Sensor Web Enablement (SWE): Sensor Interoperability and Accessibility

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Outline

• Introduction
• SWE Overview
• Sensor Web Concept
• SWE Framework
• Information Models and Schema
• Web Services
• Applications
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- Sensor Web Concept
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- Applications

Introduction

The objective of this talk is to highlight the new open spatial standards that can be used to guarantee the accessibility and interoperability of spatial information resources.

Different applications of these widely selected and rapidly growing standards will be described.
**Introduction**

- **What is Spatial Information?**
  - Location & exploitation of [natural resources](#) – minerals, soils, vegetation, landscape.
  - Viewing and analysis of [networks](#) – transport, water, energy and telecoms.
  - Location & distribution of [people, businesses, assets, new developments, services and other built infrastructure](#).
  - Coordination of responses to [emergencies, natural and man made disasters](#) – floods, epidemics, terrorism.
  - Monitoring and management of spatially distributed variables – [health statistics, demographics, weather](#).

Ref. [1]
Introduction

• Interoperability

- Interoperability is the ability of two or more systems or components to exchange information and to use the information that has been exchanged [2].

- The ability of two or more autonomous, heterogeneous, distributed digital entities (e.g. systems, applications, procedures, directories, inventories or data sets) to communicate and cooperate among themselves despite differences in language, context, format or content. These entities should be able to interact with one another in meaningful ways without special effort by the user - the data producer or consumer - be it human or machine [3].

X and Y are able to interact effectively at run-time to achieve shared goals.

Introduction

• Accessibility

Accessibility is a general term used to describe the degree to which a product (e.g., device, service, environment) is accessible by as many people as possible. Accessibility can be viewed as the “ability to access” the functionality, and possible benefit, of some system or entity. [Wikipedia]
Introduction

• Semantic Web

The Semantic Web has three key aspects.

1. Data is encoded with self-describing XML identifiers, enabling a standard XML parser to parse the data.

2. The identifiers’ meanings (properties) are expressed using the Resource Description Framework. RDF encodes the meaning in sets of triples, each triple being like an elementary sentence’s subject, verb, and object, with each element defined by a URI (uniform resource identifier) on the Web.

3. Ontologies express the relationships between identifiers.

These two data sources can publish data in XML as:

“<Temperature><Celsius>20</Celsius></Temperature>” and
“<Temperature><Fahrenheit>68</Fahrenheit></Temperature>.”

An associated RDF document can describe that Celsius and Fahrenheit are temperature units, and an ontology can define the relationship between Celsius and Fahrenheit. So, a data-processing system can automatically infer that these two data points represent the same temperature value.

Ref. [4]
Introduction

• XML Schema

XML Schemas express shared vocabularies and allow machines to carry out rules made by people. They provide a means for defining the structure, content and semantics of XML documents [W3C].

The XML Schema Definition language provides more control over structure and content than DTD.

A simple element is defined as

```xml
<xs:element name="name" type="type"/>
```

where:
- `name` is the name of the element
- the most common values for `type` are
  - xs:boolean
  - xs:integer
  - xs:date
  - xs:string
  - xs:decimal
  - xs:time

Other attributes a simple element may have:
- `default="default value"` if no other value is specified
- `fixed="value"` no other value may be specified

Introduction

• Situation Awareness

“Situation awareness is the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.”

(Mica Endsley, 1988)

http://www.satechnologies.com/
Introduction

• Situation Awareness

**Semantic Analysis**
- Thematic
- Spatio-Temporal
- Trust

**Provenance**
- Relate Situation Entities
- Identify Situation Entities
- Collect Relevant Data

Ref. [7]

Introduction

• Ontology

“Ontology is about the exact description of things and their relationships.” **World Wide Web Consortium (W3C)**

• Situation Awareness Ontology

  - Domain Ontology
  - Spatial Ontology
  - Temporal Ontology
Outline

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• Applications

SWE Overview

• Open Geospatial Consortium (OGS)

  ▪ Consortium of 370+ companies, government agencies, and academic institutes.

  ▪ OGC Mission is to lead in the development, promotion and harmonization of open spatial standards.

  ▪ Open Standards development by consensus process.

