Syntactic and Semantic-based approaches for Geoinformation Management

Surya S. Durbha, PhD
Associate Professor
CSRE, IITB

Outline

- Background
- Standards-based Geospatial Approaches
- Sensor Web enablement of GeoSensors
- Need for Semantic approaches for integrating Geoinformation

Earth Observation from Multiple Vantage Points

- Multiple vantage points for Earth observation leads to widespread real time sensors and multiple archives of imagery and other datasets.

Keywords

- Geographical Information Systems Spatial Data, Vector, Raster

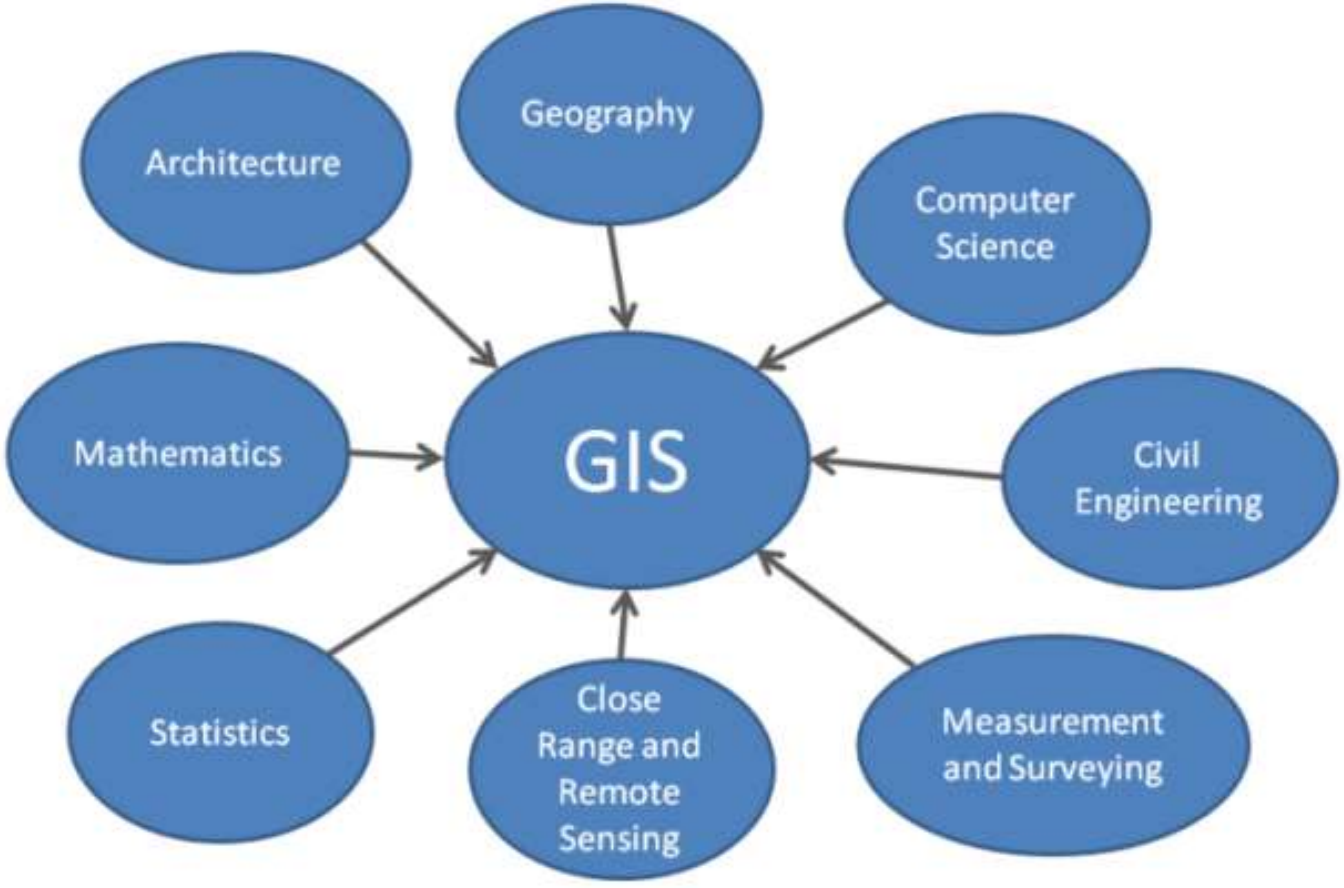
Standards, information sharing

- OGC, Web Services, Interoperability
- Data Integration, Decision Support

Geoinformatics Information Systems, Computer Science, Remote Sensing

Overview and Definition of GIS

- It brings together the ideas developed in various fields
- Focus of GIS activity centers around
  - Hardware and software
  - Information processing
  - Applications



Environmental Attributes

Map Layer

Geology

Hazard Areas

Existing Land Use

Noise Contours

Floodplain

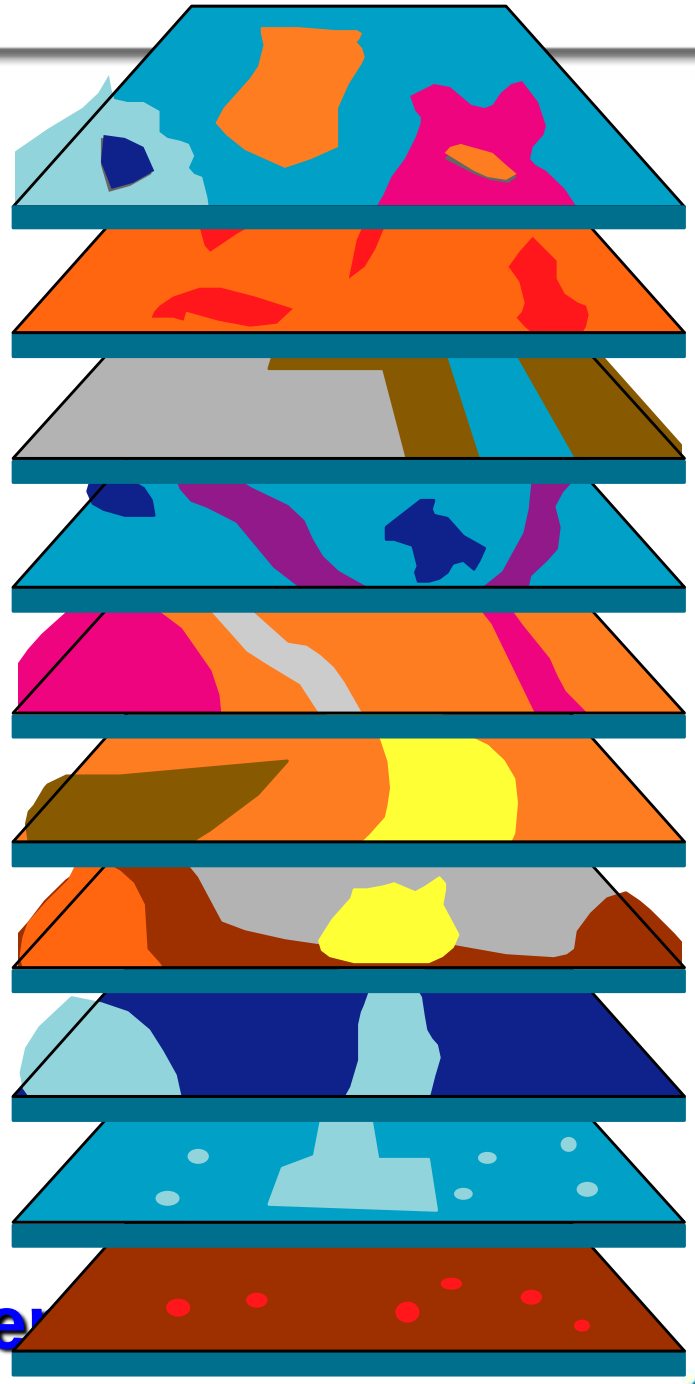
Soils

Vegetation

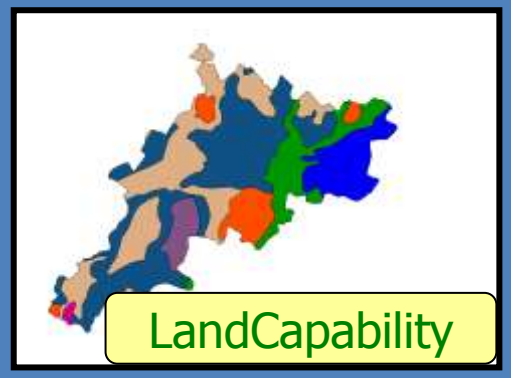
Surficial Hydrology

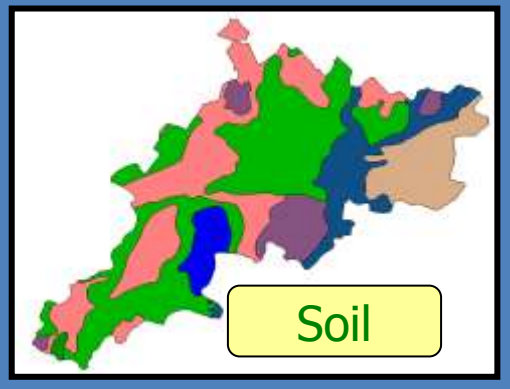
EI Study Areas

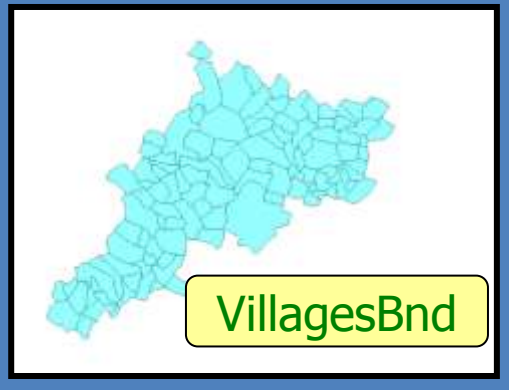
Planning Study Index Refere

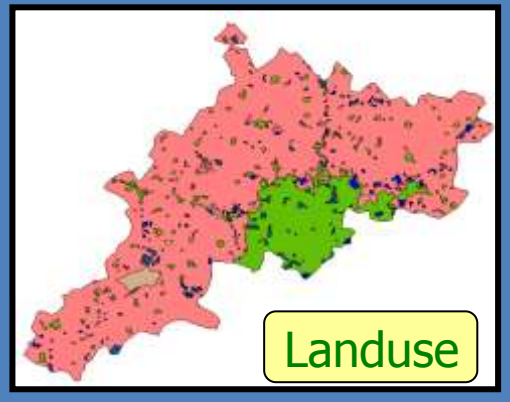


Spatial Data Layers









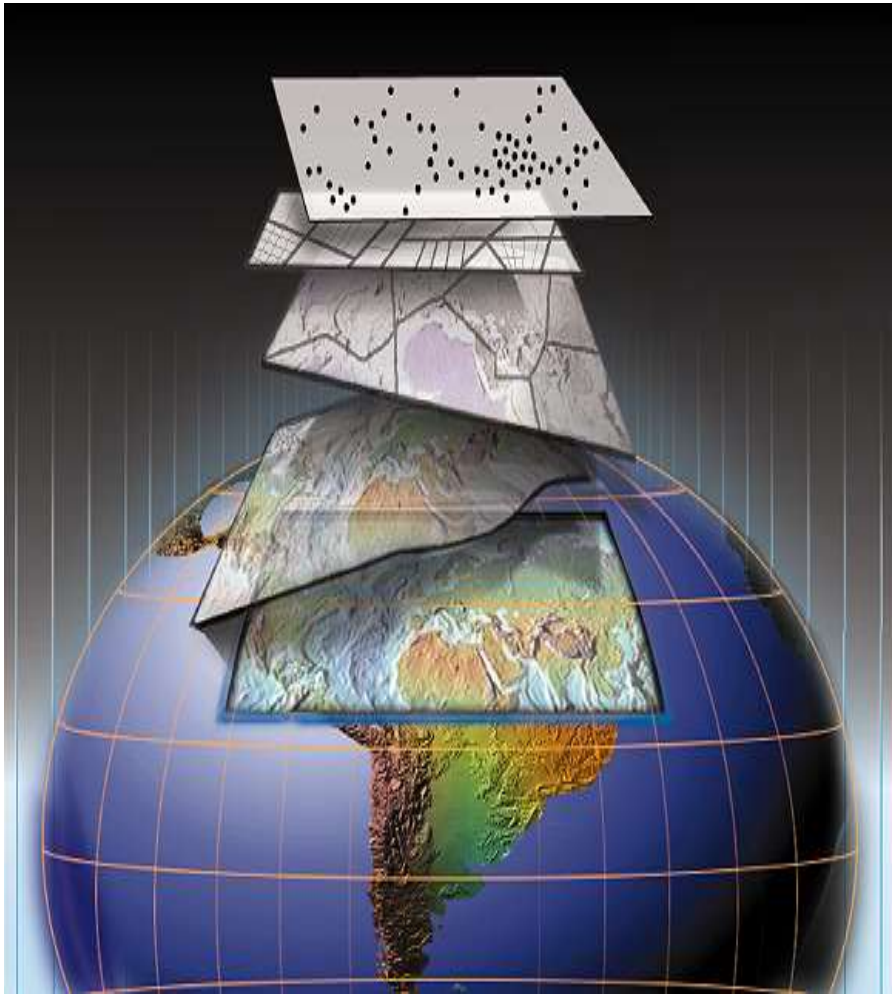
What Does A GIS Do?

GIS can answer the following questions:

1. **Location** - What is at a given location?
2. **Condition** - Where does it occur?
3. **Routing** - What is the best way?
4. **Trend** - What has changed?
5. **Pattern** - What is the pattern?
6. **Modeling** - What happens if ?

Who needs access to coordinated geographic information?

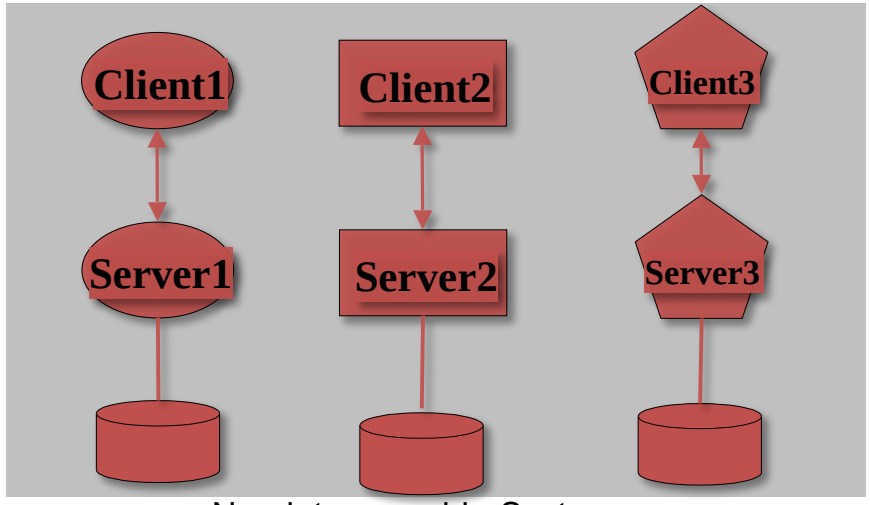
- Land Records Adjudication
- Disaster Response
- Transportation Management
- Water, gas & electric planning
- Public Protection
- Defense
- Natural Resource Management
- Telecommunications Infrastructure
- Economic Development
- Civic Entrepreneurs
- Regional Stewards



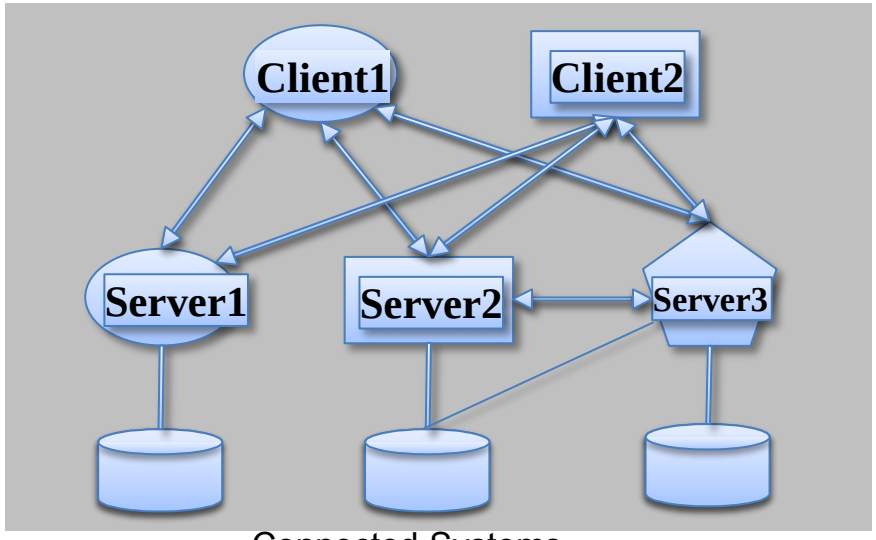
Standards based Geospatial approaches

Geospatial Interoperability

- **Geospatial Interoperability enables** disparate and geographically distributed systems/information sources to use and exchange geospatial information
  - Standards-driven geospatial web services provide interoperability and the ability to harmonize varied data sources.
- Interoperability enables to build cost effective systems, and helps to reduce redundancy in an organizations spatial infrastructure.
- Geospatial Web services is the de facto way to access and publish:
  - Data, Services and metadata
  - Spatial Data Infrastructures (SDI) are adopting these standards to facilitate interoperability with other SDI systems world wide.

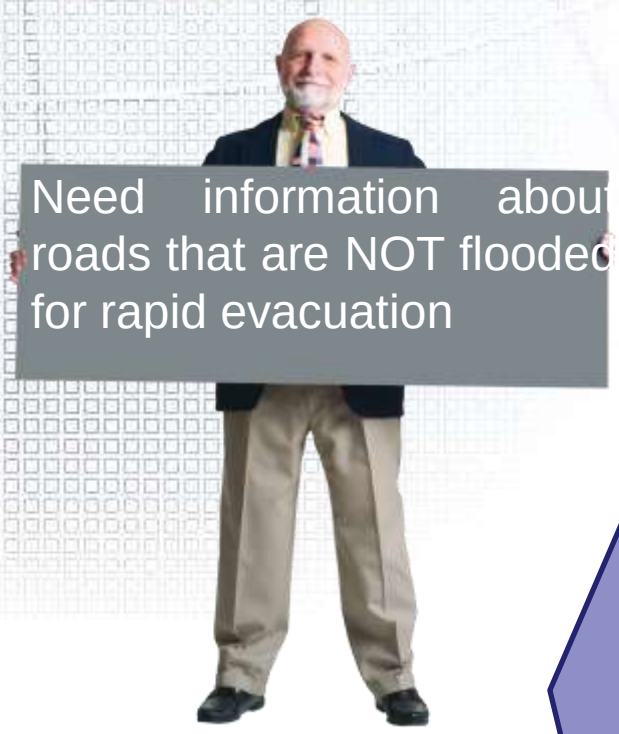


Non-interoperable Systems



Connected Systems

Understanding the context for information discovery



Disaster Management

Context 1

Web service that provides data about traffic and road condition based on several parameters

Context 2

…Context N

The Open Geospatial Consortium (OGC)

Vision:

Develops standards for geospatial web services

Mission:

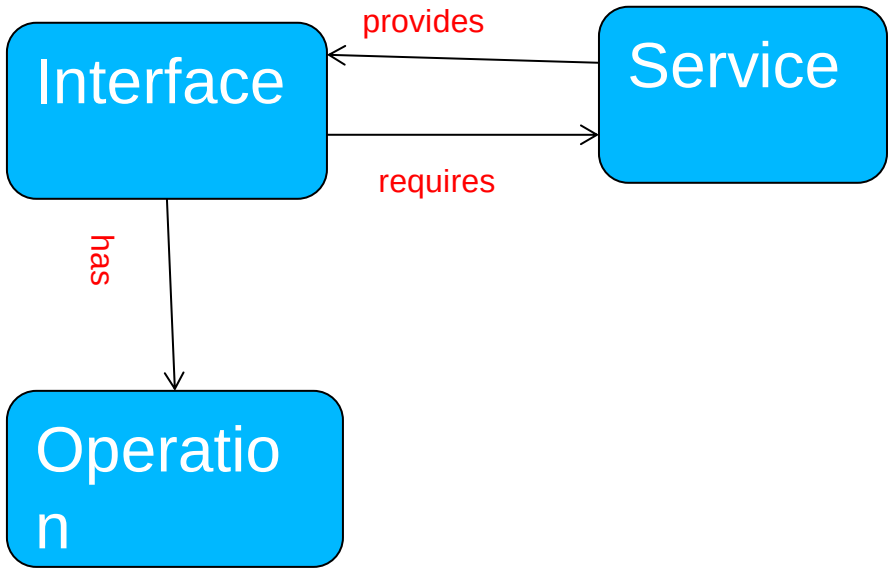
A world in which everyone benefits from geographic information and services made available across any network, application, or platform

- Need to integrate Geospatial data from heterogeneous data sources.
- Incompatibilities in structural, syntactical and semantic representation hinders interoperability.
- Lack of interoperability impedes development of integrated decision support systems, reduces the ability to respond to time critical events and in general provide the right information at the right time.

Web Services

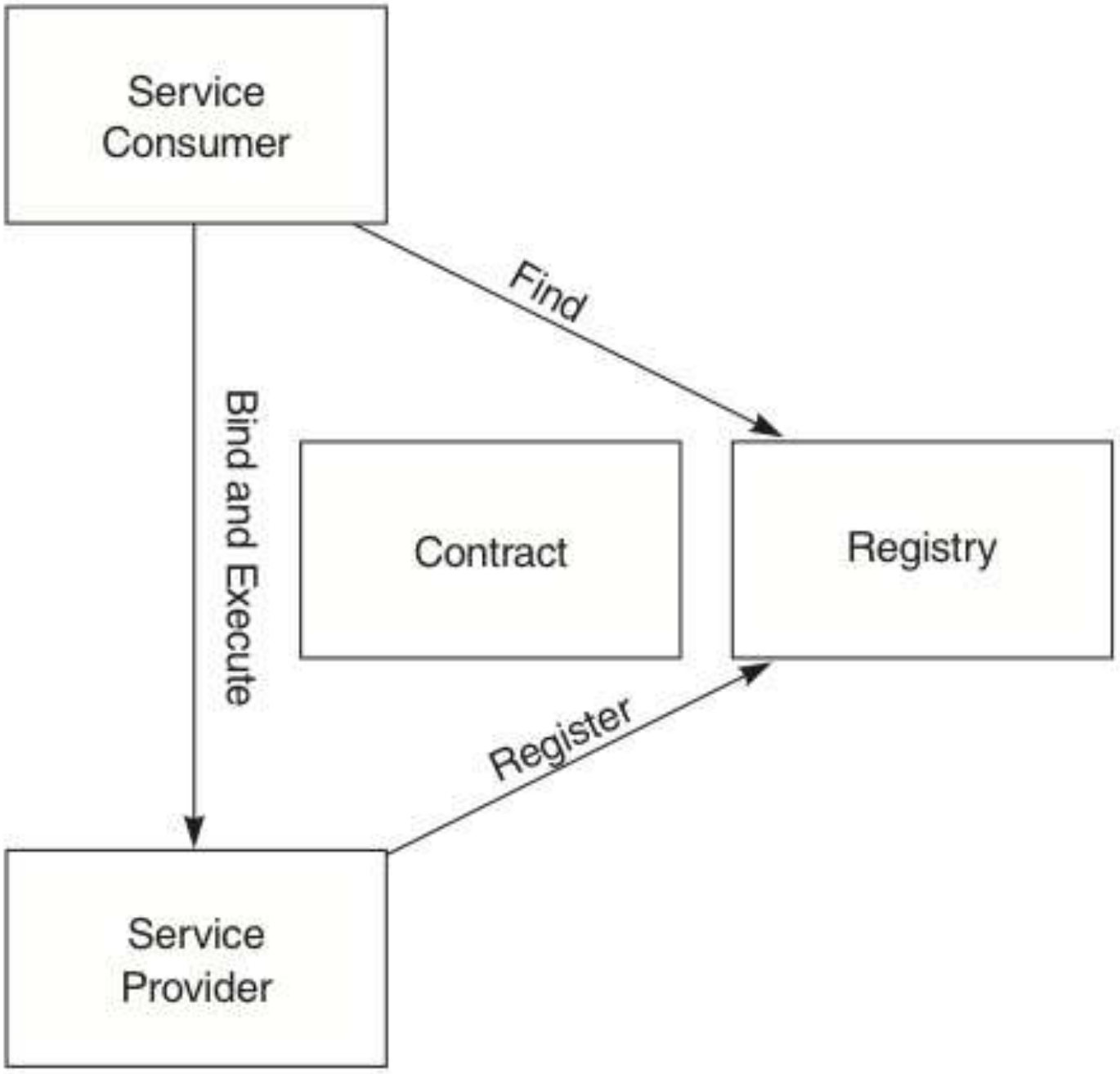
Services, Interfaces and Operations

- **Service** - distinct part of the functionality that is provided by an entity through interfaces,
- **Interface** - named set of operations that characterize the behavior of an entity
- **Operation** - transformation or query that an object may be called to execute. Each operation has a name and a list of parameters.



"A service is a function that is well-defined, self-contained, and does not depend on the context or state of other services."-Source: Web Services and Service-Oriented Architecture: The Savvy Manager's guide

Web Services



- A service registry is a directory of services available in an SOA system.
- It contains the physical location of services, versions and validity periods of services, service documentation, and policies.
- A service registry is one of the main building blocks of an SOA architecture.

SOA and XML

- SOA needs a common platform to base its infrastructure.
- XML is the foundation for virtually all web services standards, such as:
  - XML schema, SOAP, Web Services Description Language (WSDL), and Universal Description, Discovery, and Integration (UDDI).
- XML resolves the challenge of working with different data formats in different applications across multiple platforms.
- XML has the benefit of ease of representation, being text-based, flexible, and extensible by nature.

