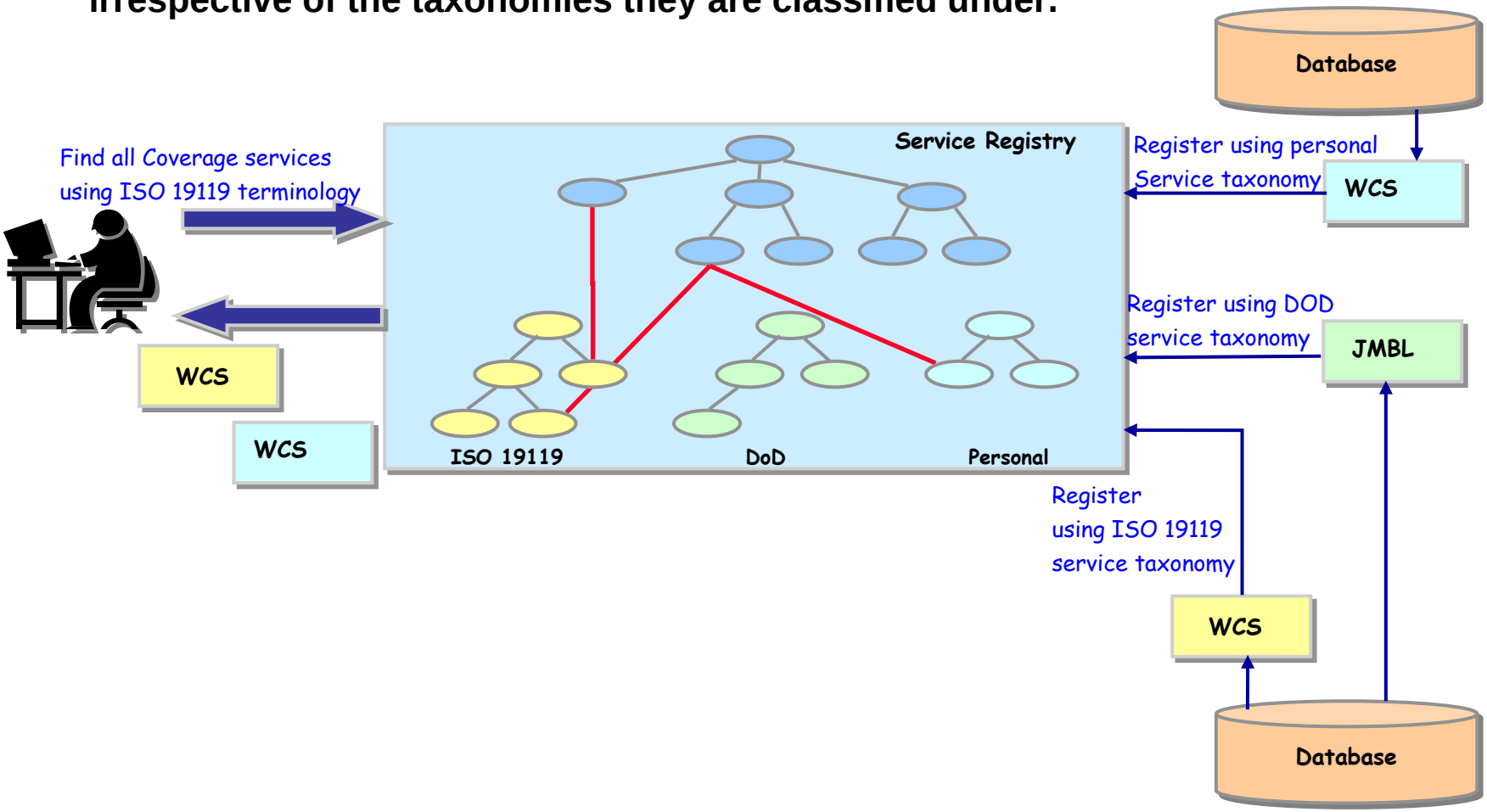


Dataset Discovery of Weather Datasets in SAS Domain

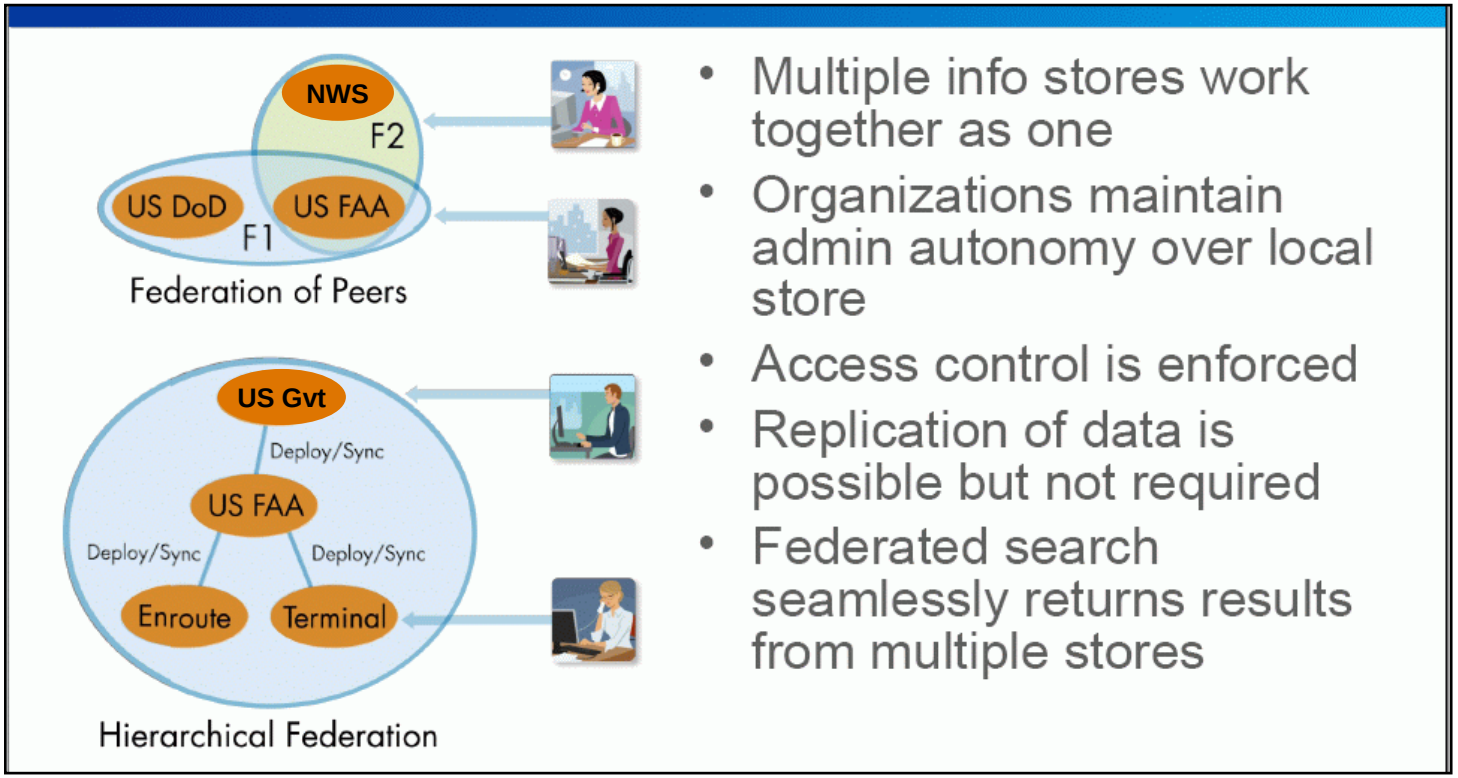


Registry Ontology Support

- **Higher level ontologies together with semantic mappings can be used to discover the right type of weather datasets and their associated data access services irrespective of the taxonomies they are classified under.**