  ▪ Interoperability Programs provide end-to-end implementation and testing before specification approval.
SWE Overview

- Motivating Scenario

High-level Sensor (S-H)

Low-level Sensor (S-L)

- How do we determine if A-H = A-L? (Same time? Same place?)
- How do we determine if E-H = E-L? (Same entity?)
- How do we determine if E-H or E-L constitutes a threat?

Ref. [3]

SWE Overview

- Objectives
  - Quickly discover sensors and sensor data (secure or public) that can meet my needs – location, observables, quality, ability to task.
  - Obtain sensor information in a standard encoding that is understandable by me and my software.
  - Readily access sensor observations in a common manner, and in a form specific to my needs.
  - Task sensors, when possible, to meet my specific needs.
  - Subscribe to and receive alerts when a sensor measures a particular phenomenon.
**Outline**

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  - **Sensor Web Concept**
- SWE Framework
- Information Models and Schema
- Web Services
- Applications

**Sensor Web Concept**

- All sensors reporting position
- All readable remotely
- All connected to the Web
- Some controllable remotely
- All with metadata registered.
Sensor Web Concept


Sensor Web Concept

http://www.ndbc.noaa.gov/
Sensor Web Concept

- Sensor Pods
  - one or more sensor leading to one or more data channel,
  - a processing unit such as a micro-controller or microprocessor,
  - a two-way communication component such as a radio and antenna,
  - an energy source such as a battery coupled with a solar cell,
  - a package to protect components against sometimes harsh environment,
  - a support such as a pole or tripod.

Sensor Web Concept

- Sensor Web Vision
  - Sensors will be web accessible.
  - Sensors and sensor data will be discoverable.
  - Sensor descriptions will use a standard encoding.
  - Sensor observations will be delivered using standard encodings.
  - Sensor observations will be accessible in real time or from archives, to any legitimate user, over the web with a standard request syntax.
  - Sensors will be tasked in a standard way.
Sensor Web Concept

• Sensor Web Vision (Cont’d)
  ▪ Sensors will be capable of issuing alerts based on observations, as well as be able to respond to alerts issued by other sensors.
  ▪ Sensor services will be capable of real-time mining of observations to find phenomena of immediate interest.
  ▪ Sensors and sensor nets will be able to act on their own (i.e. be autonomous).
  ▪ Software will immediately be capable of geolocating and processing observations from a newly-discovered sensor.

Sensor Web Concept

• Challenging Problems
  - Query processing
  - Reliability
  - Continuous, integrated push-based and pull-based processing
  - Federated and shared infrastructure.
Sensor Web Concept

- Challenging Problems

![Diagram showing sensor data fusion and aggregation]

<table>
<thead>
<tr>
<th>Time</th>
<th>Source</th>
<th>News</th>
<th>Reputation/Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 pm</td>
<td>Blog</td>
<td>Accident on route...</td>
<td>20%</td>
</tr>
</tbody>
</table>

Possibly stale data, from untrusted sources

<table>
<thead>
<tr>
<th>Time</th>
<th>Name</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 pm</td>
<td>John S. or Bob R.</td>
<td>40% (US), 90% (RR)</td>
</tr>
<tr>
<td>2 pm</td>
<td>Jane S.</td>
<td>80% (80% if above in John R.)</td>
</tr>
</tbody>
</table>

Probabilistic data with complex correlations

<table>
<thead>
<tr>
<th>Time (x, y)</th>
<th>Temperature</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 pm (20, 20)</td>
<td>20 ± 0.5</td>
<td>99%</td>
</tr>
<tr>
<td>2:10 pm (20, 20)</td>
<td>22 ± 1.5</td>
<td>99%</td>
</tr>
</tbody>
</table>

Data with confidence and accuracy bounds

Ref. [4]

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**SWE Framework**

**Providers—Heterogeneous Sensor Network**
- Airborne
- Satellite
- In-Situ monitors
- Surveillance
- Bio/Chem/Rad Detectors

**Models and Simulations**
- nested
- national, regional, urban
- adaptable
- data assimilation

**Users—Decision Support Tools**
- discovery
- access
- tasking
- alert notification

Web services and encodings based on Open Standards (OGC, ISO, OASIS, IEEE)