Representational State Transfer(REST)

- The acronym REST stands for Representational State Transfer, this basically means that each unique URL is a representation of some object.
- In RESTful web services, the emphasis is on simple point-to-point communication over HTTP using XML
- You can get the contents of that object using an HTTP GET, to delete it, you then might use a POST, PUT, or DELETE to modify the object

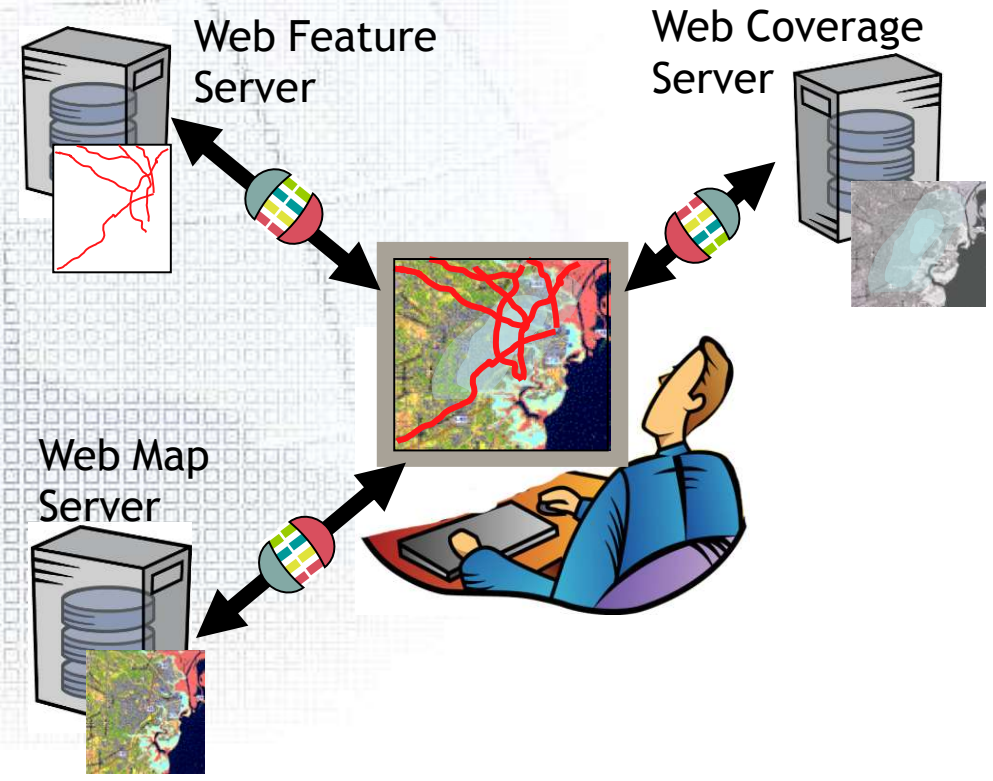
- REST Web service follows four basic design principles:
- Use HTTP methods explicitly.
- Be stateless.
- Expose directory structure-like URIs.
- Transfer XML, JavaScript Object Notation (JSON), or both.

GET/POST operations (REST)

- GET is a read-only operation. It can be repeated without affecting the state of the resource and can be cached
- POST is a read-write operation and may change the state of the resource and provoke side effects on the server.

- To create a resource on the server, use POST.
- To retrieve a resource, use GET.
- To change the state of a resource or to update it, use PUT.
- To remove or delete a resource, use DELETE.

OGC Web Services (OWS)

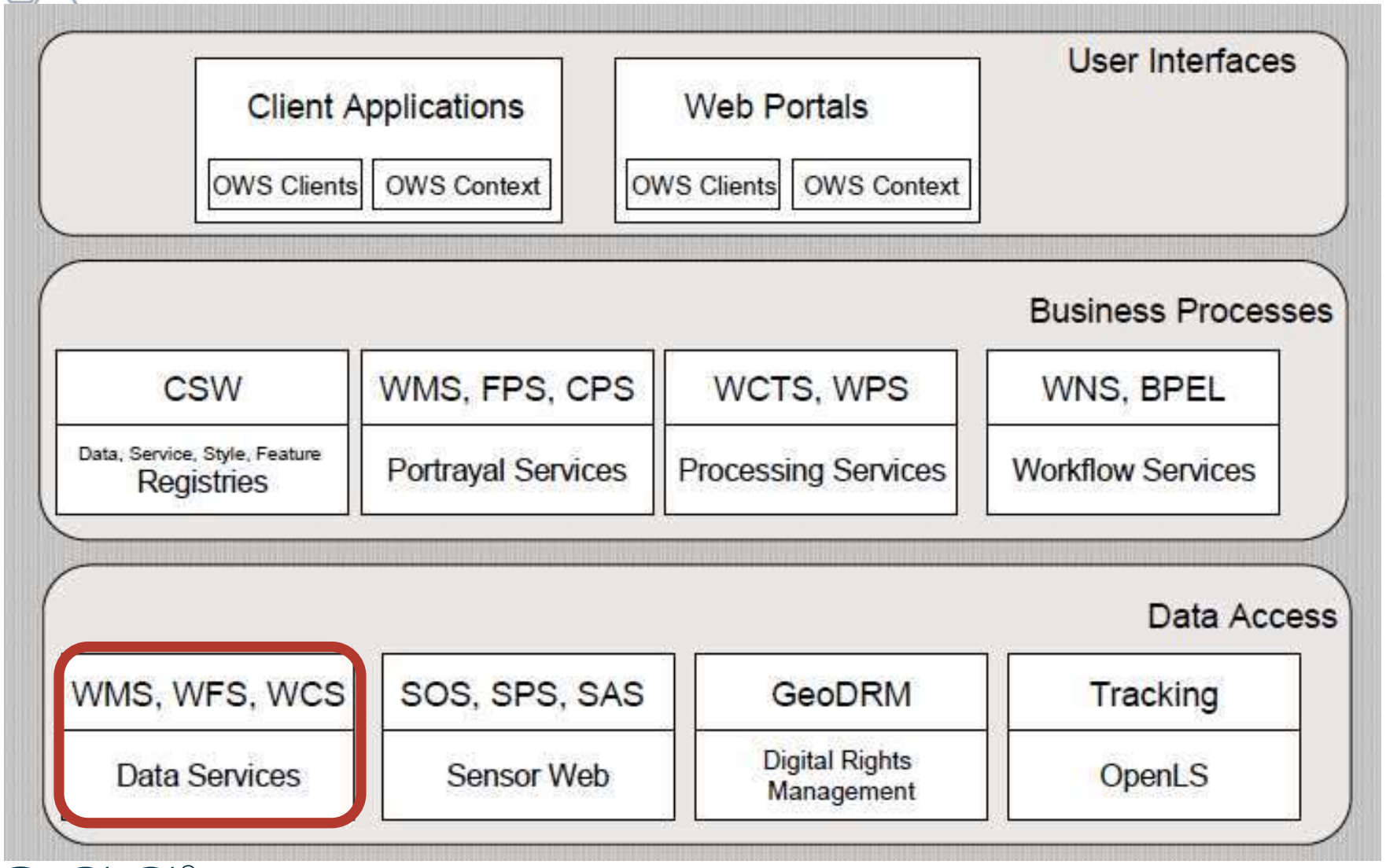


- Web Map Service (WMS)
- Web Feature Service (WFS)
- Web Coverage Service (WCS)
- Catalogue (CSW)
- Geography Markup Language (GML)
- OGC KML
- Others…

Relevant to geospatial information applications: Critical Infrastructure, Emergency Management, Weather, Climate, Homeland Security, Defense & Intelligence, Oceans Science, others

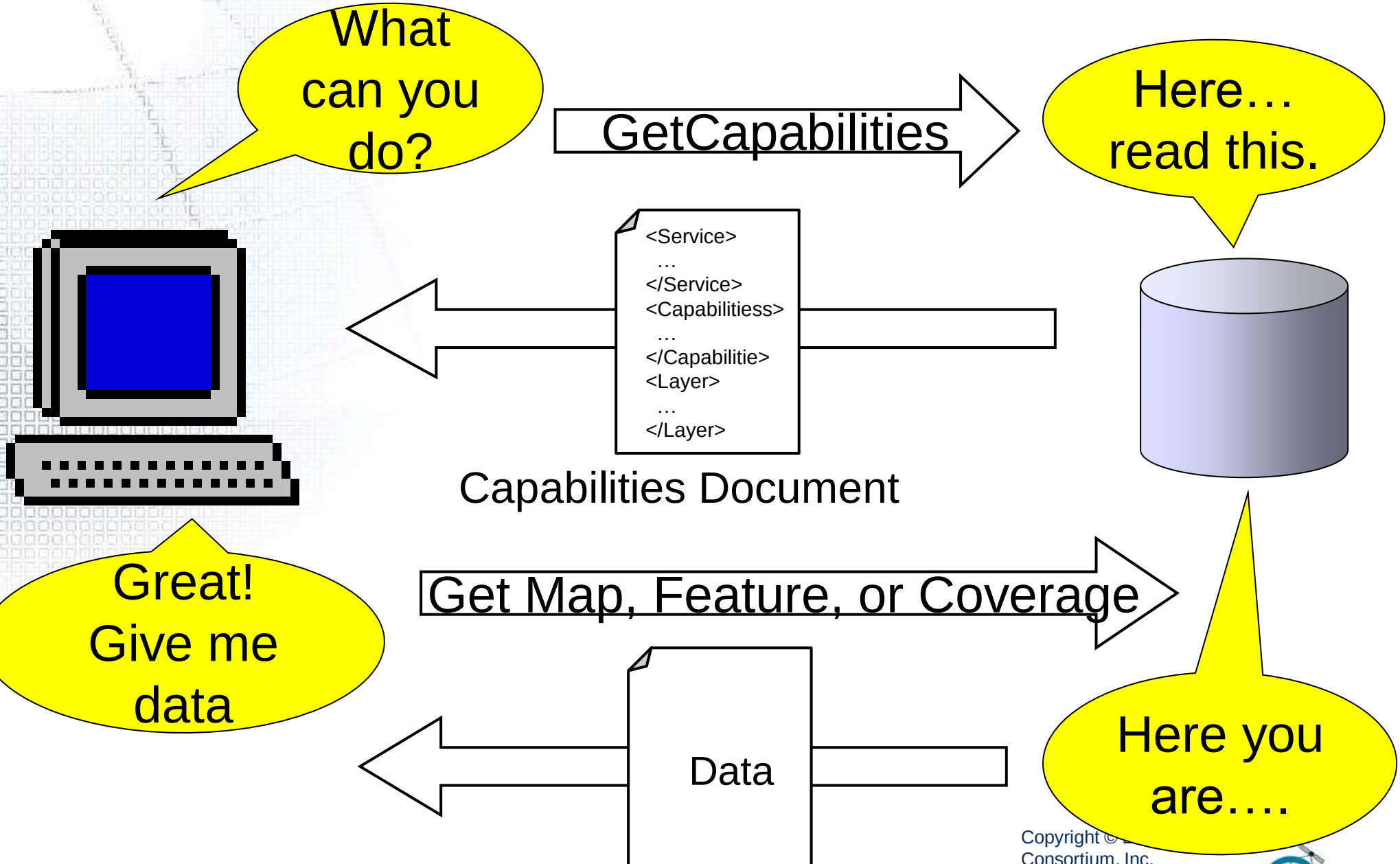
George Percival, OGC Standards: an Overview Tutorial,2010

Copyright (c) 2009 Opengeospatial Consortium


User Interfaces
Client Applications
OWS Clients
OWS Context
Web Portals
OWS Clients
OWS Context
Business Processes
CSW
Data, Service, Style, Feature Registries
WMS, FPS, CPS
Portrayal Services
WCTS, WPS
Processing Services
WNS, BPEL
Workflow Services
Data Access
WMS, WFS, WCS
Data Services
SOS, SPS, SAS
Sensor Web
GeoDRM
Digital Rights Management
Tracking
OpenLS

OGC®

OGC Web Services



Copyright © 2
Consortium, Inc.

Web based services with a focus on geospatial information

1. Data Discovery: Provide search and discovery to geospatial data and services

1. Data Visualization – Provide visualization images of the actual geospatial data

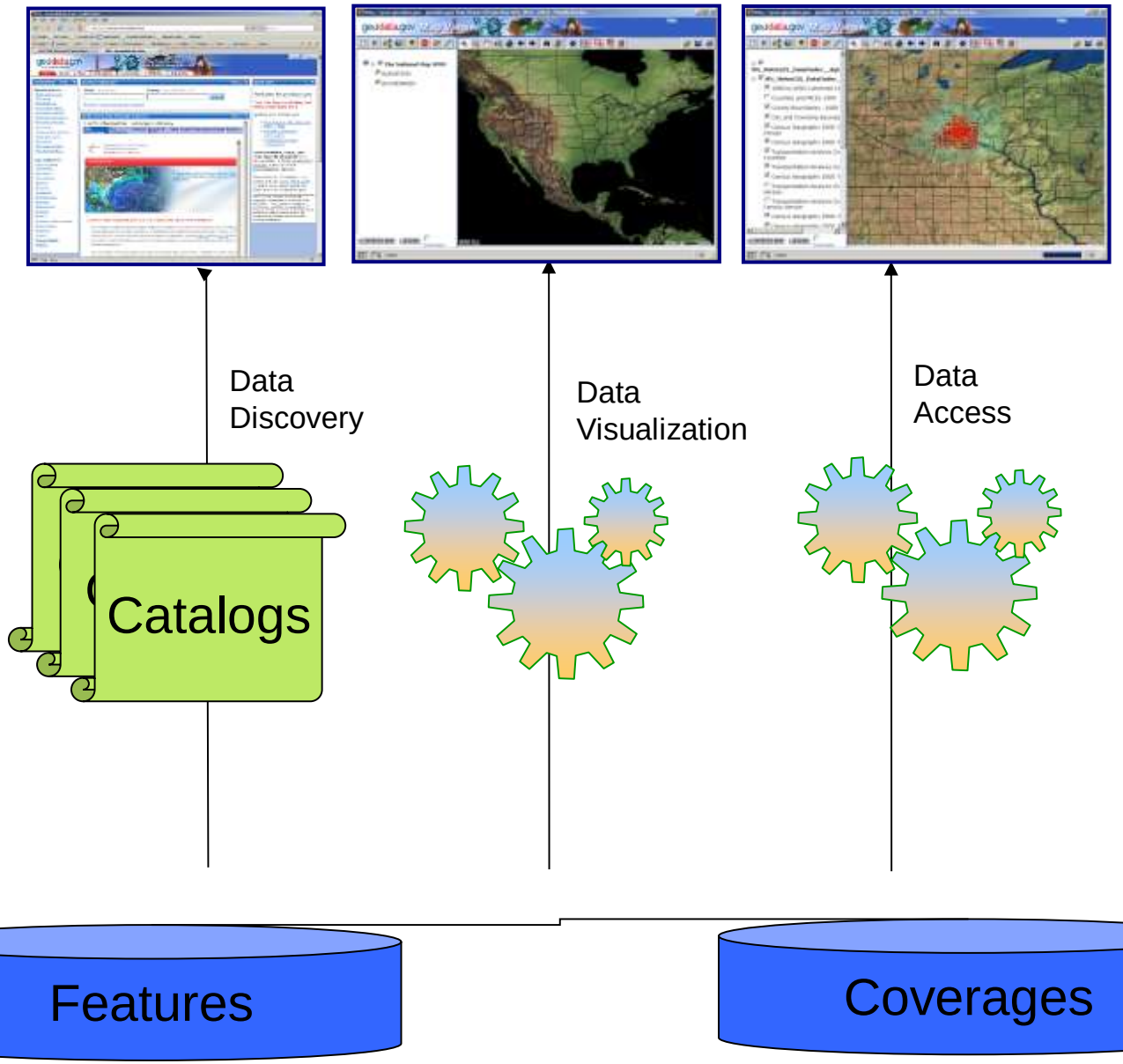
1. Data Access – Provides access to the actual geospatial data

Geospatial Web Services Types

User Applications

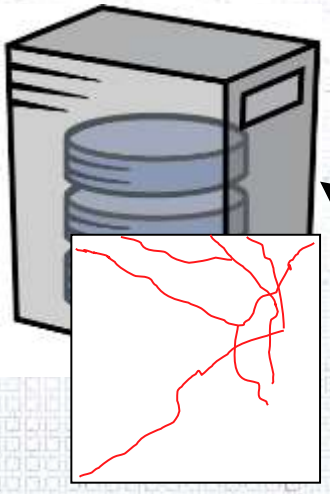
Geospatial Web Services

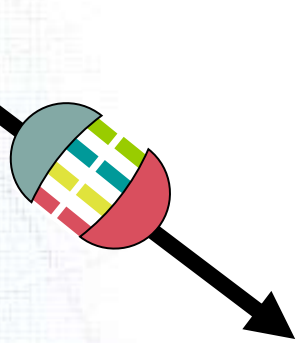
Content Repositories

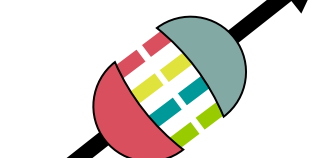


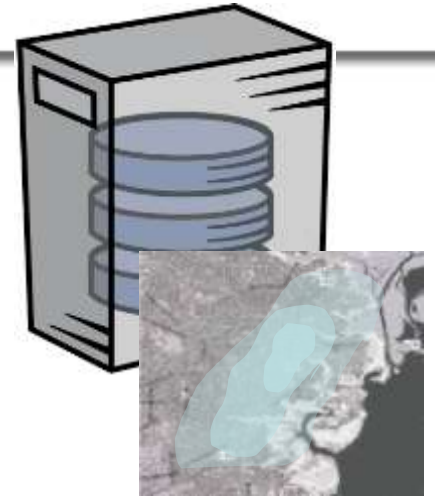
Web Feature Server

Web Coverage Server

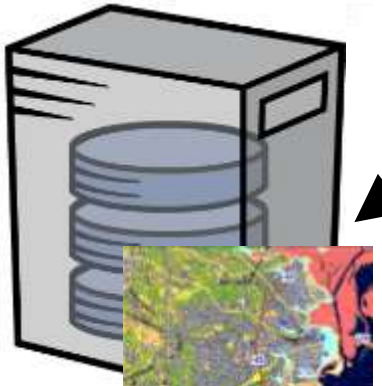






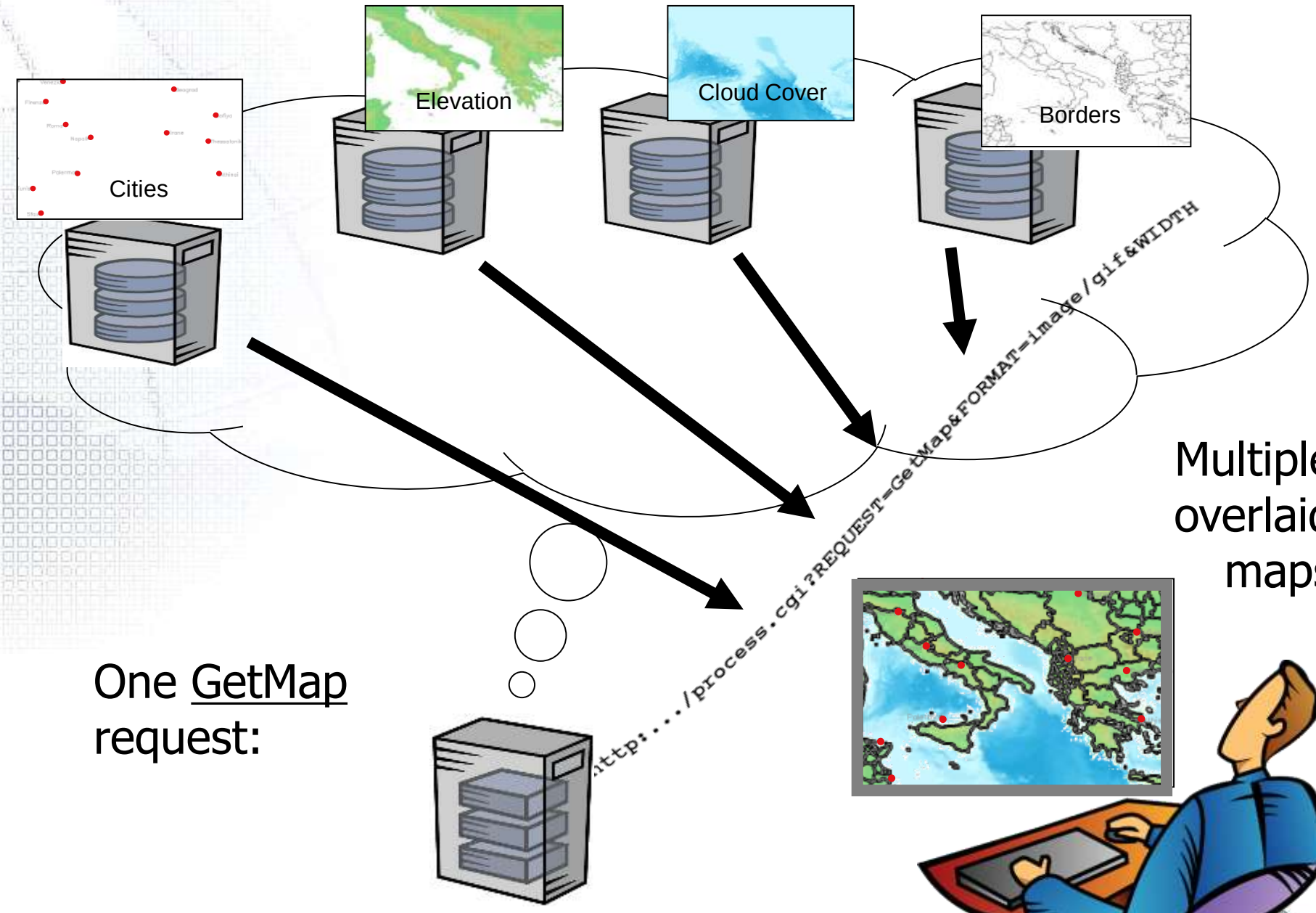


Web Map Server



With OGC web services, an analyst or operator can dynamically access that data which is relevant to the task at hand, directly from the authoritative data steward, using a variety of tools.

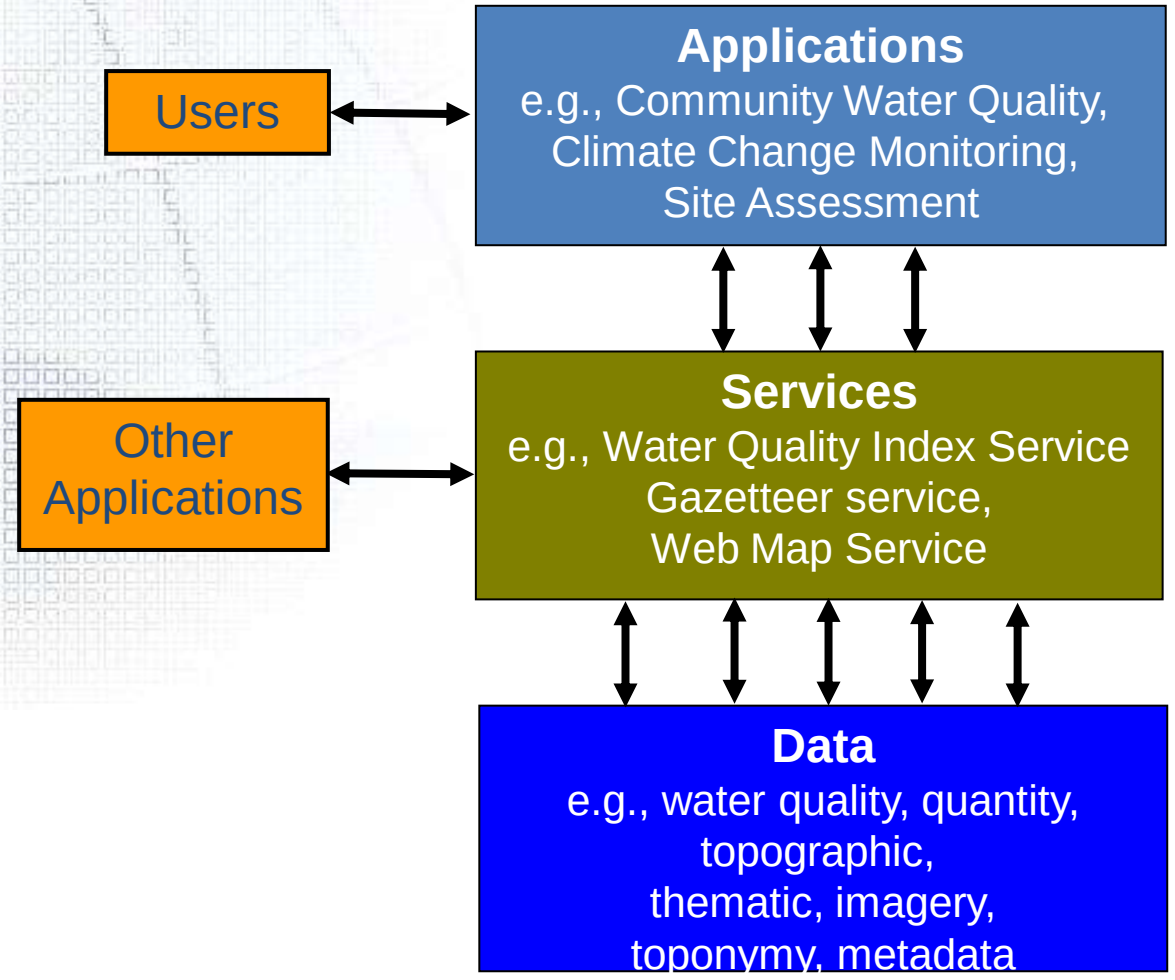
Web Map Service (WMS) can get multiple maps



Multiple overlaid maps

One GetMap request:

Standards based Web Services

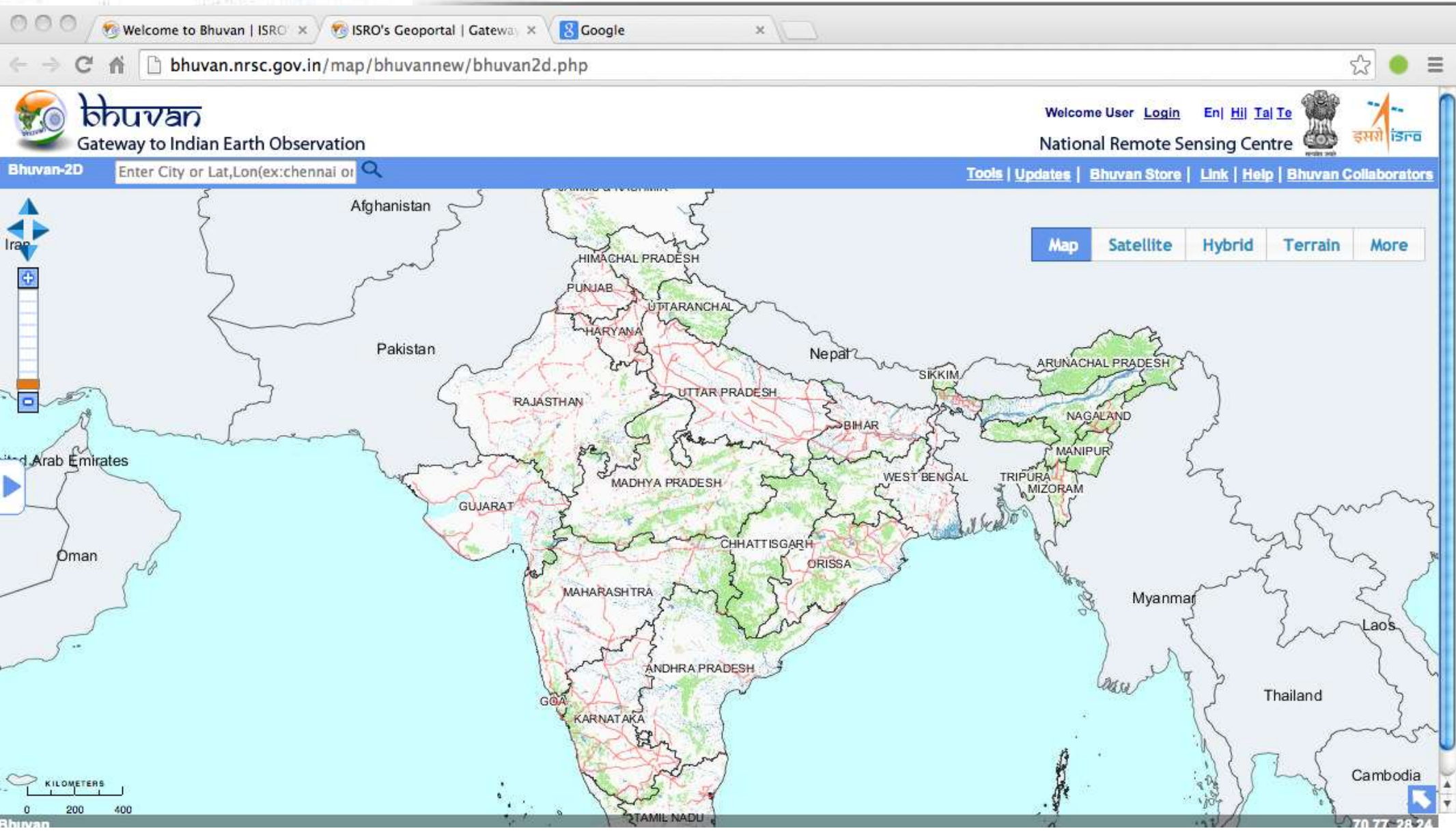


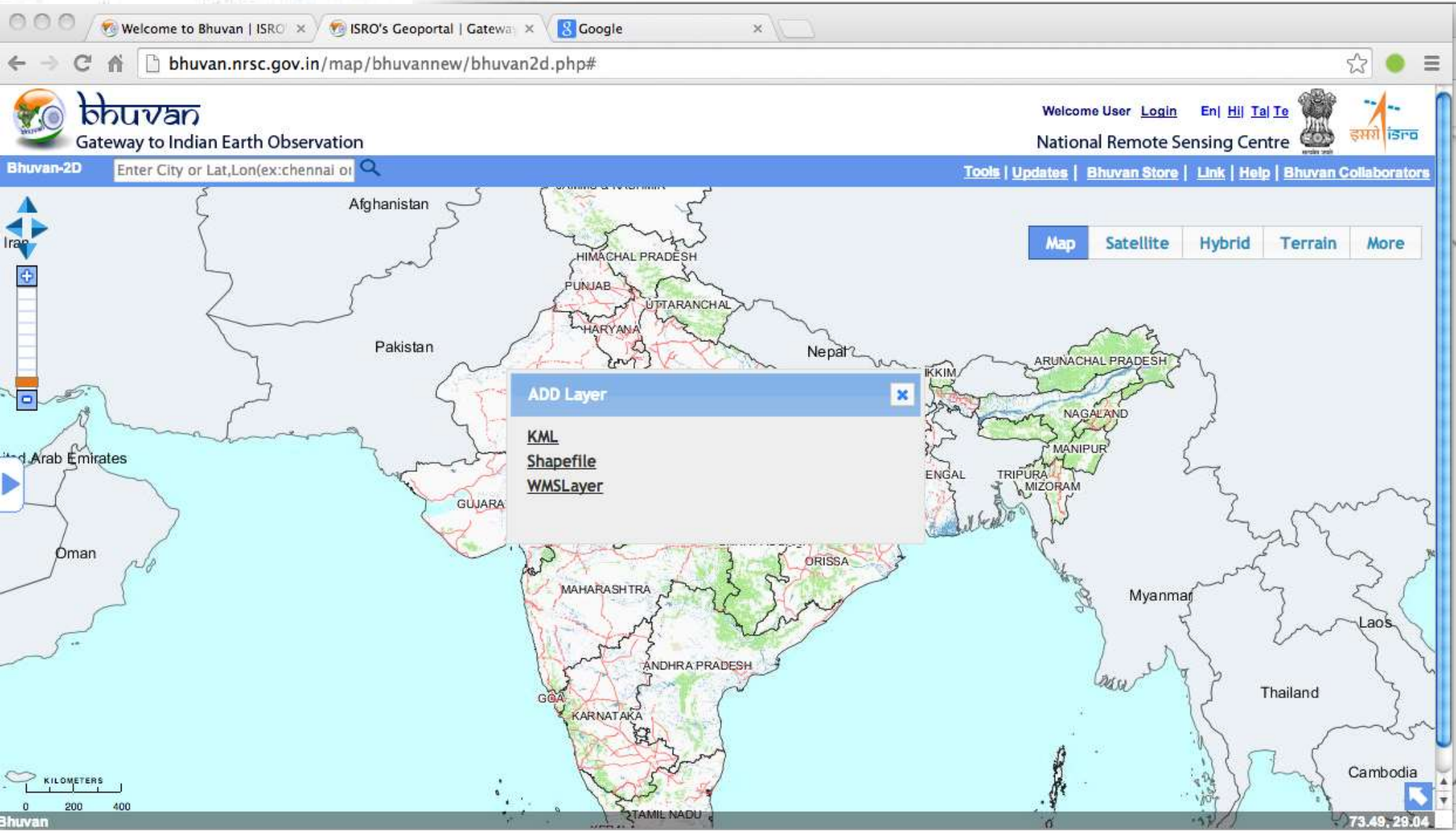
A community website which calculates water quality for a given community

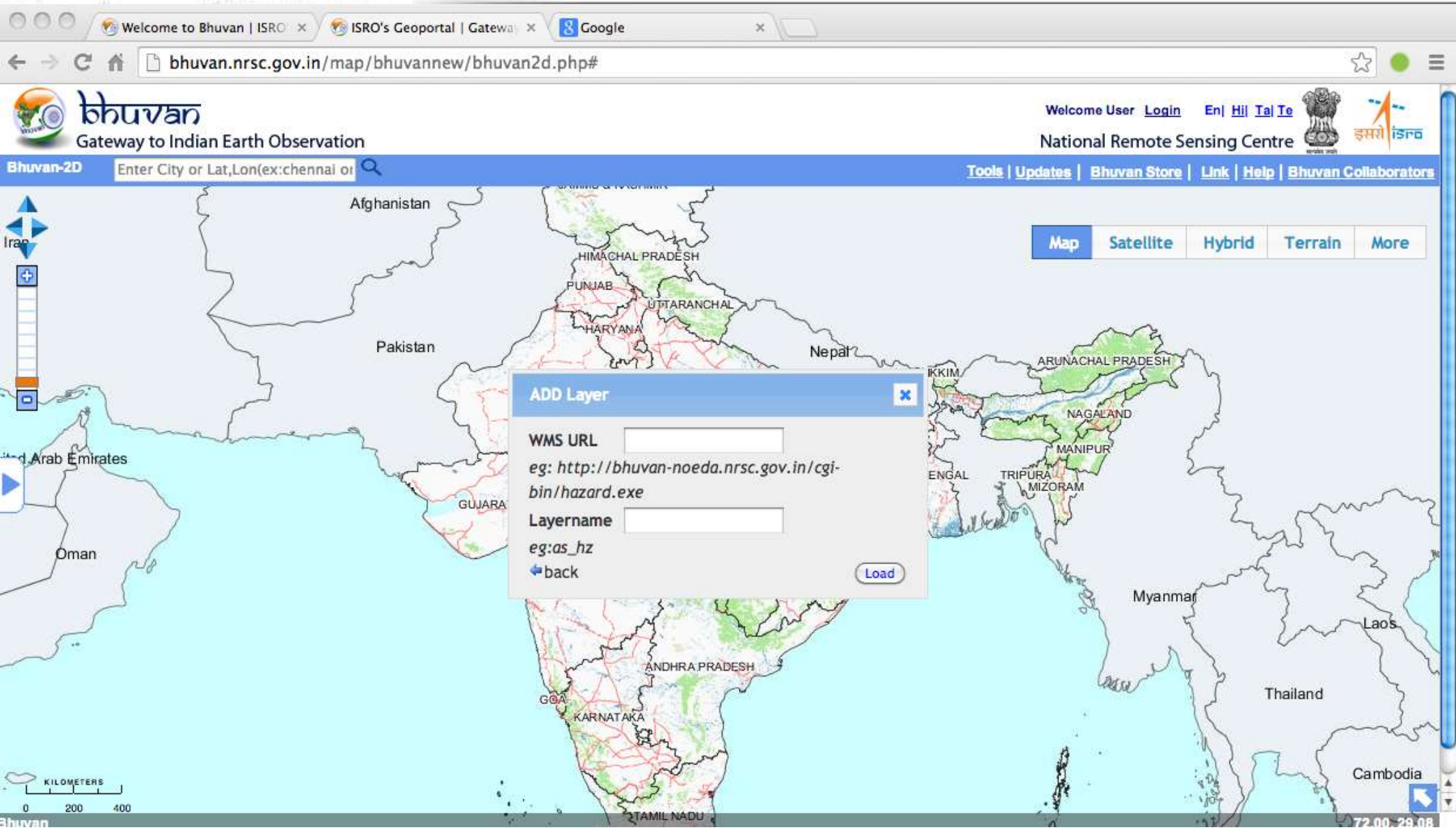
Uses Gazetteer service, Water Quality Index Service

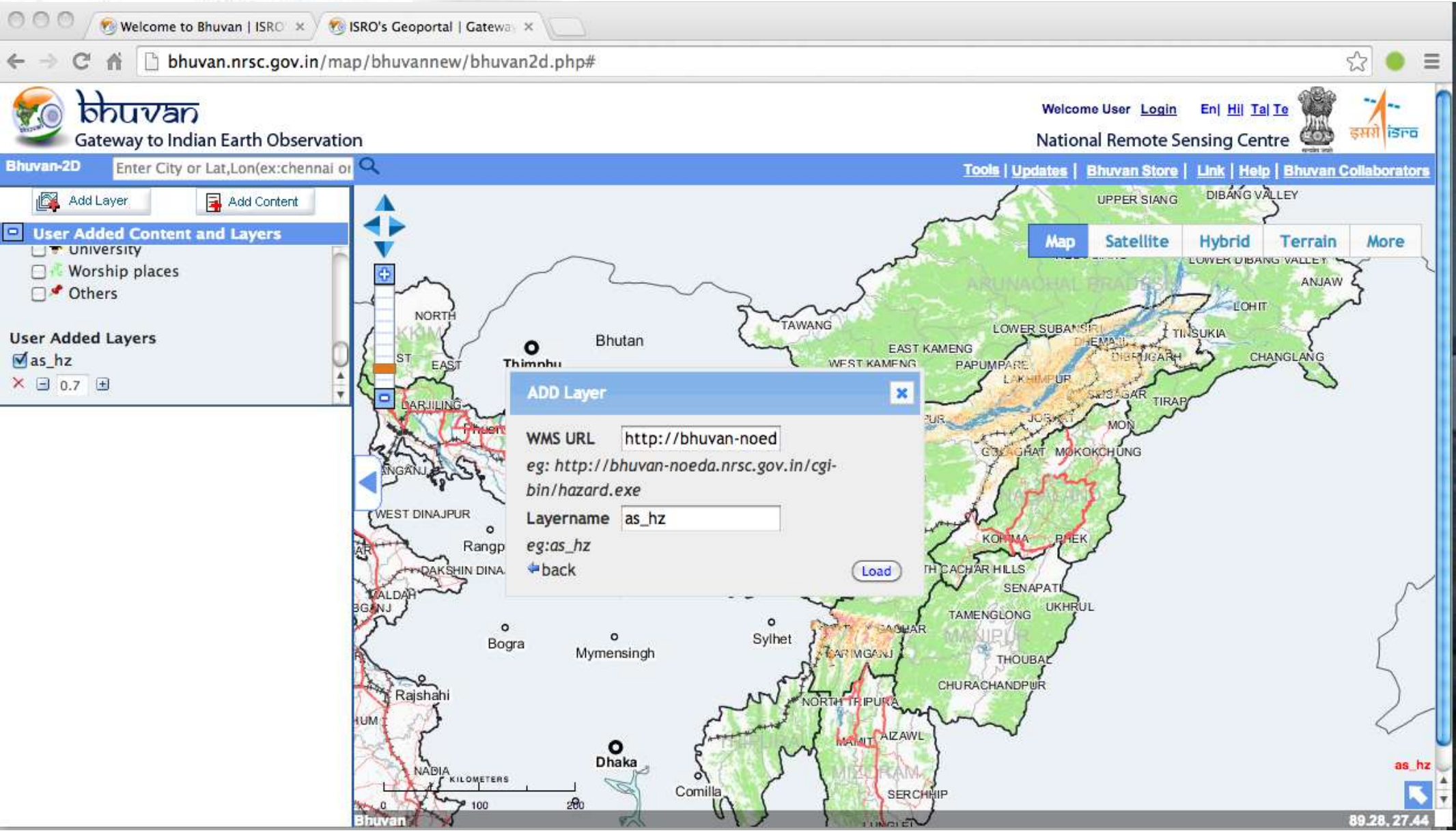
Web Map Service

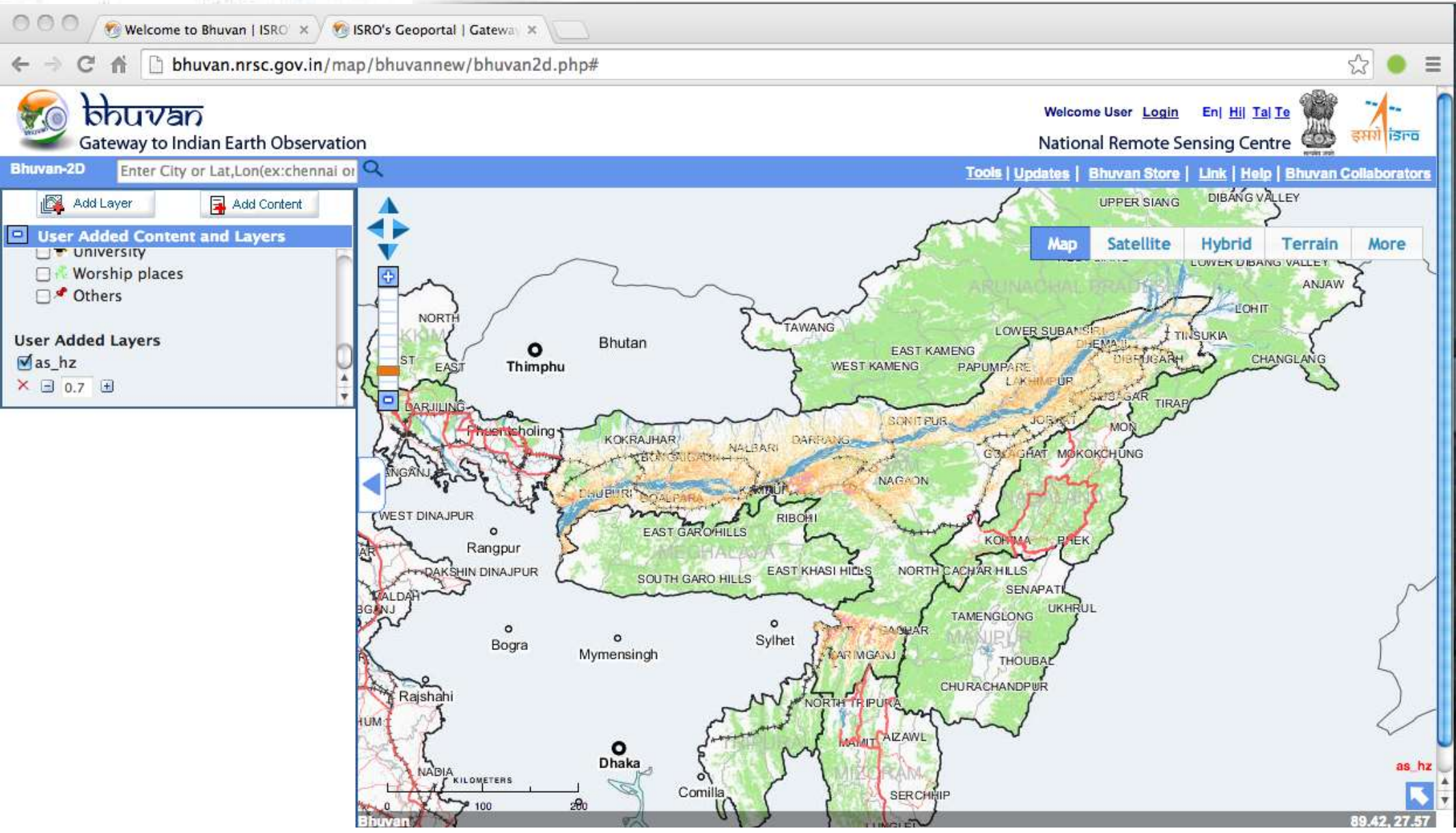
based on Geographical Names, Road network features Base maps

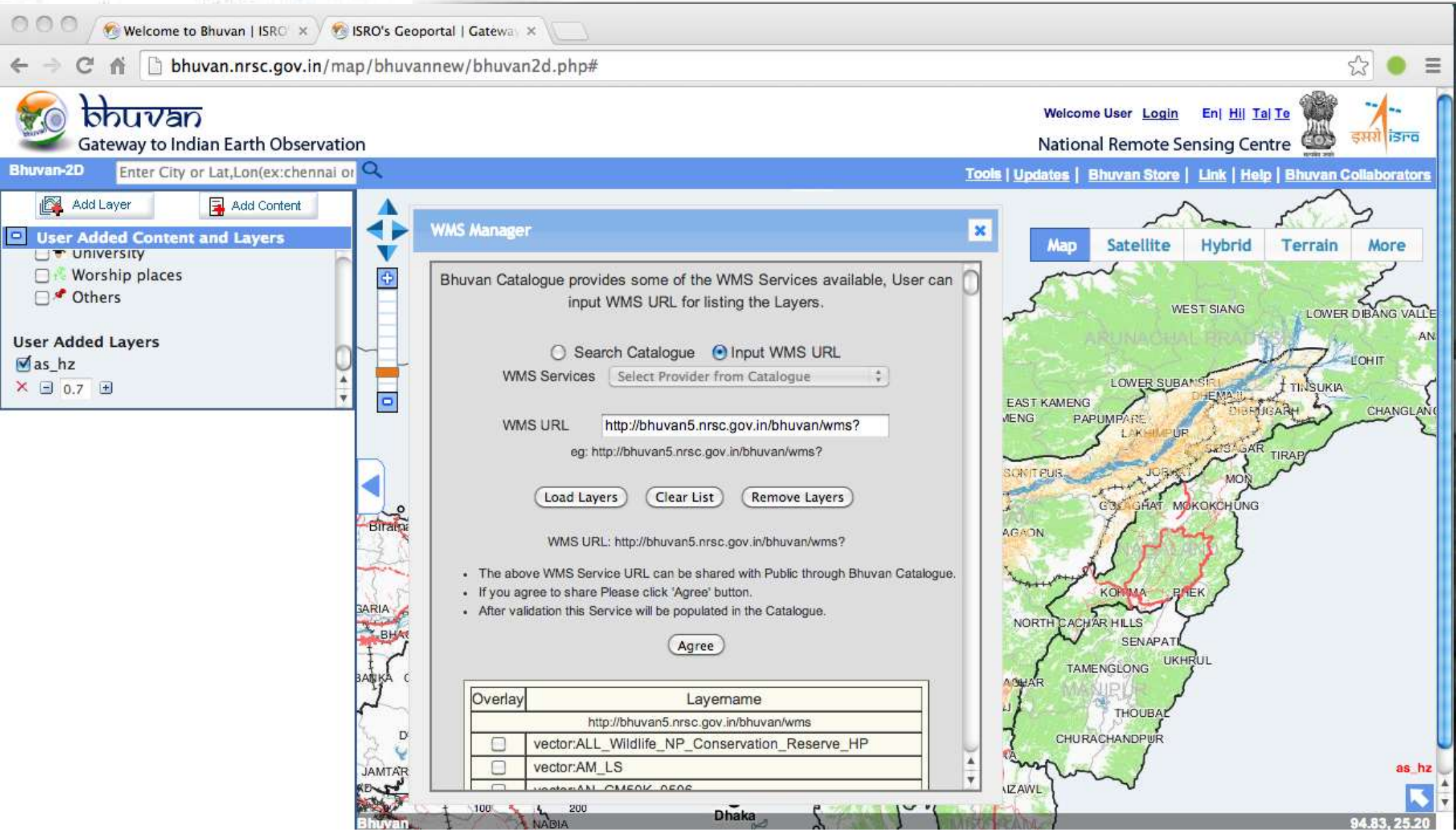

Welcome to Bhuvan | ISRO
ISRO's Geoportal | Gateway
Google
bhuvan.nrsc.gov.in/map/bhuvannew/bhuvan2d.php
bhuvan
Gateway to Indian Earth Observation
Welcome User Login
En| Hi| Ta| Te
National Remote Sensing Centre
Bhuvan-2D
Enter City or Lat,Lon(ex:chennai or
Tools | Updates | Bhuvan Store | Link | Help | Bhuvan Collaborators
Map
Satellite
Hybrid
Terrain
More
Afghanistan
Pakistan
Nepal
HIMACHAL PRADESH
PUNJAB
UTTARANCHAL
HARYANA
RAJASTHAN
UTTAR PRADESH
BIHAR
SIKKIM
ARUNACHAL PRADESH
NAGALAND
MANIPUR
TRIPURA
MIZORAM
WEST BENGAL
MADHYA PRADESH
GUJARAT
CHHATTISGARH
ORISSA
MAHARASHTRA
ANDHRA PRADESH
GOA
KARNATAKA
TAMIL NADU
Oman
Myanmar
Laos
Thailand
Cambodia
KILOMETERS
0 200 400

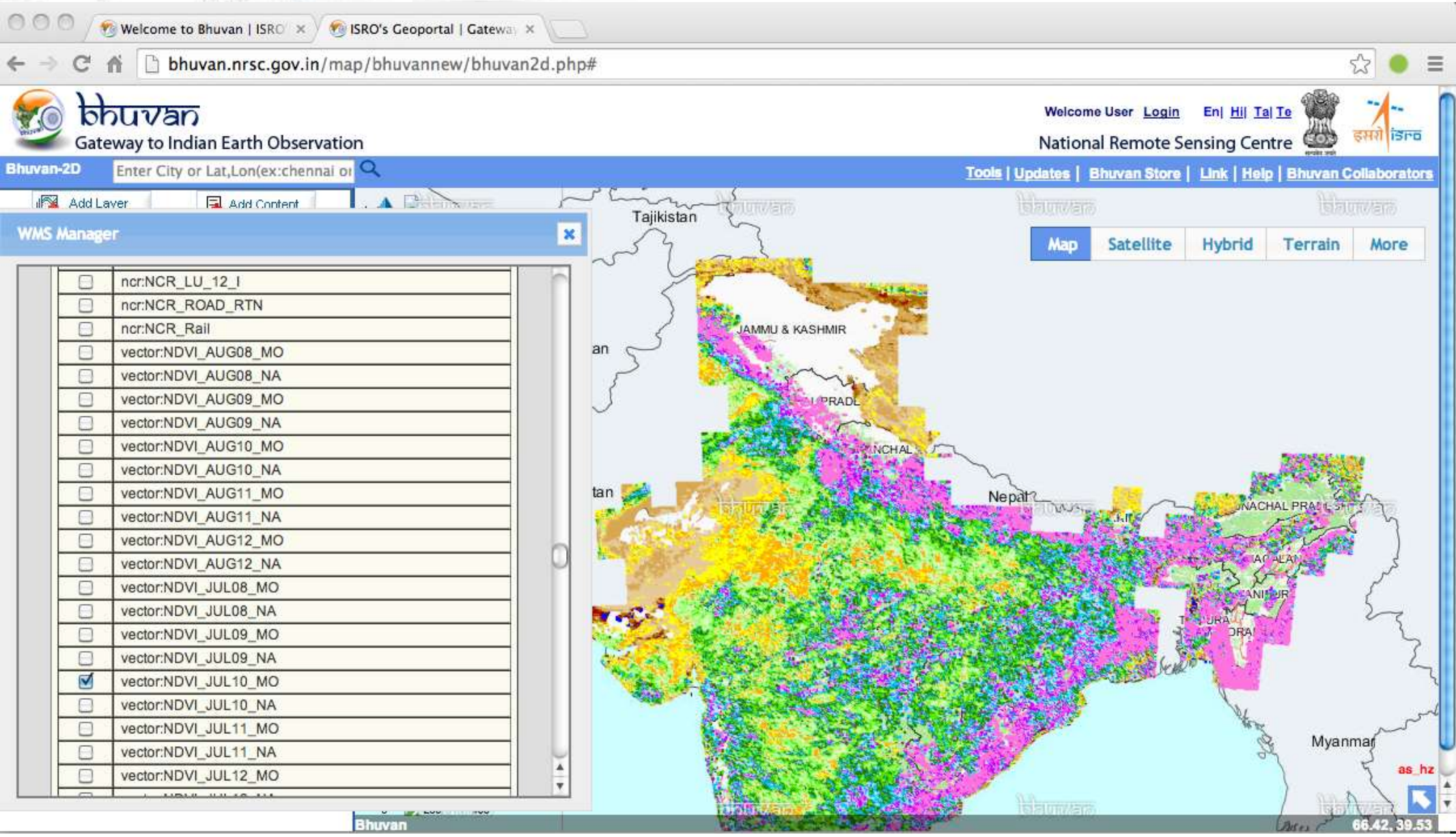

Welcome to Bhuvan | ISRO
ISRO's Geoportal | Gatewa
Google
bhuvan.nrsc.gov.in/map/bhuvannew/bhuvan2d.php#
bhuvan
Gateway to Indian Earth Observation
Welcome User Login
En| Hi| Ta| Te
National Remote Sensing Centre
Bhuvan-2D
Enter City or Lat,Lon(ex:chennai or
Tools | Updates | Bhuvan Store | Link | Help | Bhuvan Collaborators
Map
Satellite
Hybrid
Terrain
More
ADD Layer
KML
Shapefile
WMSLayer
Afghanistan
Pakistan
Nepal
HIMACHAL PRADESH
PUNJAB
UTTARANCHAL
HARYANA
ARUNACHAL PRADESH
NAGALAND
MANIPUR
TRIPURA
MIZORAM
Oman
GUJARA
ORISSA
MAHARASHTRA
Myanmar
Laos
Thailand
Cambodia
ANDHRA PRADESH
GOA
KARNATAKA
TAMIL NADU
KILOMETERS
0 200 400
Bhuvan
73.49, 29.04