Next Step – Federated Registries

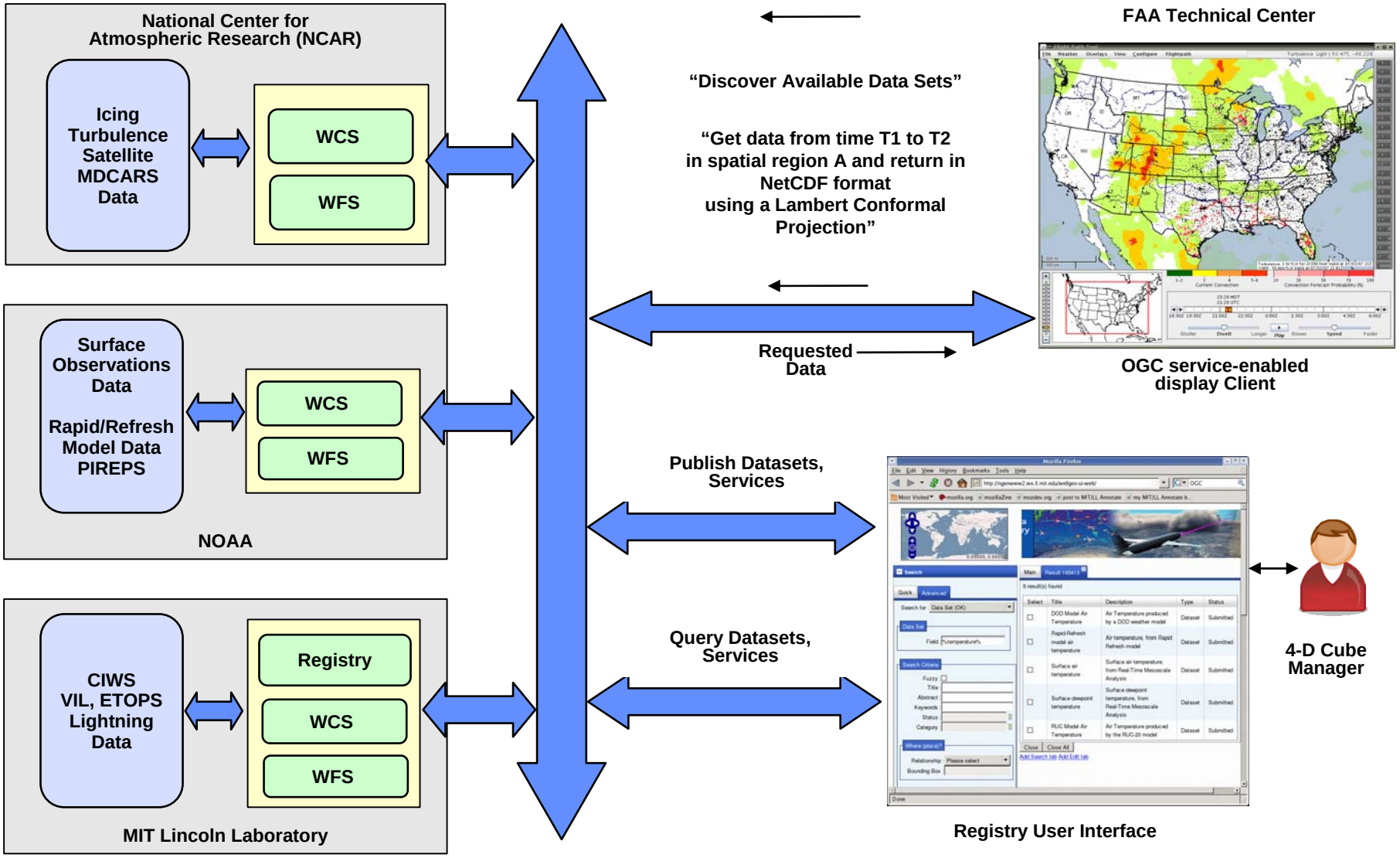


- Multiple info stores work together as one
- Organizations maintain admin autonomy over local store
- Access control is enforced
- Replication of data is possible but not required
- Federated search seamlessly returns results from multiple stores

Outline

- NNEW architecture
  - Related systems
  - High-level architectural concept
- Foundational standards
- Data model standards
- Service standards
- Registry/repository
- Status of prototyping and demonstration efforts
- Summary

Data Discovery and Access using OGC Services (Sept '08 Demo)



Summary

- NNEW program well underway
  - Diverse set of participants in current prototyping phase
- Focus is on standards and reference implementations for the 4-D Weather Cube
- WXXM is anticipated to be a key weather data model as the program moves ahead
  - Interoperability with AIXM enhanced by use of common standards base
- Links
  - NNEW Wiki

    https://wiki.ucar.edu/display/NNEWD/NNEW+Dissemination+home+page
  - Open Geospatial Consortium

    http://opengeospatial.org

Questions?