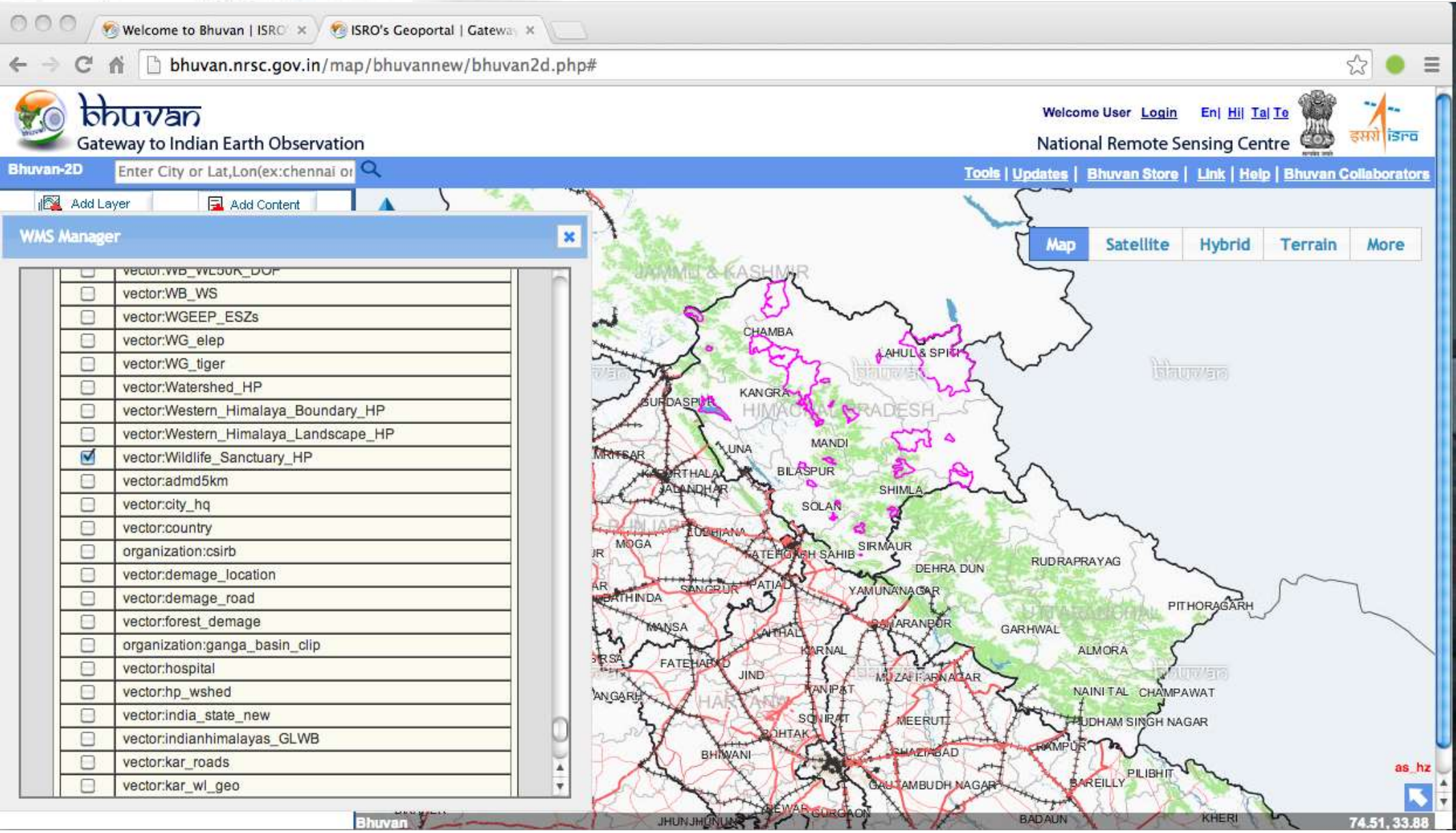

Welcome to Bhuvan | ISRO
ISRO's Geoportal | Gatewa
Google
bhuvan.nrsc.gov.in/map/bhuvannew/bhuvan2d.php#
bhuvan
Gateway to Indian Earth Observation
Welcome User Login
En| Hi| Ta| Te
National Remote Sensing Centre
Bhuvan-2D
Enter City or Lat,Lon(ex:chennai or
Tools | Updates | Bhuvan Store | Link | Help | Bhuvan Collaborators
Map
Satellite
Hybrid
Terrain
More
Afghanistan
Pakistan
Nepal
HIMACHAL PRADESH
PUNJAB
UTTARANCHAL
HARYANA
ARUNACHAL PRADESH
NAGALAND
MANIPUR
TRIPURA
MIZORAM
Myanmar
Laos
Thailand
Cambodia
Oman
ANDHRA PRADESH
GOA
KARNATAKA
TAMIL NADU
ADD Layer
WMS URL
eg: http://bhuvan-noeda.nrsc.gov.in/cgi-bin/hazard.exe
Layername
eg:as_hz
back
Load
KILOMETERS
0
200
400

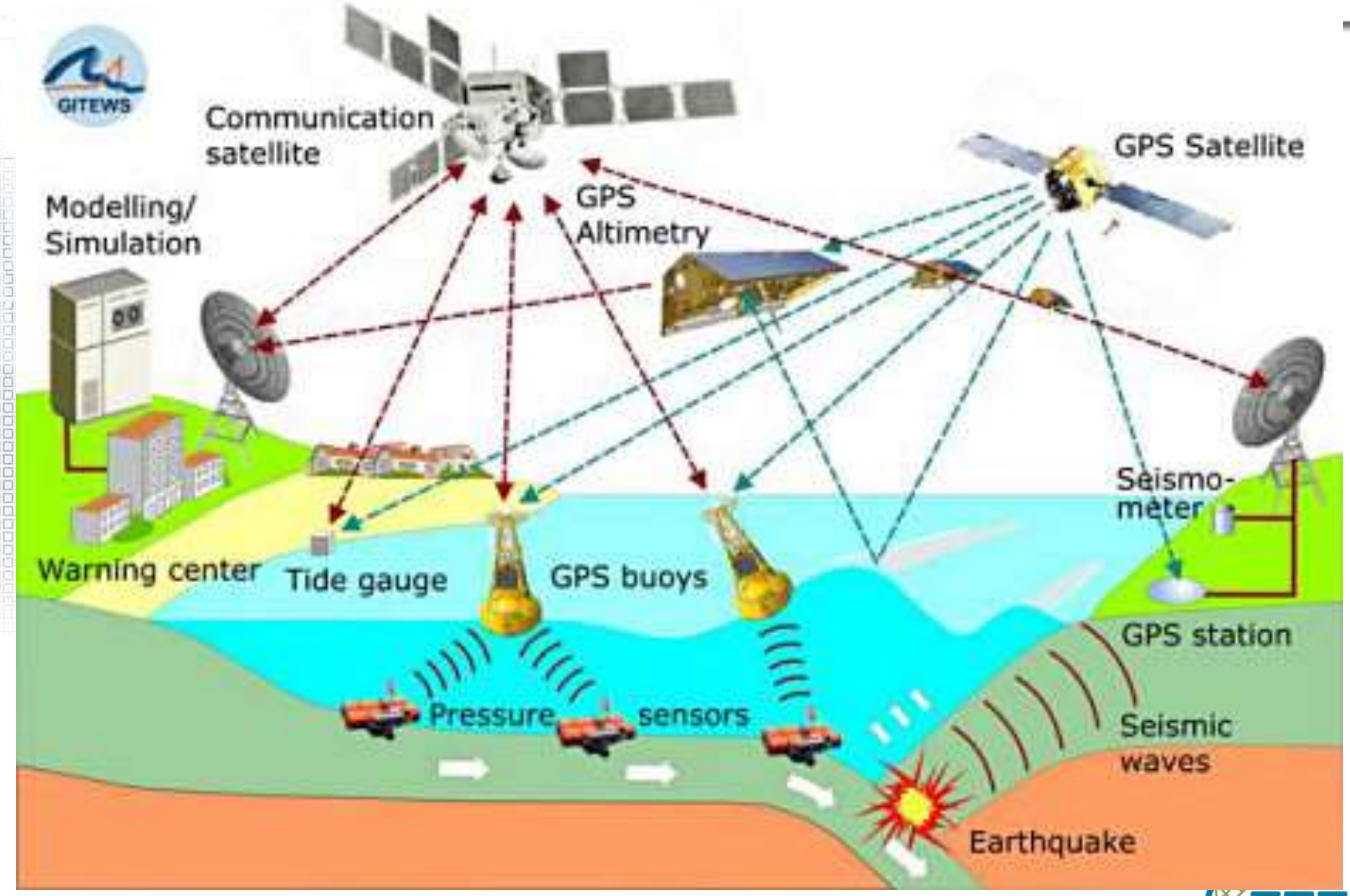

Welcome to Bhuvan | ISRO
ISRO's Geoportal | Gatewa
bhuvan.nrsc.gov.in/map/bhuvannew/bhuvan2d.php#
bhuvan
Gateway to Indian Earth Observation
Welcome User Login
En| Hi| Ta| Te
National Remote Sensing Centre
Bhuvan-2D
Enter City or Lat,Lon(ex:chennai or
Tools | Updates | Bhuvan Store | Link | Help | Bhuvan Collaborators
Add Layer
Add Content
User Added Content and Layers
University
Worship places
Others
User Added Layers
as_hz
0.7
Map
Satellite
Hybrid
Terrain
More
ADD Layer
WMS URL
http://bhuvan-noed
eg: http://bhuvan-noeda.nrsc.gov.in/cgi-bin/hazard.exe
Layername
as_hz
eg:as_hz
back
Load
Bhutan
Thimphu
TAWANG
EAST KAMENG
PAPUMPARE
LOWER SUBANSIRI
TINSUKIA
CHANGLANG
LOHIT
ANJAW
UPPER SIANG
DIBANG VALLEY
TIRAP
MOKOKCHUNG
KOHIMA
PHEK
SENAPATI
UKHRUL
TAMENGLONG
THOUBAL
CHURACHANDPUR
NORTH TRIPURA
AIZAWL
SERCHHIP
Dhaka
Sylhet
Bogra
Mymensingh
Rajshahi
Comilla
WEST DINAJPUR
DARJILING
NADIA
KILOMETERS
0
100
200
as_hz
Bhuvan
89.28, 27.44


Welcome to Bhuvan | ISRO
ISRO's Geoportal | Gateway
bhuvan.nrsc.gov.in/map/bhuvannew/bhuvan2d.php#
bhuvan
Gateway to Indian Earth Observation
Welcome User Login En| Hi| Ta| Te
National Remote Sensing Centre
Bhuvan-2D
Enter City or Lat,Lon(ex:chennai or
Tools | Updates | Bhuvan Store | Link | Help | Bhuvan Collaborators
Add Layer
Add Content
User Added Content and Layers
University
Worship places
Others
User Added Layers
as_hz
0.7
Map
Satellite
Hybrid
Terrain
More
Bhutan
Thimphu
Rangpur
Bogra
Mymensingh
Sylhet
Rajshahi
Dhaka
Comilla
KILOMETERS
0
100
200
as_hz
89.42, 27.57


Welcome to Bhuvan | ISRO
ISRO's Geoportal | Gatewa
bhuvan.nrsc.gov.in/map/bhuvannew/bhuvan2d.php#
bhuvan
Gateway to Indian Earth Observation
Welcome User Login
En| Hi| Ta| Te
National Remote Sensing Centre
Bhuvan-2D
Enter City or Lat,Lon(ex:chennai or
Tools | Updates | Bhuvan Store | Link | Help | Bhuvan Collaborators
Add Layer
Add Content
User Added Content and Layers
University
Worship places
Others
User Added Layers
as_hz
0.7
WMS Manager
Bhuvan Catalogue provides some of the WMS Services available, User can input WMS URL for listing the Layers.
Search Catalogue
Input WMS URL
WMS Services
Select Provider from Catalogue
WMS URL
http://bhuvan5.nrsc.gov.in/bhuvan/wms?
eg: http://bhuvan5.nrsc.gov.in/bhuvan/wms?
Load Layers
Clear List
Remove Layers
WMS URL: http://bhuvan5.nrsc.gov.in/bhuvan/wms?
The above WMS Service URL can be shared with Public through Bhuvan Catalogue.
If you agree to share Please click 'Agree' button.
After validation this Service will be populated in the Catalogue.
Agree
Overlay
Layername
http://bhuvan5.nrsc.gov.in/bhuvan/wms
vector:ALL_Wildlife_NP_Conservation_Reserve_HP
vector:AM_LS
Map
Satellite
Hybrid
Terrain
More
WEST SIANG
LOWER DIBANG VALLE
LOHIT
TINSUKIA
EAST KAMENG
PAPUMPARE
DIBRUGARH
CHANGLANG
TIRAP
MON
MOKOKCHUNG
KOHIMA
PHEK
NORTH CACHAR HILLS
SENAPATI
UKHRUL
TAMENGLONG
MANIPUR
THOUBAL
CHURACHANDPUR
AIZAWL
Dhaka
as_hz
94.83, 25.20

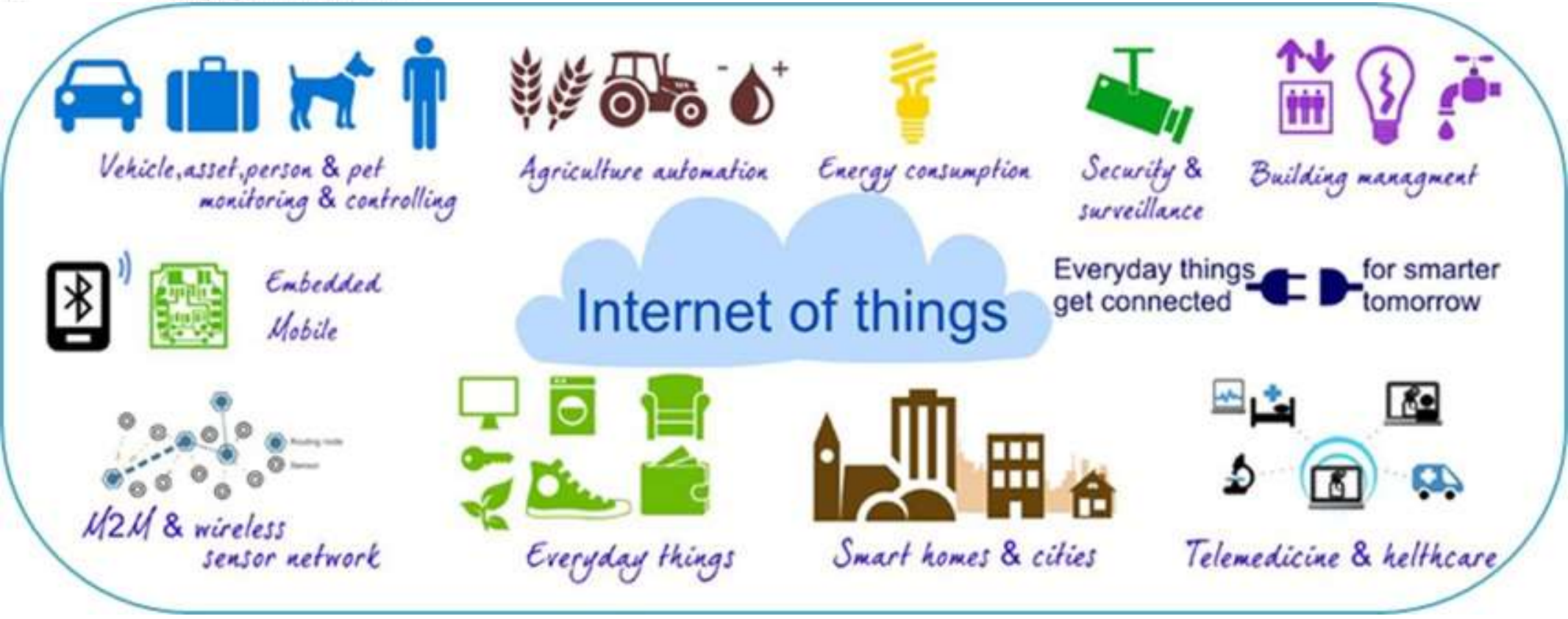

Welcome to Bhuvan | ISRO
ISRO's Geoportal | Gatewa
bhuvan.nrsc.gov.in/map/bhuvannew/bhuvan2d.php#
bhuvan
Gateway to Indian Earth Observation
Welcome User Login En| Hi| Ta| Te
National Remote Sensing Centre
Bhuvan-2D
Enter City or Lat,Lon(ex:chennai or
Tools | Updates | Bhuvan Store | Link | Help | Bhuvan Collaborators
Add Layer
Add Content
WMS Manager
ncr:NCR_LU_12_I
ncr:NCR_ROAD_RTN
ncr:NCR_Rail
vector:NDVI_AUG08_MO
vector:NDVI_AUG08_NA
vector:NDVI_AUG09_MO
vector:NDVI_AUG09_NA
vector:NDVI_AUG10_MO
vector:NDVI_AUG10_NA
vector:NDVI_AUG11_MO
vector:NDVI_AUG11_NA
vector:NDVI_AUG12_MO
vector:NDVI_AUG12_NA
vector:NDVI_JUL08_MO
vector:NDVI_JUL08_NA
vector:NDVI_JUL09_MO
vector:NDVI_JUL09_NA
vector:NDVI_JUL10_MO
vector:NDVI_JUL10_NA
vector:NDVI_JUL11_MO
vector:NDVI_JUL11_NA
vector:NDVI_JUL12_MO
Tajikistan
JAMMU & KASHMIR
Nepal
Myanmar
Map
Satellite
Hybrid
Terrain
More
Bhuvan
66.42, 39.53


Welcome to Bhuvan | ISRO
ISRO's Geoportal | Gatewa
bhuvan.nrsc.gov.in/map/bhuvannew/bhuvan2d.php#
bhuvan
Gateway to Indian Earth Observation
Welcome User Login
En| Hi| Ta| Te
National Remote Sensing Centre
Bhuvan-2D
Enter City or Lat,Lon(ex:chennai or
Tools | Updates | Bhuvan Store | Link | Help | Bhuvan Collaborators
Add Layer
Add Content
WMS Manager
vector:WB_WS
vector:WGEEP_ESZs
vector:WG_elep
vector:WG_tiger
vector:Watershed_HP
vector:Western_Himalaya_Boundary_HP
vector:Western_Himalaya_Landscape_HP
vector:Wildlife_Sanctuary_HP
vector:admd5km
vector:city_hq
vector:country
organization:csirb
vector:demage_location
vector:demage_road
vector:forest_demage
organization:ganga_basin_clip
vector:hospital
vector:hp_wshed
vector:india_state_new
vector:indianhimalayas_GLWB
vector:kar_roads
vector:kar_wl_geo
Map
Satellite
Hybrid
Terrain
More
JAMMU & KASHMIR
CHAMBA
LAHUL & SPITI
KANGRA
GURDASPUR
HIMACHAL PRADESH
MANDI
UNA
BILASPUR
SHIMLA
SOLAN
SIRMAUR
DEHRA DUN
RUDRAPRAYAG
PITHORAGARH
GARHWAL
ALMORA
CHAMPAWAT
NAINITAL
UDHAM SINGH NAGAR
MEERUT
BHIWANI
BAREILLY
PILIBHIT
KHERI
BADAUN
Bhuvan
74.51,33.88

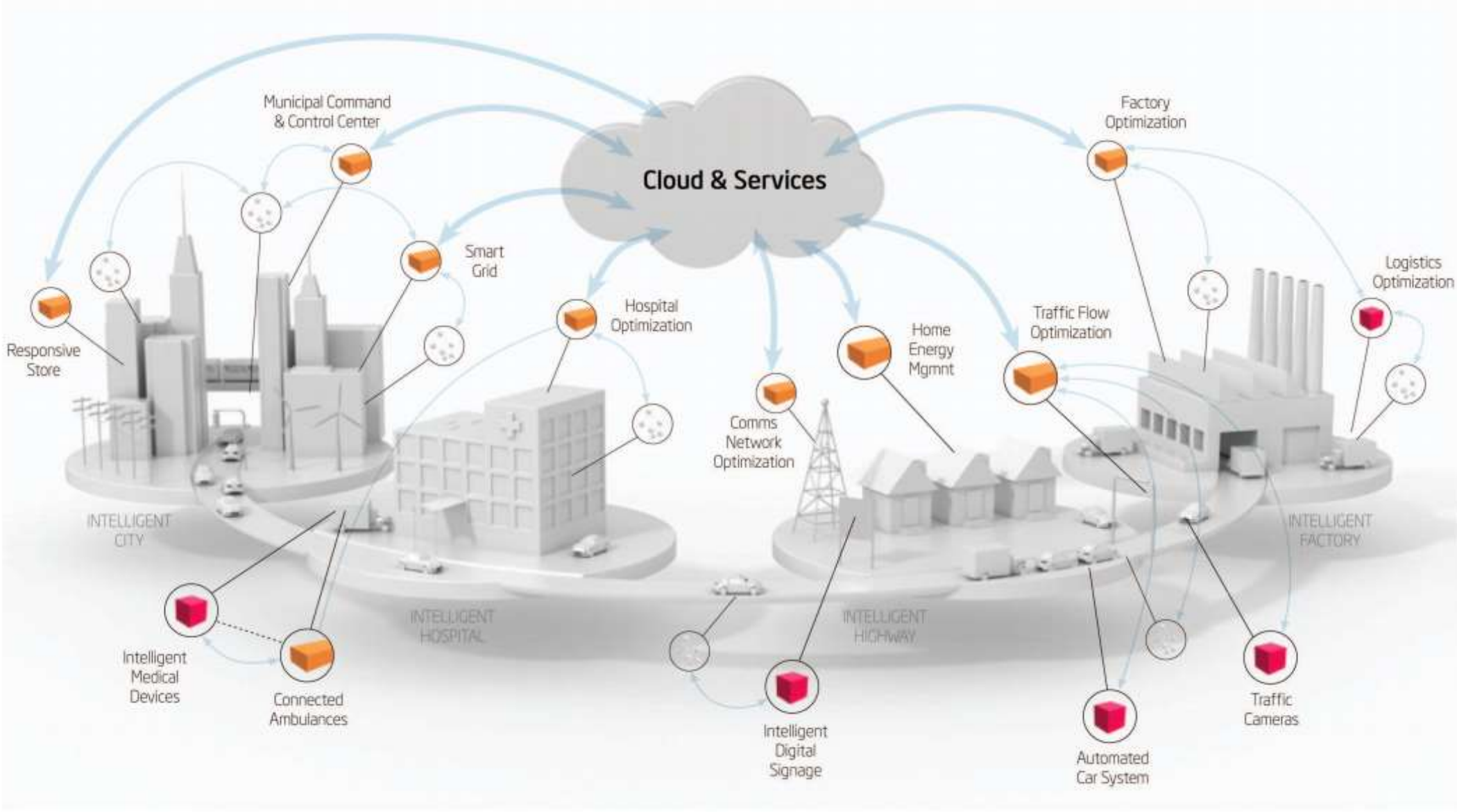


http://www.sensorsmag.com/files/sensor/nodes/2007/1437/Figure4.jpg

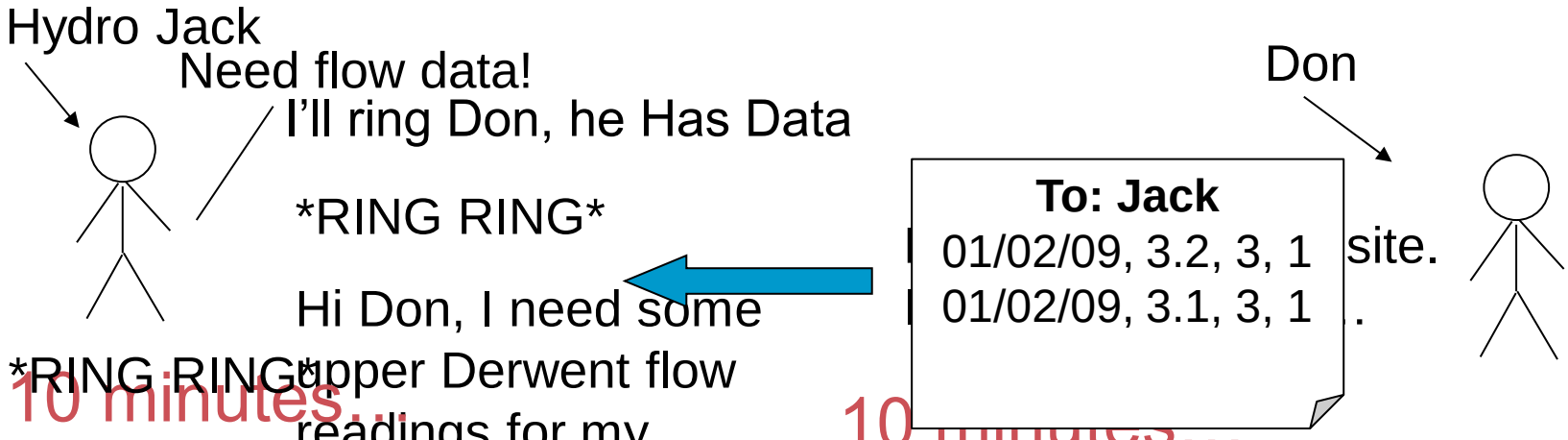
Many Application Areas



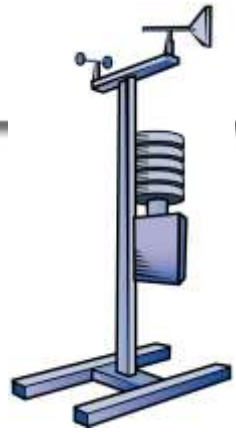
http://2.bp.blogspot.com/-sDQw7QOfEnU/VEvOpzbnL5I/AAAAAAAAALE/ytwoKIz0wX0/


Cloud & Services
Municipal Command & Control Center
Factory Optimization
Smart Grid
Hospital Optimization
Home Energy Mgmnt
Traffic Flow Optimization
Logistics Optimization
Responsive Store
Comms Network Optimization
INTELLIGENT CITY
INTELLIGENT HOSPITAL
INTELLIGENT HIGHWAY
INTELLIGENT FACTORY
Intelligent Medical Devices
Connected Ambulances
Intelligent Digital Signage
Automated Car System
Traffic Cameras

The problem


Hydro Jack
Need flow data!
I'll ring Don, he Has Data
RING RING
Hi Don, I need some upper Derwent flow readings for my geochemical model. Any ideas?
RING RING
10 minutes...
Ok. Got the data. Where is the site located?
Coordinates?
What reference system??
Ok. What sensor is used?
Oh…how accurate is that?
DON?
Don
To: Jack
01/02/09, 3.2, 3, 1
01/02/09, 3.1, 3, 1
site.
.
10 minutes...
Oh, it's at laughing jack bridge.
Ummm. (papers shuffle)
147.123 -41.588
I think it's GDA94
It's calculated from the stream gauge reading using a rating curve..
Umm.....
CLICK

Sensor Webs



- *Sensors connected to and discoverable on the Web*
- *Sensors have position & generate observations*
- *Sensor descriptions available*
- *Services to task and access sensors*
- *Local, regional, national scalability*

Automobile
As Sensor Probe

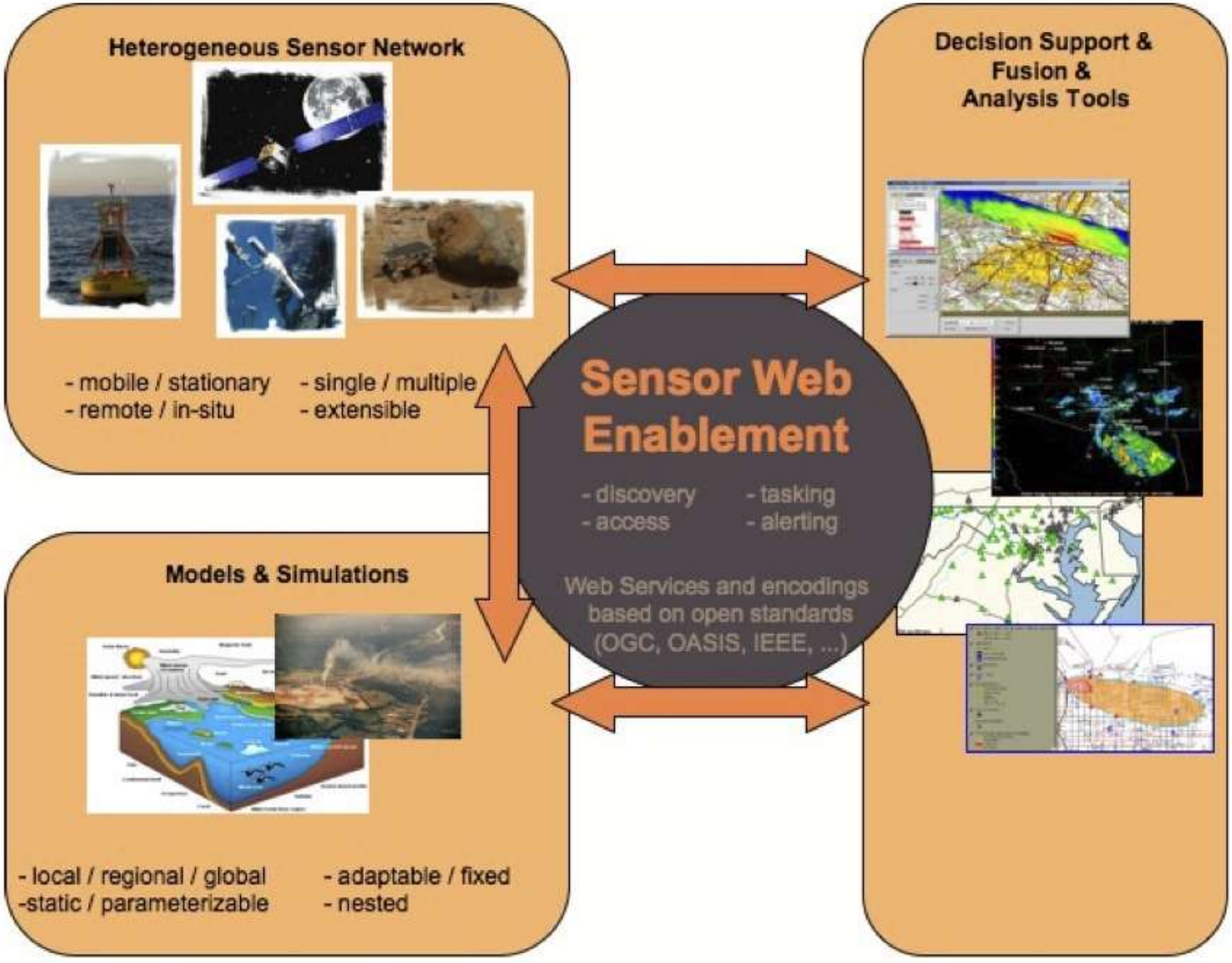
Environmental
Monitor

Traffic
Monitoring

Satellite-borne Imaging Device

Health
Monitor

Webcam


Heterogeneous Sensor Network
- mobile / stationary
- remote / in-situ
- single / multiple
- extensible
Models & Simulations
- local / regional / global
-static / parameterizable
- adaptable / fixed
- nested
Sensor Web Enablement
- discovery
- access
- tasking
- alerting
Web Services and encodings based on open standards (OGC, OASIS, IEEE, ...)
Decision Support & Fusion & Analysis Tools

Sensor Web Vision I

- Sensors will be web accessible
- Sensors and sensor data will be discoverable
- Sensors will be self-describing to humans and software (using a standard encoding)
- Most sensor observations will be easily accessible in real time over the web

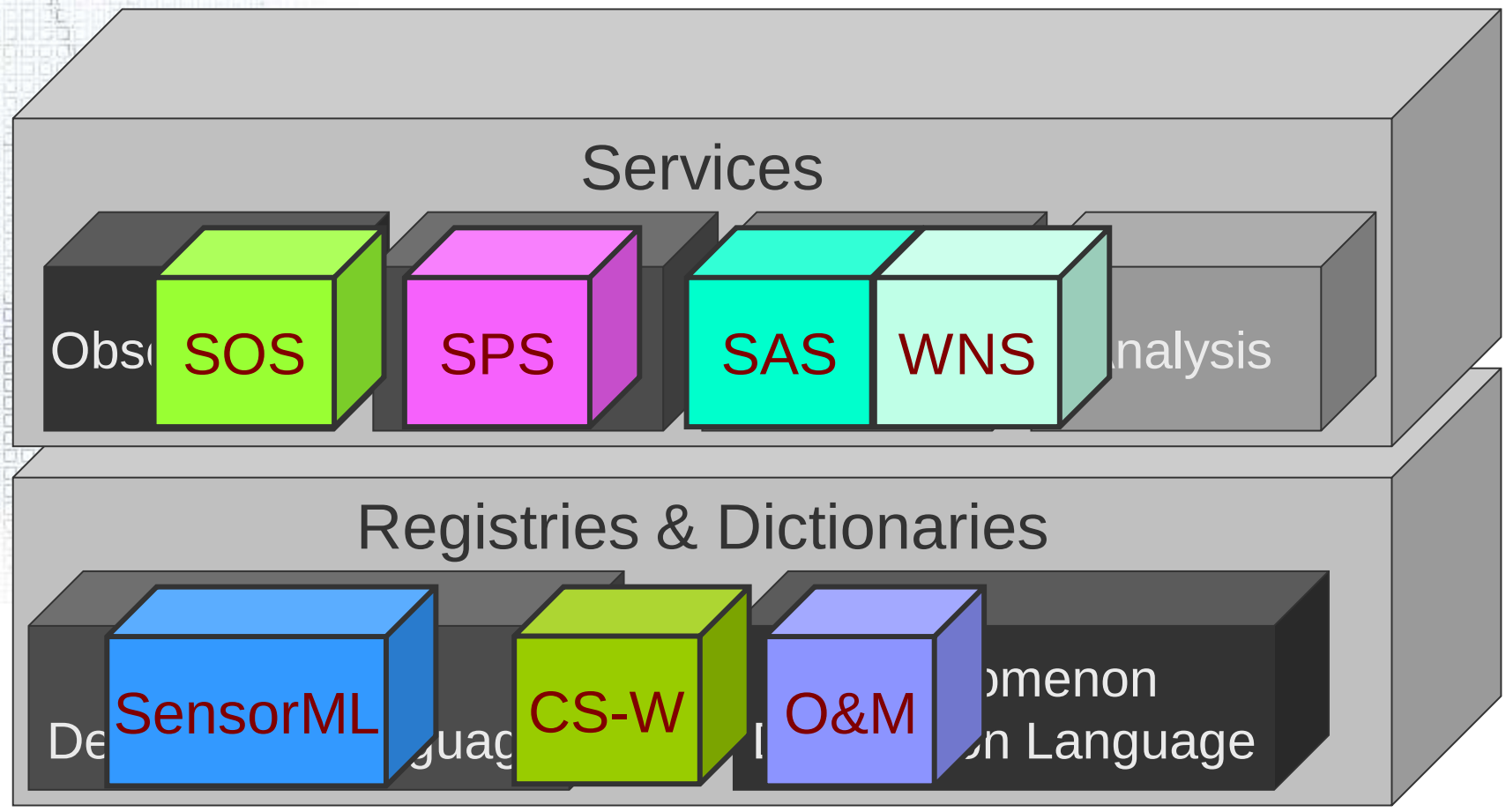
Sensor Web Vision II

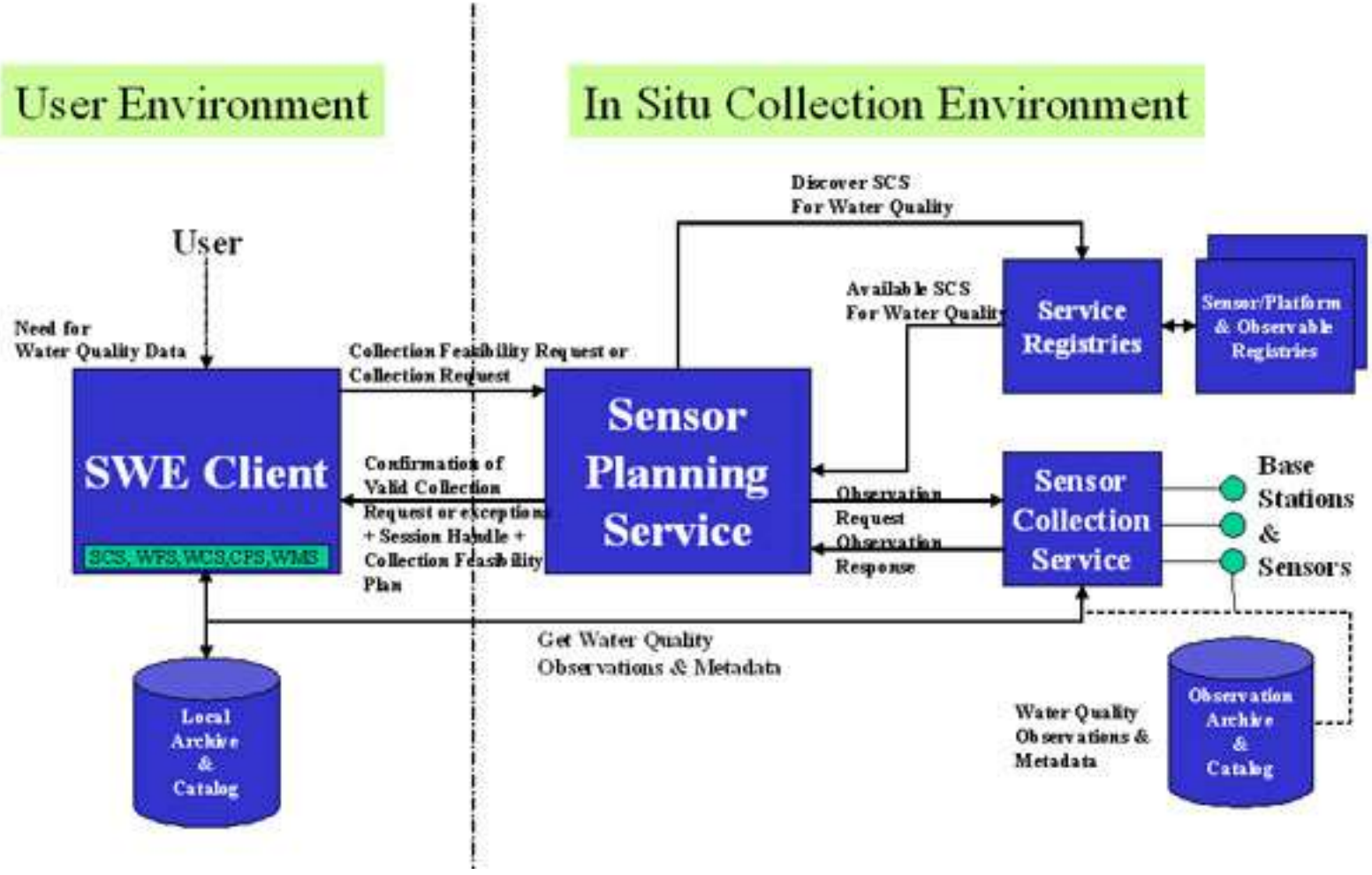
- Standardized web services will exist for accessing sensor information and sensor observations
- Sensor systems will be capable of real-time mining of observations to find phenomena of immediate interest
- Sensor systems will be capable of issuing alerts based on observations, as well as be able to respond to alerts issued by other sensors

Sensor Web Vision III

- Software will be capable of on-demand geolocation and processing of observations from a newly-discovered sensor without *a priori* knowledge of that sensor system
- Sensors, simulations, and models will be capable of being configured and tasked through standard, common web interfaces
- Sensors and sensor networks will be able to act on their own (i.e. be autonomous)

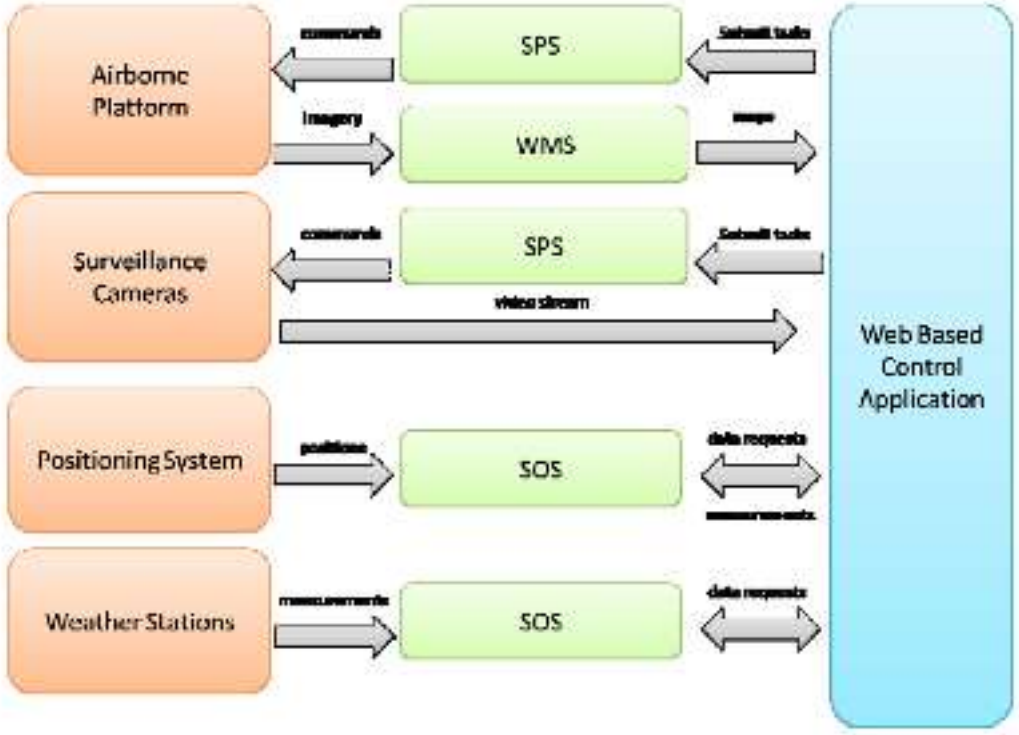
Building Blocks: OGC SWE





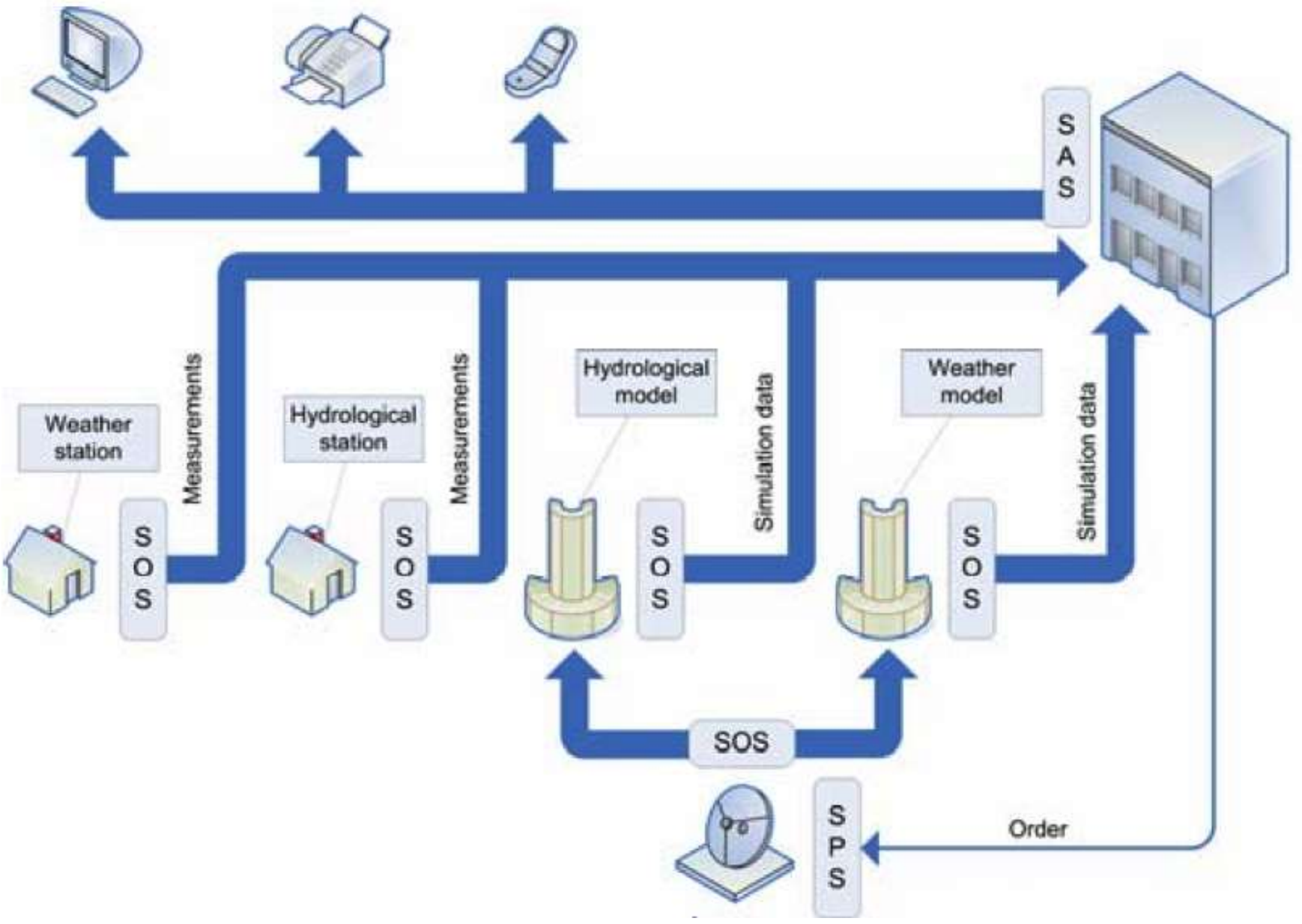
Source: crisisgrid.org

Forest Fire Monitoring



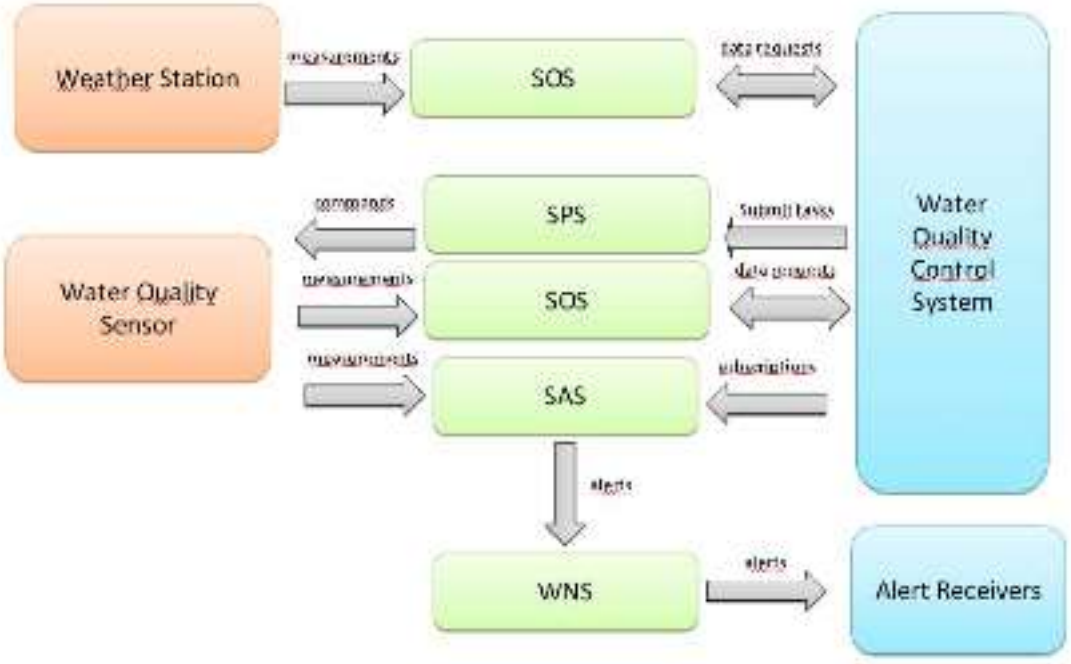
Jirka, S., Broring, A., Stasch, C.: Applying OGC Sensor Web Enablement to Risk Monitoring ¨ and Disaster Management. In: GSDI 11 World Conference, Rotterdam, Netherlands (June 2009)

Flood Monitoring and Prediction



Source: Nataliia Kussul, Andrii Shelestov, Sergii Skaku
THE SENSOR WEB TESTBED FOR FLOOD MONITORING AND PREDICTION

Water Quality Monitoring

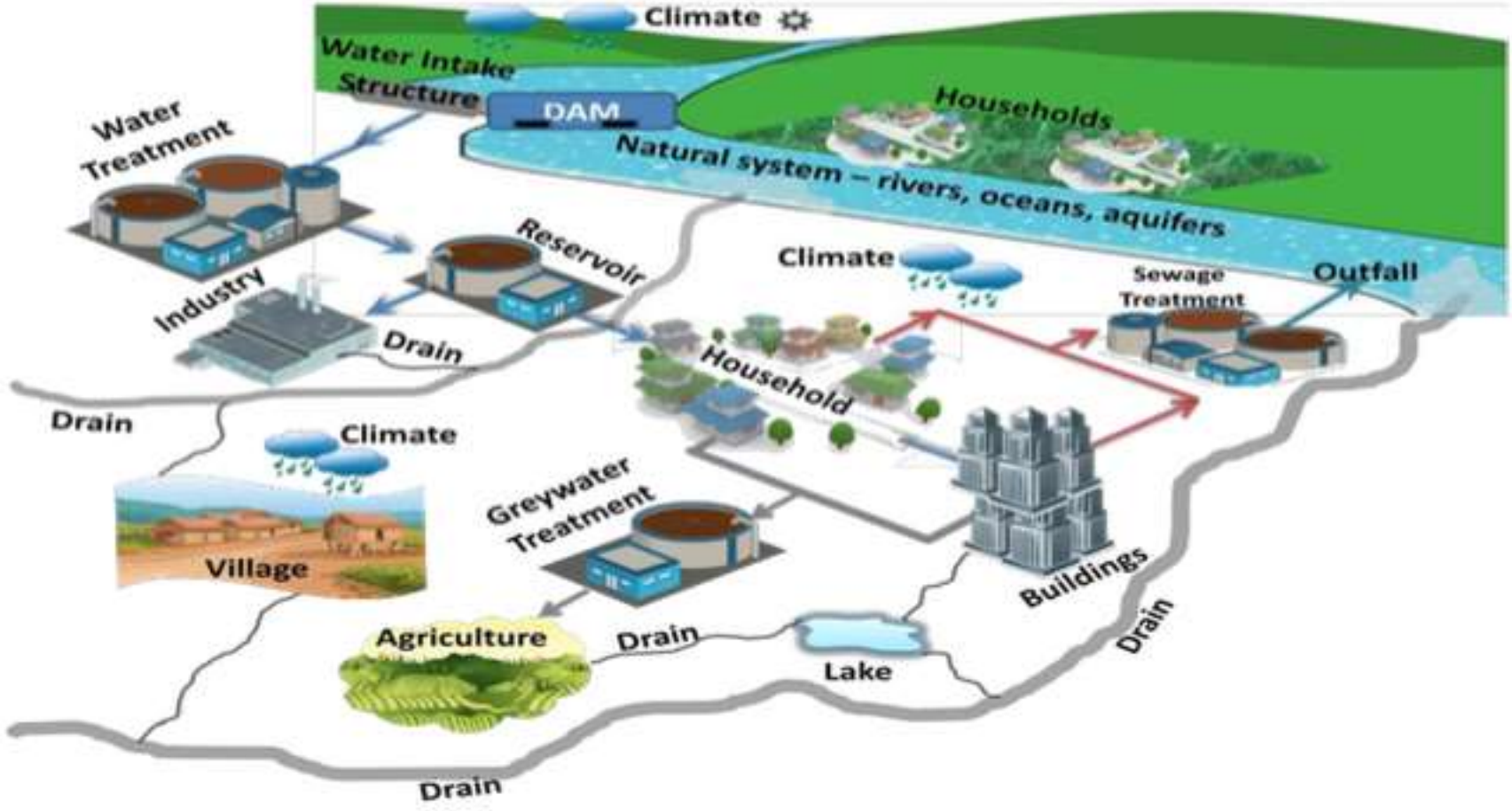


Jirka, S., Broring, A., Stasch, C.: Applying OGC Sensor Web Enablement to Risk Monitoring and Disaster Management. In: GSDI 11 World Conference, Rotterdam, Netherlands (June 2009)

'IMpacting Research, INnovation and Technology' (IMPRINT-India)

Domain: Water Resources and River Systems

MHRD has entrusted IITs and IISc to identify the needs of the country in research and technology requirements so as to enable proper planning for manpower, research infrastructure and resources in ten domains of national interest. The outcome of this exercise would be policy documents on education and research.



IMpacting Research, INnovation and Technology' (IMPRINT-India)

Major Science Questions

- ★ What are the key gaps in data availability, monitoring and dissemination at various spatial and temporal scales that affect water resources and river systems?
- ★ To what extent water availability and water demands changed historically and how these are likely to change in future?
- ★ How sensitive are the river basins towards changes in land-use/ land- cover and climate?

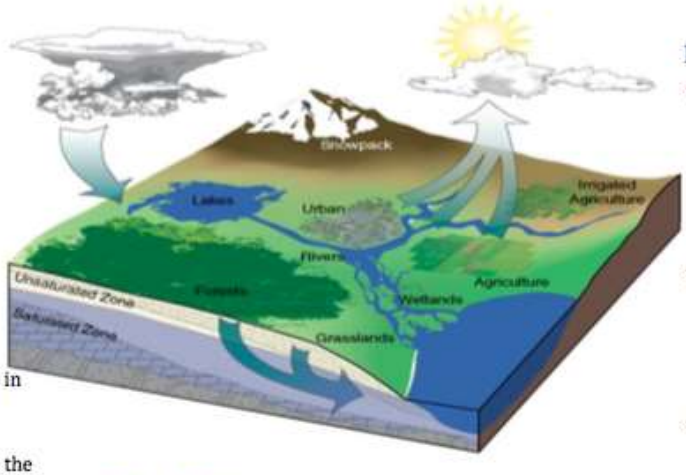
IMpacting Research, INnovation and **Technology' (IMPRINT** - India)

IMPRINT INDIA DOMAIN
WATER RESOURCES AND RIVER SYSTEMS

An impending water crisis stares the country in her face today. To illustrate: many of our rivers and water bodies are heavily polluted, posing severe health problems; many cities and towns face acute water shortage every year; much of the population has no access to safe drinking water; overexploited groundwater resources are affecting agricultural output in large tracts of the country; and rapidly vanishing water bodies have gravely damaged aquatic ecosystems and their resilience. The low efficiencies of irrigation water use and poor water management practices and policies at all levels have contributed to the overall aquatic crisis. The focus of the IMPRINT initiative in this domain is to evolve appropriate educational and research policies that can overcome the critical challenges of water resources and river systems.

Themes

- ★ River Basins
- ★ Water in Urban Systems
- ★ Water in Rural Ecosystems
- ★ Water & Agriculture
- ★ Water & Industry
- ★ Spatial Data Infrastructure for Real-Time Data Acquisition and Dissemination



Grand Challenges

- ★ Close water and nutrient loop in agriculture, rural, urban and industrial sectors
- ★ Define, maintain and improve the health of water bodies
- ★ Convert rapid flows to sluggish flows to increase water availability for human and ecosystems
- ★ Increase water-use efficiency through cost effective technology, interventions, measurements, pricing mechanisms, informed opinions and public policies
- ★ Recognize and disseminate traditional knowledge and practices regarding management of water and water bodies

Major Science Questions

- ★ What are the key gaps in data availability, monitoring and dissemination at various spatial and temporal scales that affect water resources and river systems?
- ★ To what extent water availability and water demands changed historically and how these are likely to change in future?
- ★ How sensitive are the river basins towards changes in land-use/ land- cover and climate?

Valuing Water

Water is not only a commodity, but its true value also includes social, cultural, environmental and economic values. All of these must be considered in appraising different policies and initiatives to realize the goals of Integrated Water Resources Management (IWRM) – social equity, environmental sustainability and economic efficiency. Unfortunately, this is rarely done in many developing countries where poor

Governance

The water crisis in many countries today is largely a governance problem. National responses to water-related disasters and shortages, allocation of transboundary water resources, management of national water resources, and building capacity and knowledge should all be jointly shared by governments and civil society. In reality,

Urban Water Cycle

Preparation of Policy Document on

Education & Research

- ★ Assessment of present status and setting benchmarks for engineering, innovation and education
- ★ Identification of - R&D gaps, policy gaps and implementation issues
- ★ Articulate shift in human resource development policy at various levels - school to higher education, vocational, etc.
- ★ Re-adjust focus, identify needs (infrastructure, financial and human resources) and set timelines for R&D
- ★ Suggest measures for addressing implementation issues

Knowledge & Capacity Development

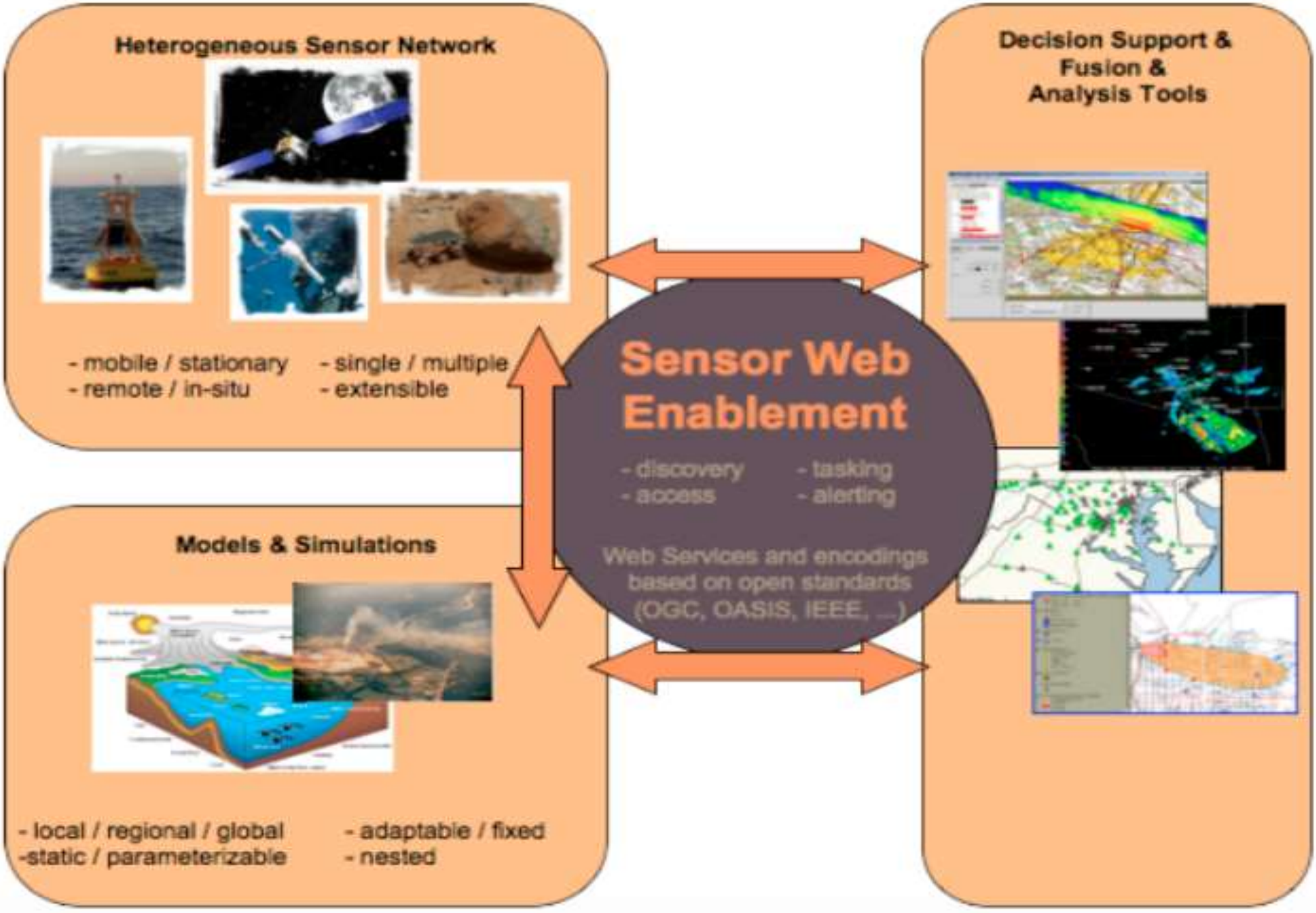
IMpacting Research, INnovation and **Technology' (IMPRINT** - India)

★ **Spatial Real-Time Data Infrastructure**

With huge gaps in data and scanty real-time data, water resource and river management lie at the mercy of thumb rules and guesstimates. A robust quality-controlled data collection system with real-time open access underlies all future knowledge-based approaches.

IMpacting Research, INnovation and **Technology' (IMPRINT**-India)

- *Discovery and access mechanisms for sensors and data within and across wireless sensor networks (WSNs)_*
- *Development of standardized catalogue or sensors registry, for querying services, individual sensors, and spatio-temporal data.*
- *Ability to retrieve the lineage of sensor observations (Data provenance)*
- *Automatic sensor installation, configuration and operation (GC)*
- *Integrating diverse sensors into observation systems*
- *Integrating data from sensor networks into the National Spatial Data Infrastructure (NSDI)*
- *Event based-notification and alerts*
- *Ability to support on-demand processing of sensor observations accessed from disparate and sensor networks belonging to multiple domains (e.g. Water and environment)*
- *Development of remotely taskable sensor systems (GC)*


Heterogeneous Sensor Network
- mobile / stationary
- remote / in-situ
- single / multiple
- extensible
Models & Simulations
- local / regional / global
-static / parameterizable
- adaptable / fixed
- nested
Sensor Web Enablement
- discovery
- access
- tasking
- alerting
Web Services and encodings based on open standards (OGC, OASIS, IEEE, ...)
Decision Support & Fusion & Analysis Tools

Geosemantic Web

Semantic Interoperability

"*Although standards from bodies like the OGC provide the basis for syntactic interoperability the usability of information that is created in one context is often of limited use in another context because of insufficient means for meaningful interpretation*"

(Bernard, Einspanier, Haubrock, et al., 2003),

Image search: Tiger

Images Showing: All image sizes

Results **22** - **42** of about **44,700,000** for **tiger**. (**0.03** seconds)

Related searches: **white** tiger tiger **cub** **cartoon** tiger **baby** tiger

Tigers firing in Russia
600 x 307 - 20k - jpg
www.fprado.com
[More from www.fprado.com]

The **Tiger** I, hunting on the ...
532 x 301 - 21k - jpg
www.fprado.com

Welcome to the **Tiger** I Information ...
600 x 387 - 77k - jpg
www.alanhamby.com

Siberian **tiger** in snow
550 x 361 - 28k - jpg
advocacy.britannica.com

Photo: **Tiger** shark just below the ...
470 x 324 - 28k - jpg
animals.nationalgeographic.com
[More from animals.nationalgeographic.com]

Royal Bengal **tiger**
432 x 489 - 30k - jpg
www.solarnavigator.net

Tiger and Earl Woods
300 x 300 - 48k - jpg
sports.espn.go.com
[More from assets.espn.go.com]

Insert your **Tiger** (10.4) install ...
500 x 522 - 59k - png
overstimulate.com

... by Tatiana the **tiger** at the San ...
376 x 394 - 39k - gif
catsworking.wordpress.com

Tiger drawing
1600 x 1200 - 314k - jpg
felinos.files.wordpress.com

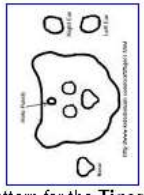
Bengal **Tigers** have unique markings.
800 x 546 - 343k - gif
library.thinkquest.org

Tiger I, used for training of ...
392 x 420 - 24k - jpg
www.fprado.com

Tiger Woods tied Arnold Palmer for ...
300 x 300 - 17k - jpg
sports.espn.go.com

Thus, the **Tiger** Shark consumes ...
450 x 300 - 24k - jpg
www.elasmo-research.org

The featured mode in **Tiger** 2005 is ...
440 x 330 - 102k - jpg
pc.gamespy.com



Print pattern for the **Tiger** Cub ...
395 x 541 - 27k - jpg
www.kidsdomain.com

The Top Gun **Tiger** cluster size is ...
356 x 433 - 42k - jpg
www.theregister.co.uk

Like the other big cats, **tigers** are ...
400 x 308 - 24k - jpg
www.21stcenturytiger.org

Types of **Tigers**
350 x 350 - 21k - jpg
greennature.com

ears opened on **tiger**
400 x 313 - 7k - jpg
www.origami-instructions.com

Eye of the **tiger**
450 x 300 - 97k - gif
www.uga.edu

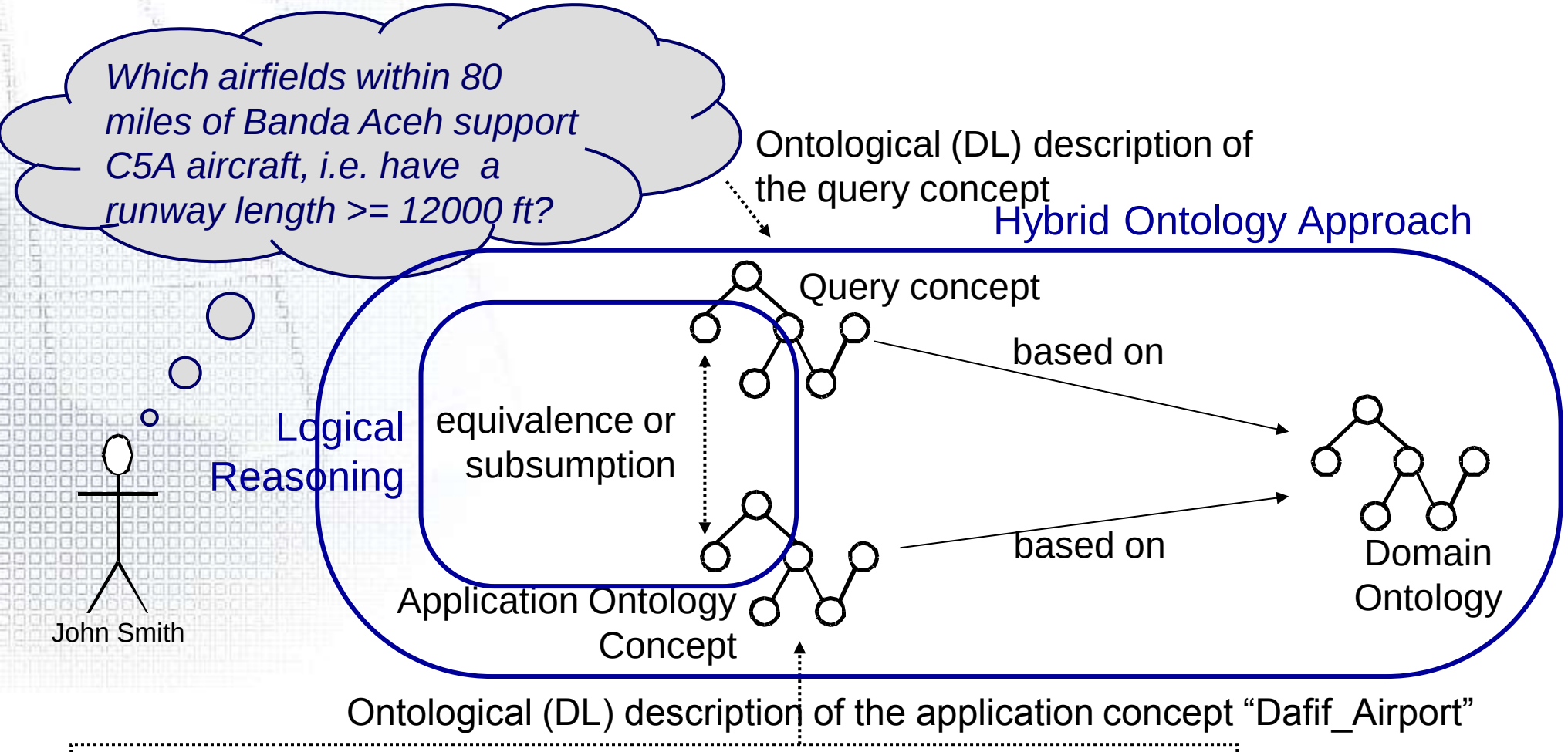
◄ Goooooooooogle ►

Previous 1 2 3 4 5 6 7 8 9 10 11 Next

Semantic Web

- Semantic means *meaning*
  - Meaning enables a more effective use of the underlying data. Meaning is often absent from most information sources, requires users or complex programming instructions to supply it.
  - Semantics give a keyword symbol useful meaning through the establishment of relationships. (e.g. Building, Bank, etc)

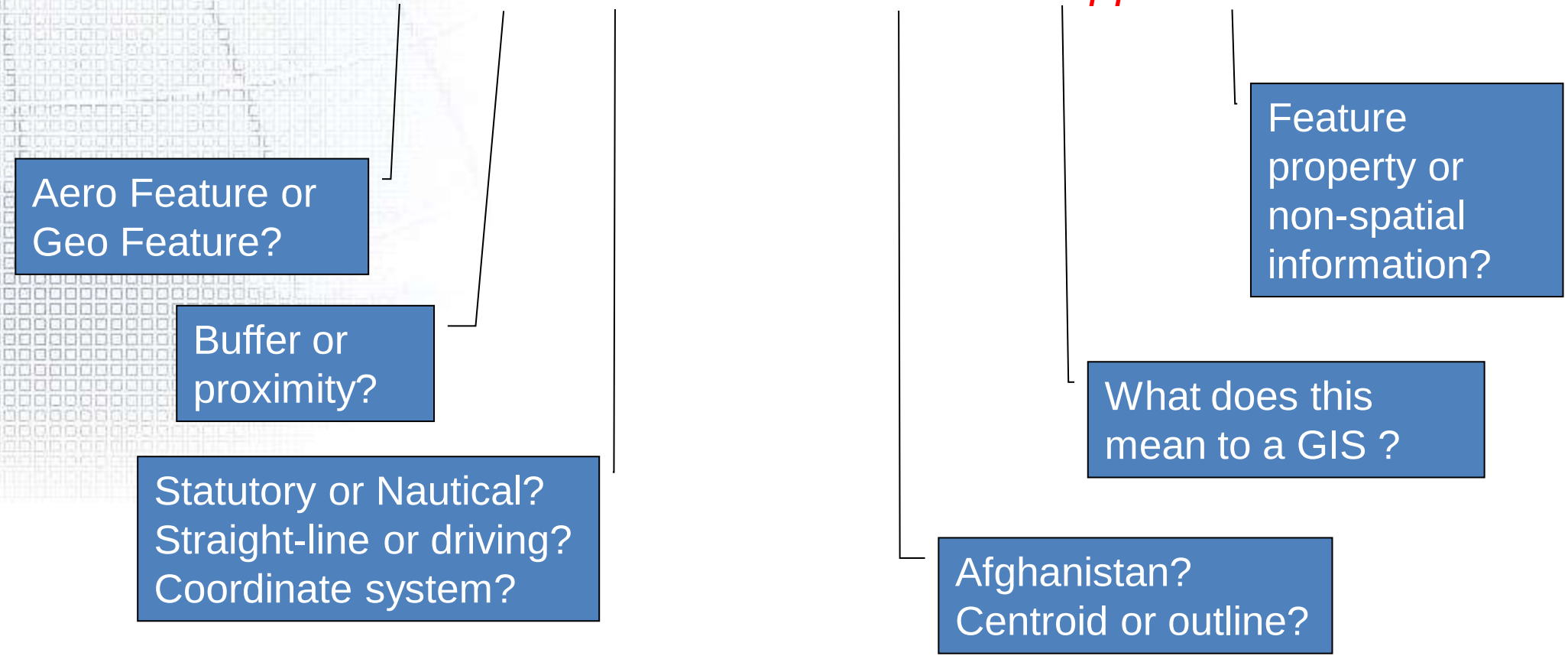
Ontologies for Enhanced GI Discovery



ID	Name	Airp_Ident	ICAO	Elev	Type
1	Greenville	US01357	KZ	00541	A
2	Festus Mem	US05536	KZ	00433	A

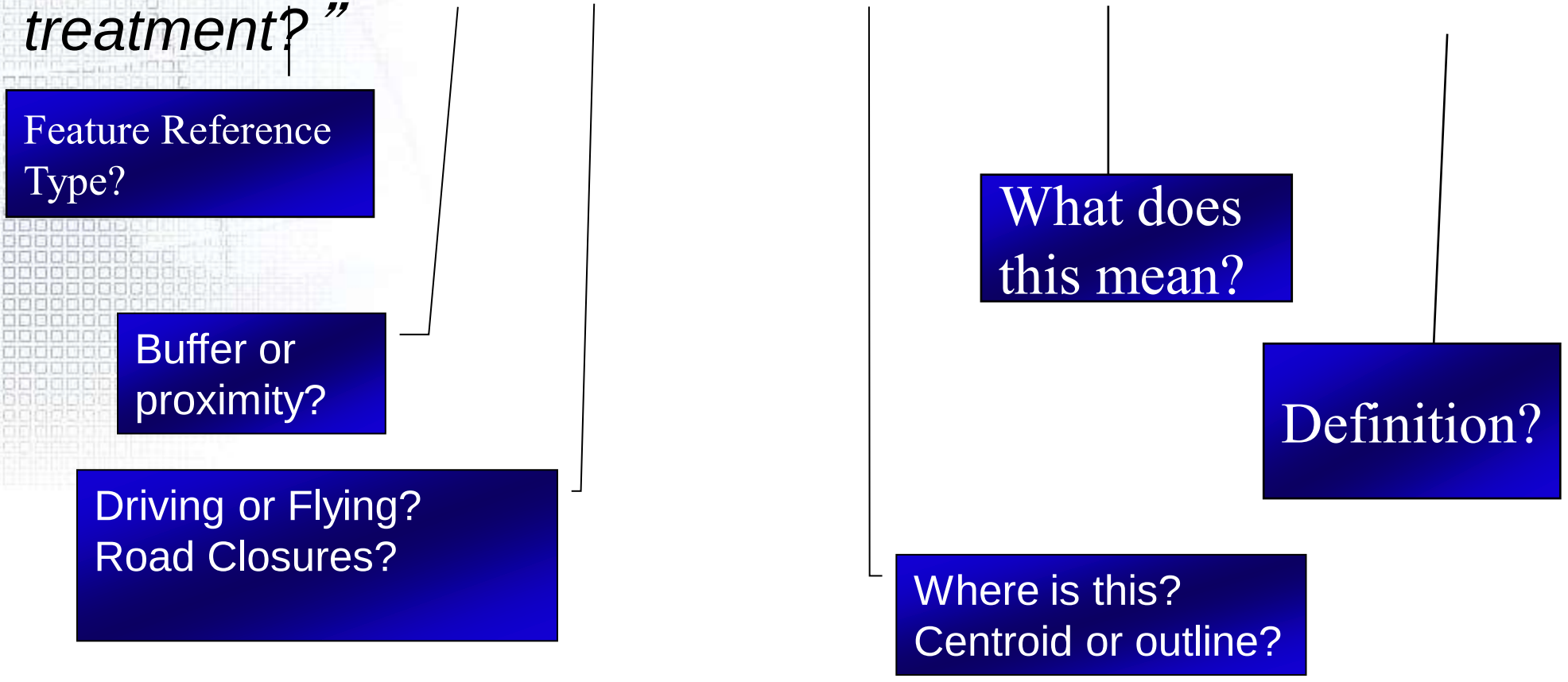
"Typical" Geospatial Query (Intelligence / Logistics Domain)

"Which airfields within 500 miles of Kandahar support C5A aircraft?"



"Typical" Analyst Query:

"Which hospitals within 30 mins of Alpine, CA provide burn treatment?"



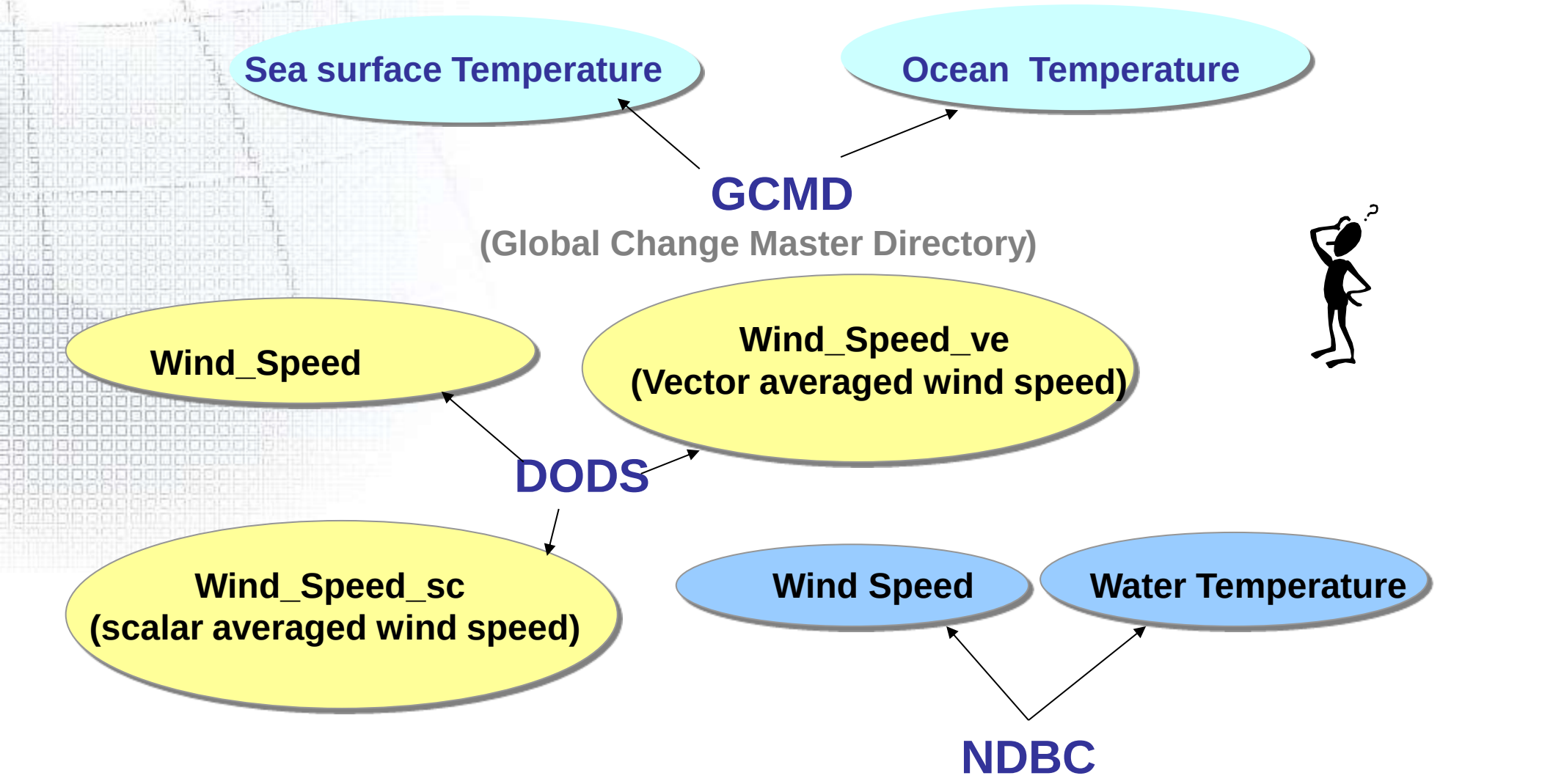
Which hospitals within 30 mins of Alpine, CA provide burn treatment?"

- We need to associate a number of factors, including hospital type and facilities – its accessibility after a disaster – and the staff available

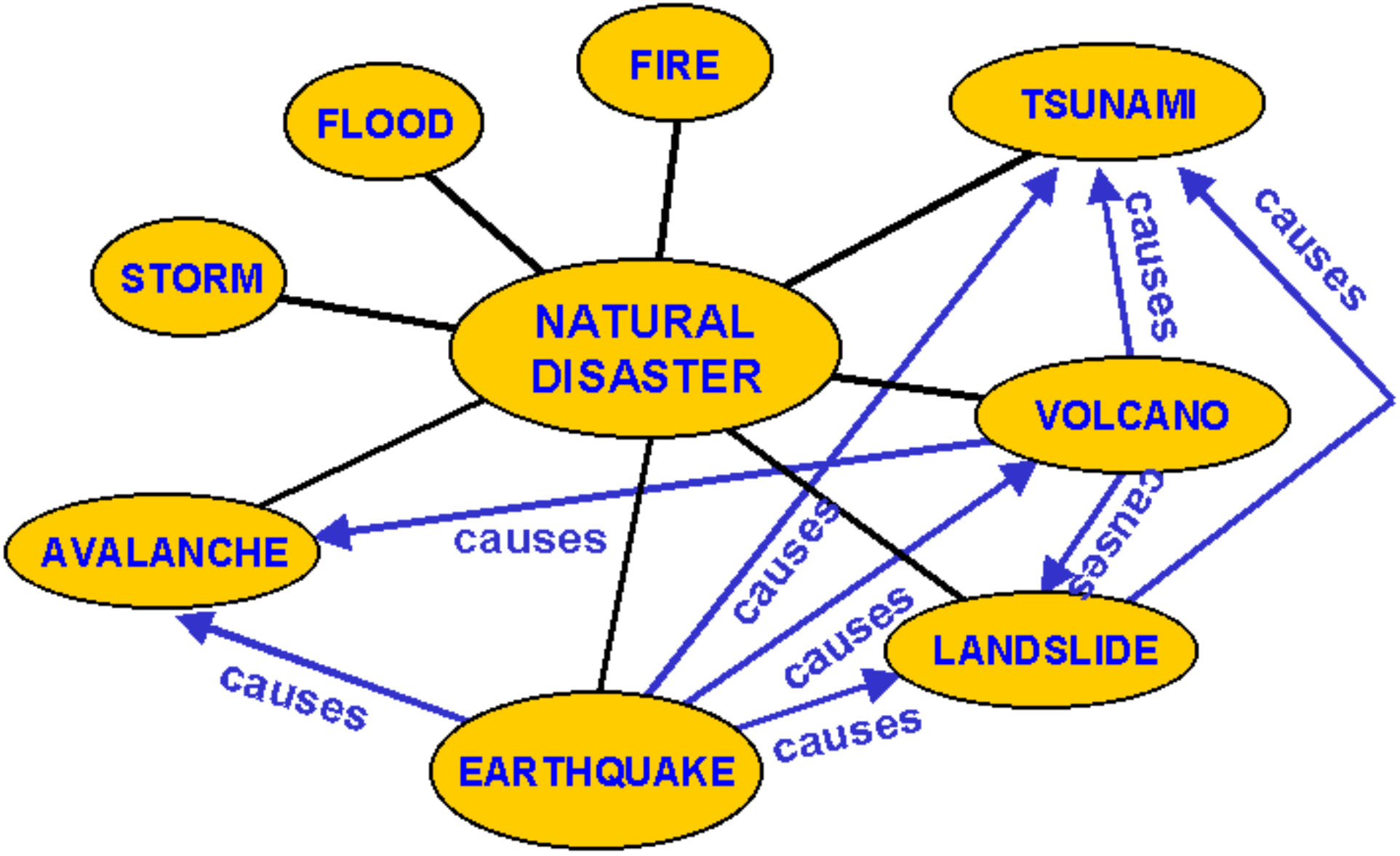
- The query needs to be structured based on Concepts & Relationships that can be retrieved and then customized for the specific query.

- Using this approach, a listing of the hospitals capable of dealing with large number of burn cases is returned to the user and information associated with the query retrieved.

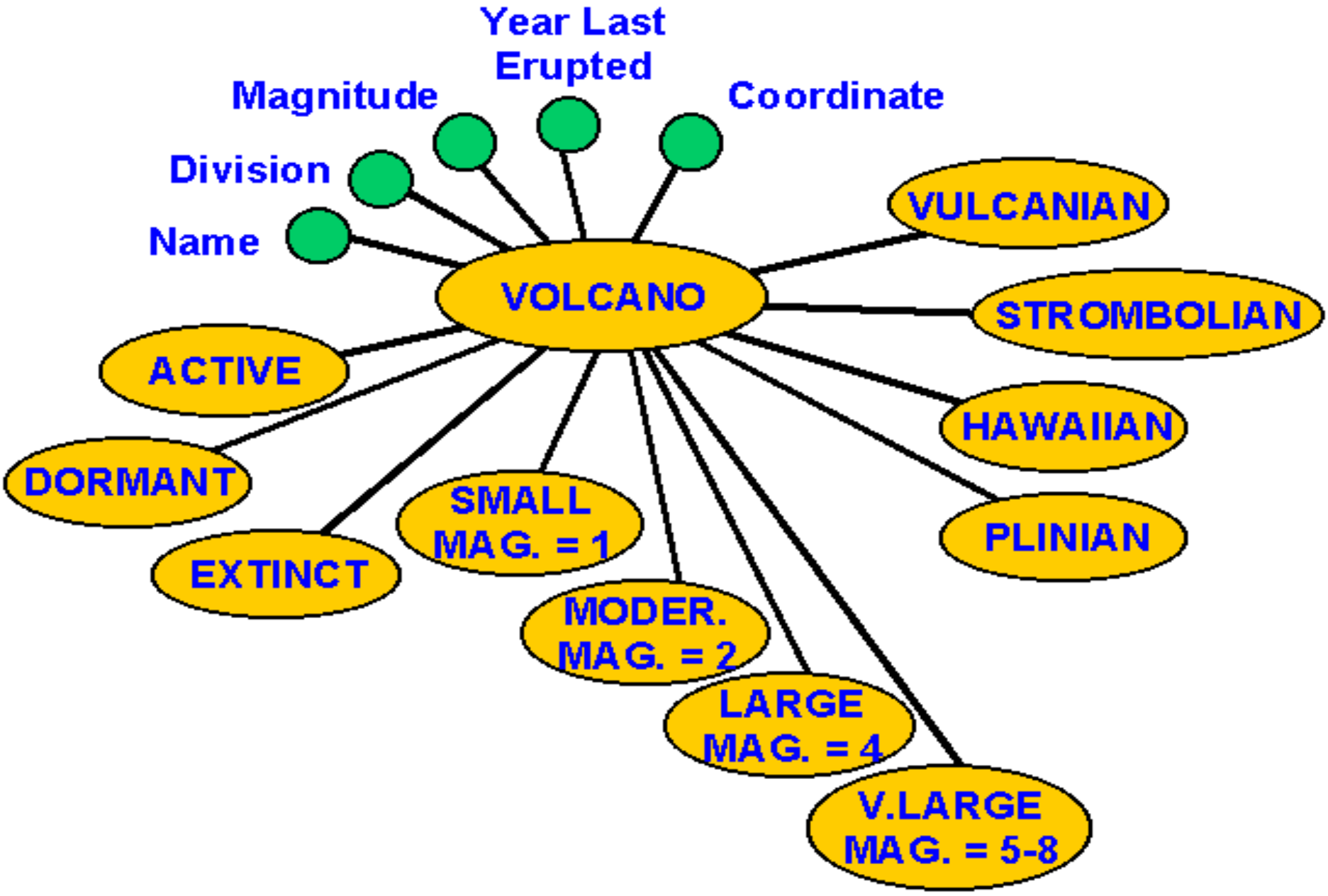
Semantic heterogeneities



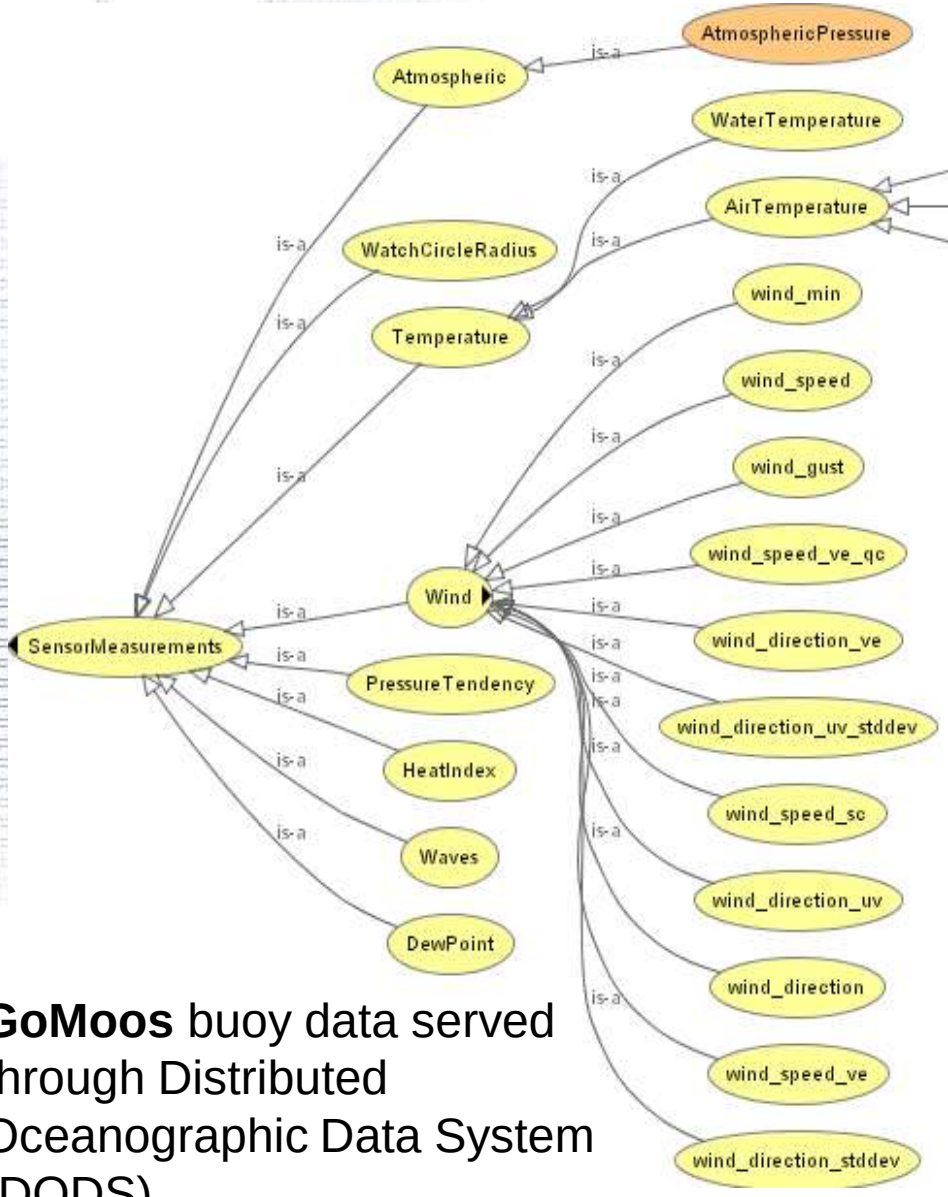
Example Ontology for Natural Disasters



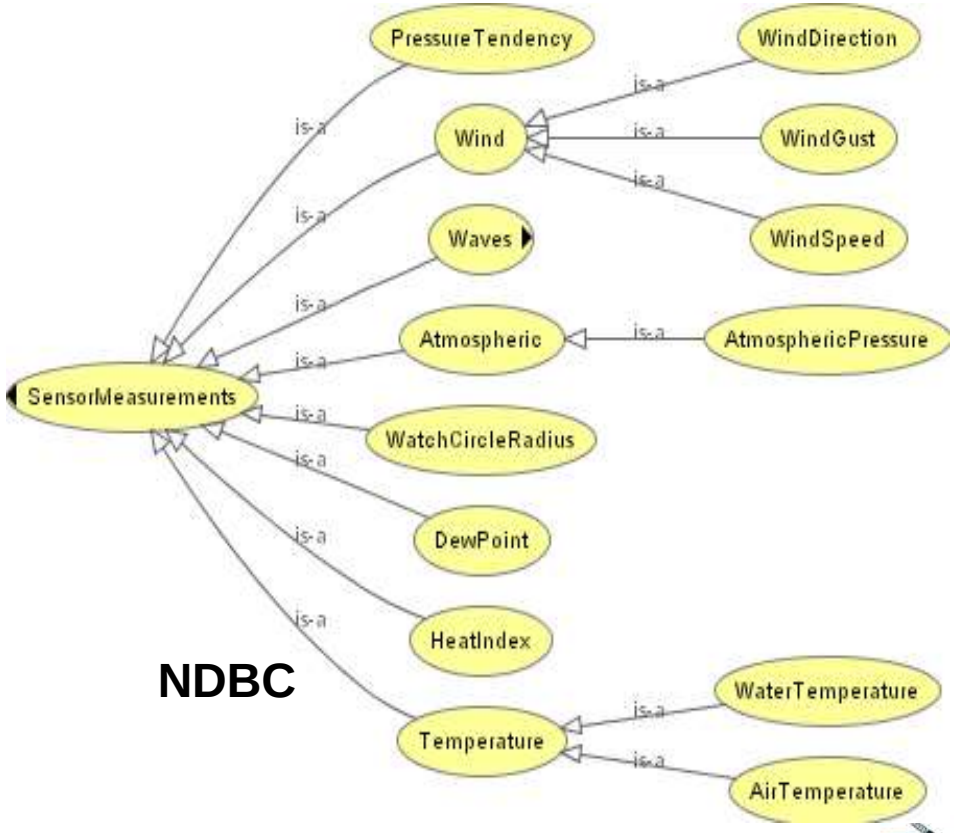
Example Ontology for Volcanoes



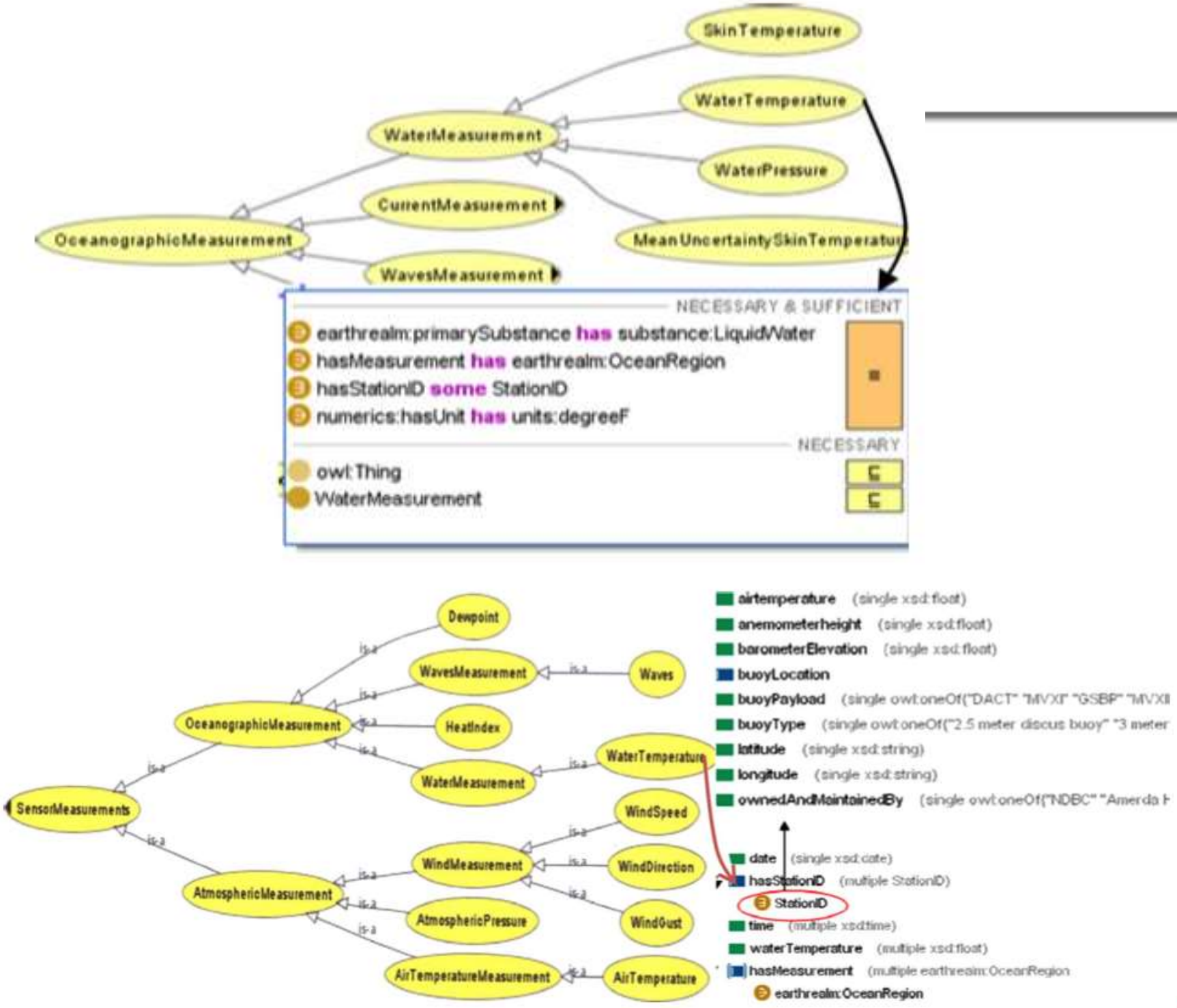
Semantic Conflicts



GoMoos buoy data served through Distributed Oceanographic Data System (DODS)



NDBC



A concept called *WaterTemperature*

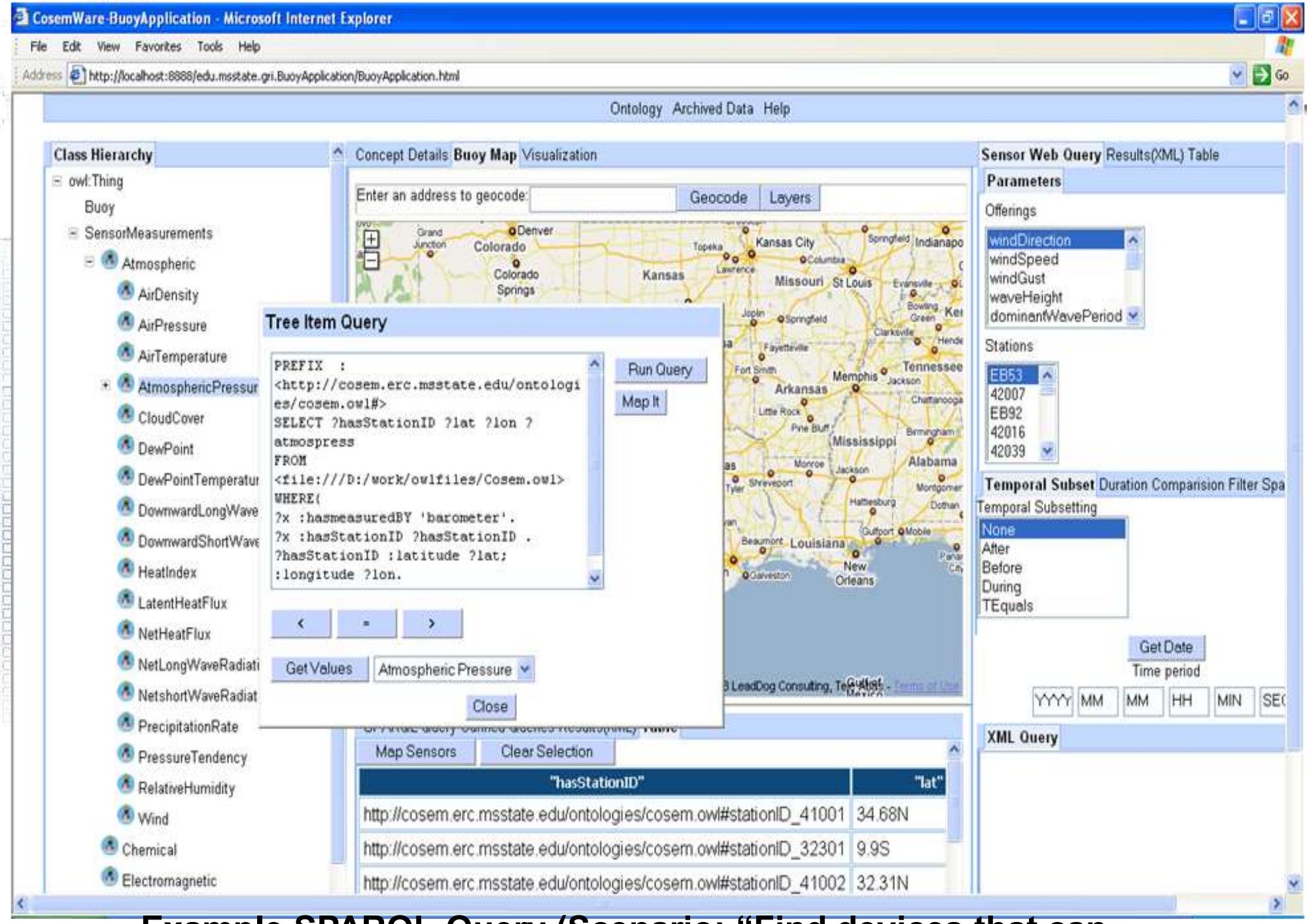
A-Box and T-Box

SPARQL A-Box Query

- SPARQL is a protocol and query language for semantic web data sources.
- Based on matching graph patterns.

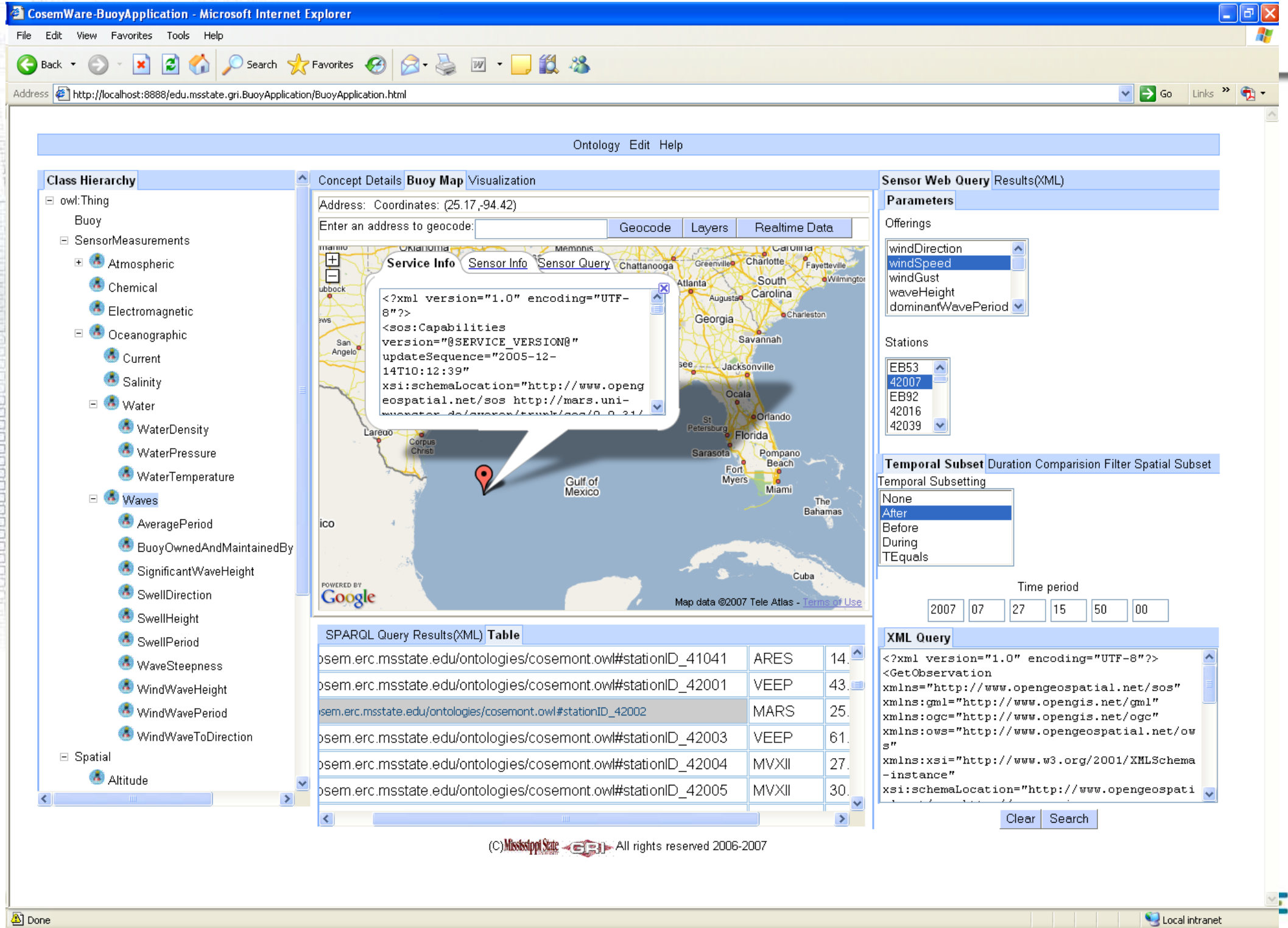
```
PREFIX rdfs:<http://www.w3.org/2000/01/rdf-scheme#>
PREFIX bu:<http://cosem.erc.msstate.edu/ontologies/cosemont.owl#>
SELECT *
FROM <file:/c:/ontologies/cosemont.owl>
WHERE
{
?s bu:hasStationID ?g.
?s bu:waterTemperature ?WaterTemperature.
?g bu:latitude  ?la.
?g bu:longitude ?lo
FILTER(?WaterTemperature>20)
}
```

Name	Syntax	Semantics
TBox		
Class Equivalence	$C \equiv D$	$C^I = D^I$
Class Subsumption	$C \sqsubseteq D$	$C^I \subseteq D^I$
Property Equivalence	$P \equiv R$	$P^I \equiv R^I$
Property Subusmption	$P \sqsubseteq R$	$P^I \subseteq R^I$
ABox		
Individual assertion	$C(i)$	$i^I \in C^I$
Property filler	$R(a,b)$	$(a^I, b^I) \in R^I$
Individual equivalence	$i = j$	$i^I = j^I$
Individual inequivalence	$i \neq j$	$i^I \neq j^I$



Example SPARQL Query (Scenario: "Find devices that can produce certain output variables")

Coastal Semantic Middleware



(a)
(b)
(c)
(d)
(e)

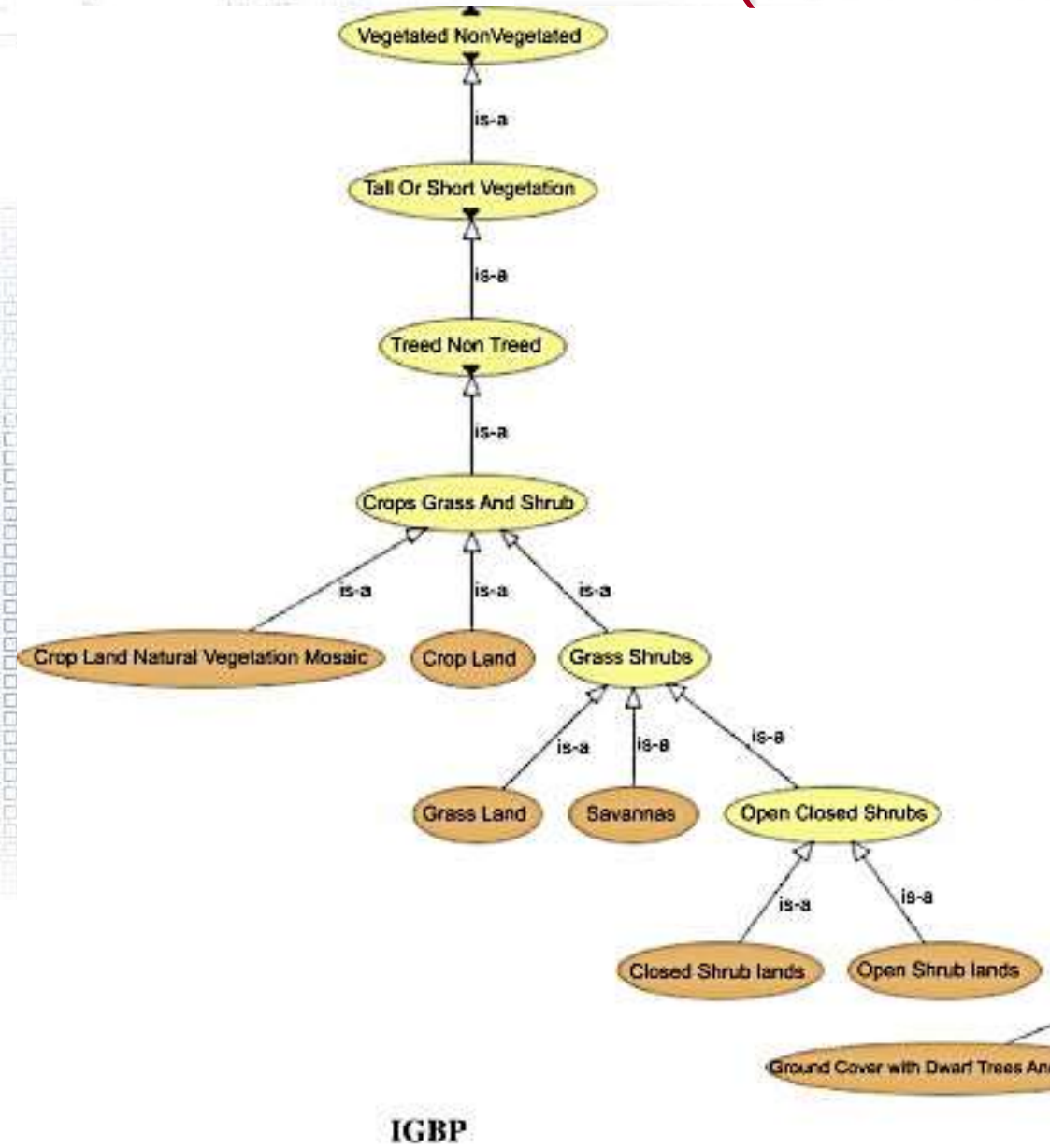
WMS Client
SEACOOS RS Layer:modis_sst
SEACOOS RS Layer:avhrr_sst
SEACOOS RS Layer:ol_sst
OK
Cancel

Heterogeneities in Classification Systems

- The problem is finding the right data that matches a given criteria.
- Classification systems exist in several domains and also unique to different countries.
- Information is normally disseminated through classification

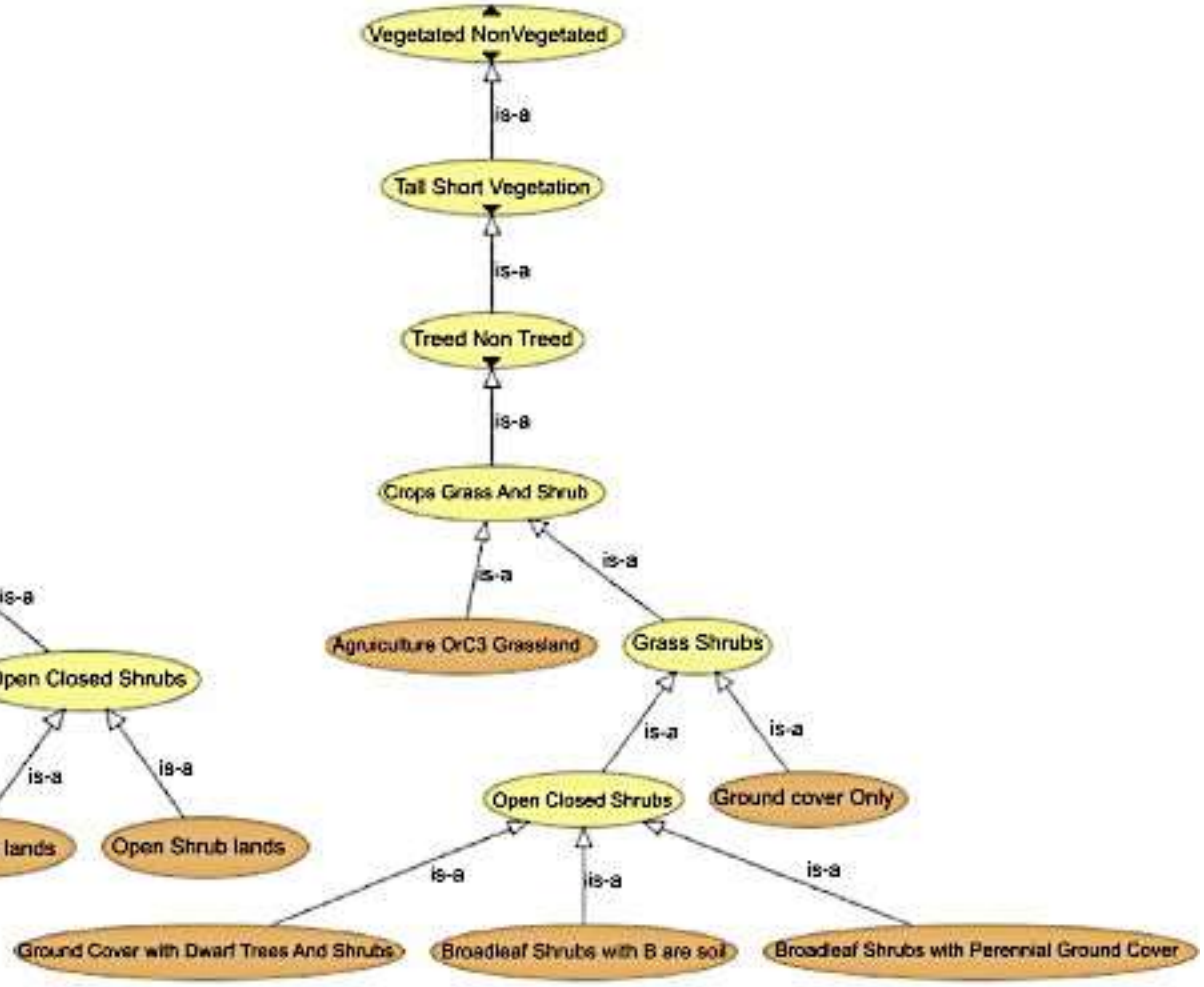
- **Land Cover**
  - International Geosphere Biosphere Programme (IGBP)
  - United States Geological Survey (USGS)
  - Olson Global Ecosystems (OGE)
  - Simple Biosphere model (SiB)
  - Simple Biosphere 2 (SiB2)
  - Biosphere Atmosphere Transfer Scheme (BATS)
- **Soils**
  - natural resources conservation service (NRCS)
  - Canadian soil classification system
  - Unified soil classification system
- **Wetlands**
  - U.S. Fish and wildlife service
  - USGS wet land classification
  - Ramsar classification system
  - Cowardian system

Semantic conflicts between classification systems (IGBP and SiB)



IGBP

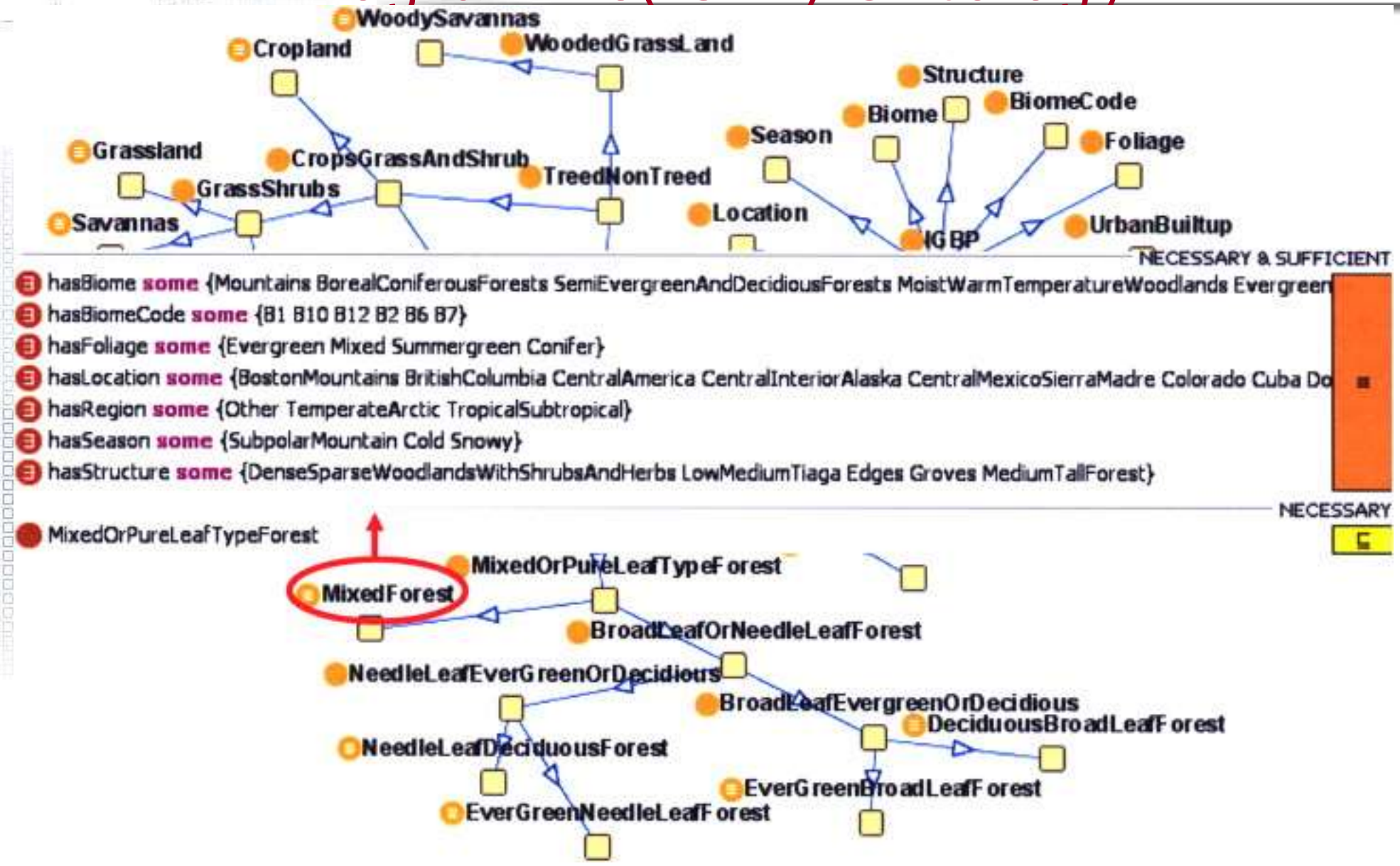
International Geosphere Biosphere Programme (IGBP)



SIB

Simple Biosphere model (SiB)

International Geosphere Biosphere Programme(IGBP) Ontology



Defined concept (mixed forest) formulated by defining necessary and sufficient conditions in a IGBP ontology

Thank you

Spatial Decision Support Systems (SDSS)

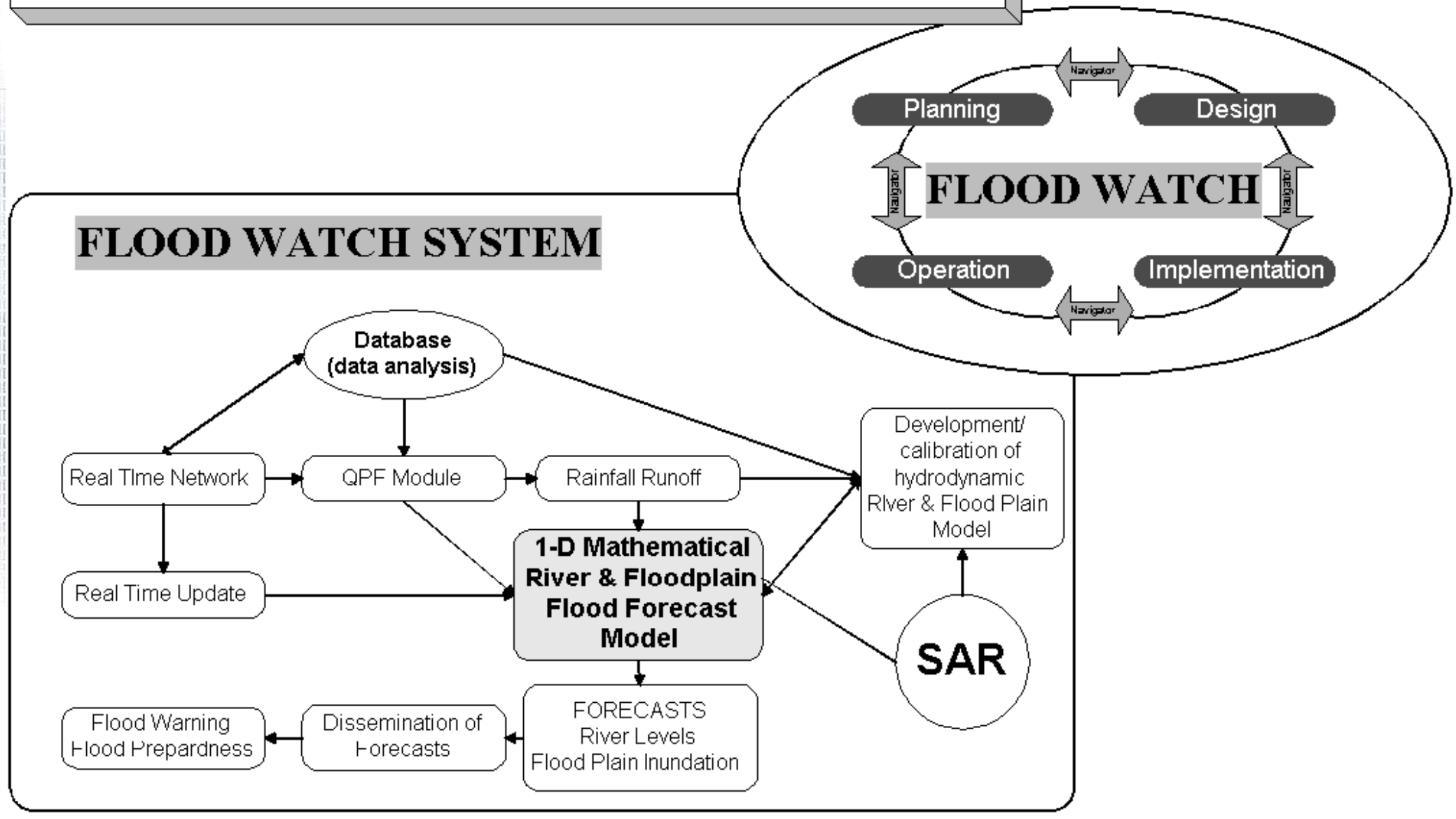
Information Systems are of two types

- **Transaction processing systems**
  - **Emphasis on recording, updating and retrieving as per the occurrence of operations**
  - **Operate in on-line or batch mode and follows well defined procedures**

  Example : Banking and Airline Reservation Systems
- **Decision Support System**
  - **Emphasis on manipulation, analysis and particularly modeling to support decision makers.**
  - **Used in market analysis, resources planning, defence** etc.

GIS belongs to the second type!

DECISION SUPPORT SYSTEM



http://proceedings.esri.com/library/userconf/proc97/proc97/to500/pap486/p4861.gif

Applications

Many Applications of network routing

Examples: Online Map service, phone service, transportation navigation service

- Identification of frequent routes
  - Crime Analysis

- Identification of congested routes
  - Network Planning

Spatial Decision Support

- Many times decisions have to be taken by administrators
  - Cannot satisfy all stakeholders
  - Cannot find money for entire needs
  - Cannot complete the task within a given time
  - Cannot protect environment while carrying out development projects
- Environment related issues are most controversial, requiring most spatial inputs

Spatial Decision Support

- Use of GIS for environmental/resources management applications includes:
  1. Data management
  2. Data Assessment
  3. Modelling and spatial analysis
  4. Management and decision support
- Applications 1 thru 3 culminate in 4... the end use?

Application or decision support?

- An application may end at any point
  - Spatial / attribute data creation end at 1
  - descriptive/mapping exercise may end at 2
  - predictive modelling exercise may end at 3
  - BUT they must start at 1 and work through these stages in sequence
- The ultimate end application must be decision making (i.e. management) and use in support of decisions made

Example: Environmental Management

- Aims of environmental management:
  - to prevent environmental deterioration and degradation
  - to promote sustainable use of the environment
  - to prevent over use or exploitation of natural resources
  - to preserve environmental diversity
- Objectives of environmental management:
  - to control the environment and/or our influences upon the environment via direct or indirect action
  - i.e. putting environmental science to work!

Decision making or support?

- Decision making vs decision support
  - GIS can provide certain tools for assisting in the decision making process
    - i.e. maps/displays as means of visualising the problem
    - overlays as means of defining relationships
    - modelling as means of predicting outcomes etc.

…the answer

- GIS functions on their own are NOT decision making tools...
  - (i.e. they only ASSIST in the decision making process)
  - …therefore, GIS is not a decision making tool, it is a decision SUPPORT tool

Decision making

- Decision making:
  - a decision is a choice between alternatives to meet specific objectives
  - the alternatives may represent:
    - different courses of action
    - different hypotheses
    - different use of a geographical entity etc.

Decision objectives

- Objectives are governed by management goals and in turn determine the range of alternatives
  - e.g. identify areas of high risk in soil erosion example in order to address the goal of preventing soil erosion
  - resulting alternatives may be different maps representing different management plans
- Process, governing the way decisions between alternatives are made, is the “decision rule”

Applications of Local Operations

Soils:

- Revised Universal Soil Loss Equation (RUSLE) uses six environmental factors in the equation:

http://www.scotland.gov.uk/Resource/Img/47121/0020519.jpg

A=R K L S C P

A=average soil loss

R=rainfall-runoff erosivity factor

K=soil erodibility factor

L=slope length factor

S=slope steepness factor

C=crop management factor

P=support practice factor

- Each factor can be prepared as as an input raster.
  - Multiply the rasters in a local operation to produce the output raster of average soil loss.

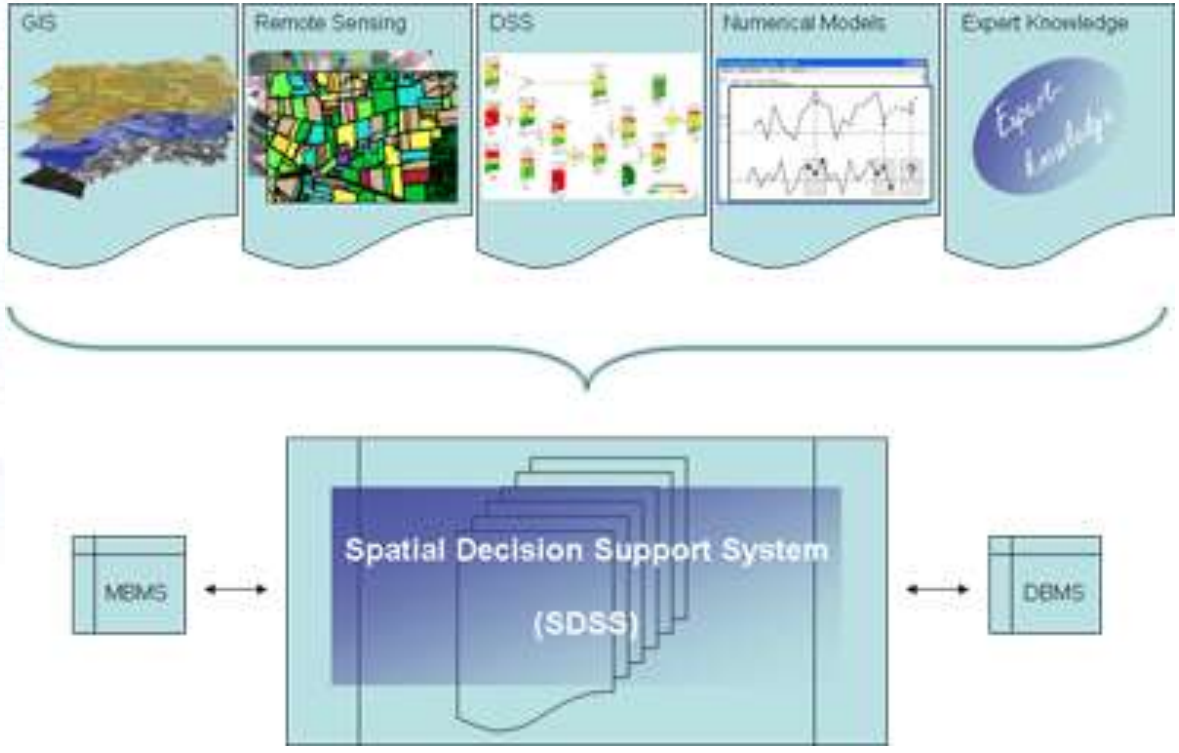
Definition of a DSS

- In general terms, DSS are:
  - computer-based systems
  - dedicated to a restricted but well defined area of application
  - systems incorporating modelling and analysis with data and database management systems
  - systems which do not make decisions, but facilitate logistics of decision making process
  - interactive systems that help decision maker carry out a decision research
  - providers of custom-built information
  - providers of user-friendly GUI with short response times

Developing Spatial DSS

- The role of GIS?
  - GIS is an INCREDIBLY USEFUL tool
  - SDSS retains the general characteristics of basic DSS but in addition they include:
    - spatial data input capabilities
    - storage of complex structures common in spatial data
    - analytical techniques unique to spatial data
    - cartographic output

- An agricultural SDSS might be comprised of:
  - climatic and economic models
  - GIS software
  - spatial data



http://www.impetus.uni-koeln.de/uploads/pics/projekt_konzepte_dss_02.png

SDSS Components

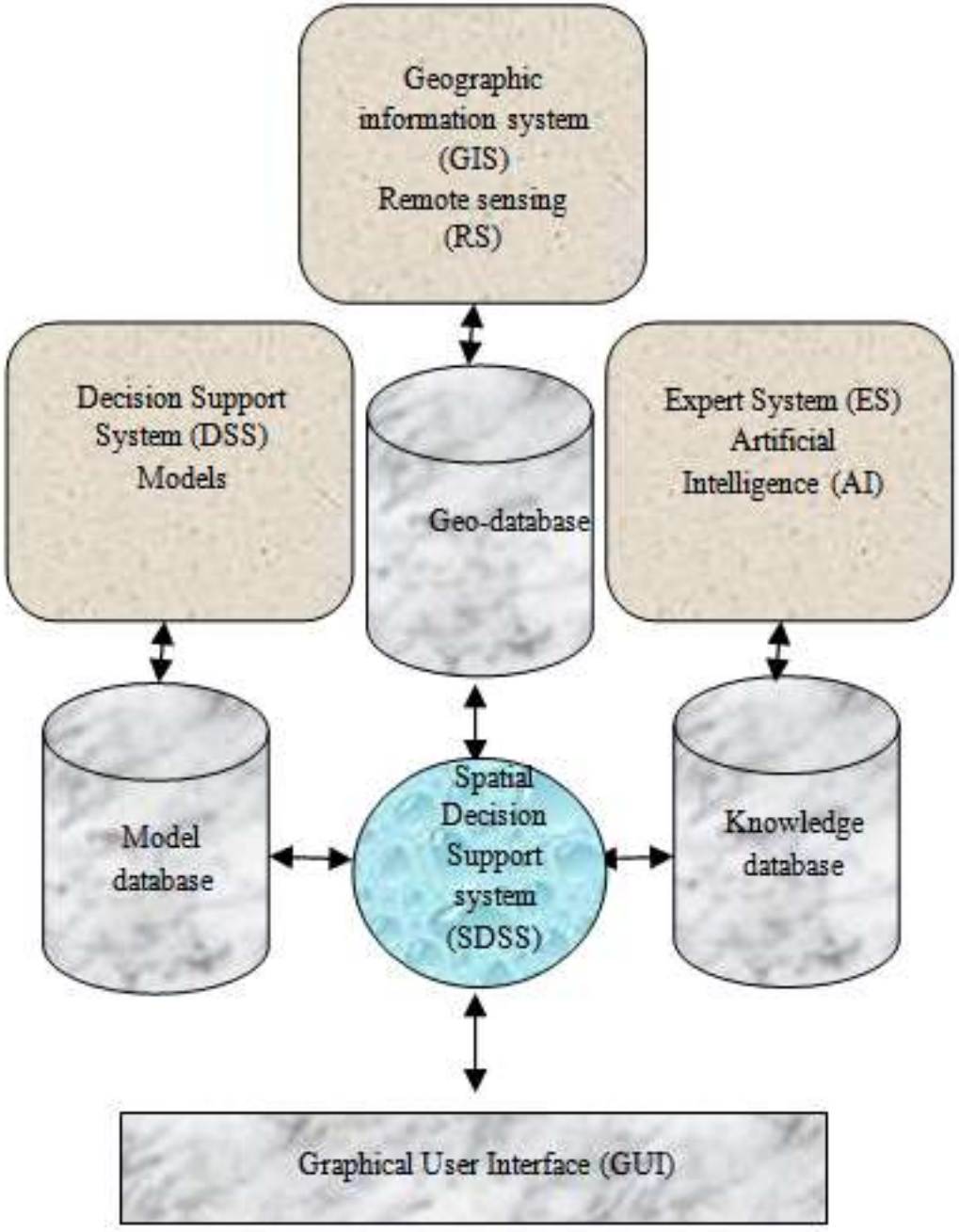
SDBMS - locational, topological and thematic data types to support cartographic display, spatial query, analytical modeling

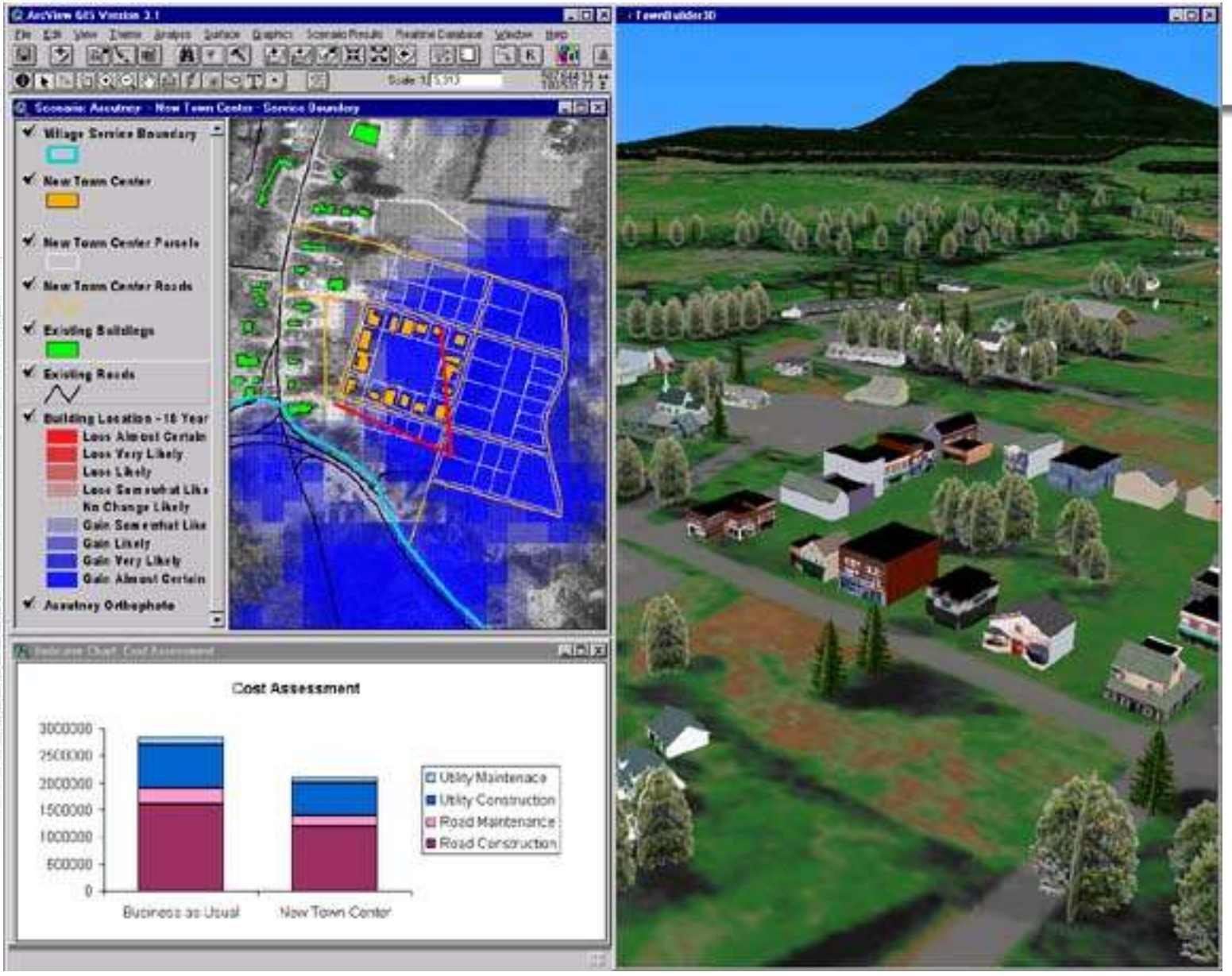
MBMS - model base management system to support statistical and numerical models which stores models instead of data

Each model may be a small piece of code to solve a part of an algorithm

SDSS Components

- Knowledge based reasoning, image processing may be part of the MBMS
- Graphical and tabular report generators
- 2-d and 3-d displays
- Bar charts, pie-charts, scatter plots, line plots, ...
- Application specific plots and reports


Geographic information system (GIS) Remote sensing (RS)
Decision Support System (DSS) Models
Geo-database
Expert System (ES) Artificial Intelligence (AI)
Model database
Spatial Decision Support system (SDSS)
Knowledge database
Graphical User Interface (GUI)



3D visualization is used to show community members how a proposed development would change the landscape.

Credit: Environmental Simulation Center, 2004.