- vendor neutral
- flexible
- extensive
- adaptable

**Sensor Web Enablement**

**1999 - 2000**
- SensorML initiated at University of Alabama in Huntsville: NASA AIST funding

**2001**
- OGC Web Services Testbed 1.1:
  - Sponsors: EPA, NASA, NIMA
  - Spec: SOS, O&M, SensorML
  - Demo: NYC Terrorist Sensors: weather stations, water quality

**2002**
- OGC Web Services Testbed 1.2:
  - Sponsors: EPA, General Dynamics, NASA, NIMA
  - Spec: SOS, O&M, SensorML, SPS, WNS, SAS
  - Demo: Terrorist, Hazardous Spill and Tornado Sensors: weather stations, wind profiler, video, UAV, stream gauges

**2003-2004**
- Specs advanced through independent R&D efforts in Germany, Australia, Canada and US
- Sensor Web Work Group established
  - Spec: SOS, O&M, SensorML, SPS, WNS, SAS
  - Sensors: wide variety
SWE Framework

2005

OGC Web Services Testbed 3.0:
Sponsors: NGA, ORNL, LMCO, BAE
Specs: SOS, O&M, SensorML, SPS, TransducerML
Demo: Forest Fire in Western US
Sensors: weather stations, wind profiler, video, UAV, satellite
SAS Interoperability Experiment

2006

SWE Specifications toward approval:
- SensorML – V0.0
- TransducerML – V0.0
- SOS – V0.0
- SPS – V0.0
- O&M – Best Practices
- SAS – Best Practices

2008

OGC Web Services Testbed 4.0:
Sponsors: NGA, NASA, ORNL, LMCO
Specs: SOS, O&M, SensorML, SPS, TransducerML, SAS
Demo: Emergency Hospital
Sensors: weather stations, wind profiler, video, UAV, satellite

SWE Framework

SWE Components

Information Models and Schema
- Observations & Measurements (O&M)
- SensorML
- GML Observations Application Schema
- TransducerML

Web Services
- Client
  - Sensor Observation Service
  - Sensor Planning Service
  - Sensor Alert Service
  - Web Notification Service
- Internet
- Catalog Service
SWE Framework

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Information Models and Schema

- Observations and Measurements (O&M)
  - An *Observation* is an Event whose result is an estimate of the value of some Property of the Feature-of-interest, obtained using a specified Procedure.

Ref. [5]

O&M Conceptual Model
Information Models and Schema

• Observations and Measurements (O&M)

  – The **featureOfInterest** is a feature of any type, which is a representation of the observation target, being the real-world object regarding which the observation is made.

  – The **observedProperty** identifies or describes the phenomenon for which the observation result provides an estimate of its value. It must be a property associated with the type of the feature of interest.

  – The **procedure** is the description of a process used to generate the result. It must be suitable for the observed property.

Example: Marine Science Observation

Ref. [5]

Feature-of-interest: Ship’s cruise track

Procedure: Thermosalinograph

Observed property: Seawater temperature

Example: Marine Science Observation
Information Models and Schema

• Observations and Measurements (O&M)

simple observation to determine the mass of a specific banana

Procedure: mass

Observed property: mass

Feature-of-interest: banana

Result: Mass in kg
Information Models and Schema

- GML Observations Application Schema

  Geography Markup Language provides the basis for domain- or community-specific “Application Schemas”, which in turn support data interoperability within a community of interest.

  GML contains a rich set of primitives which are used to build application specific schemas or application languages:

  - Feature
  - Geometry
  - Coordinate Reference System
  - Topology
  - Time
  - Dynamic feature
  - Coverage (including geographic images)

  XML Schema

  basic data types
Information Models and Schema

- **GML Observations Application Schema**

  ```xml
  <gml:Point gml:id="p21" srsName="urn:ogc:def:crs:EPSG:6.6:4326">
    <gml:coordinates>45.67, 88.56</gml:coordinates>
  </gml:Point>
  
  <gml:Point gml:id="p21" srsName="urn:ogc:def:crs:EPSG:6.6:4326">
    <gml:pos dimension="2">45.67 88.56</gml:pos>
  </gml:Point>
  
  <gml:LineString gml:id="p21" srsName="urn:ogc:def:crs:EPSG:6.6:4326">
    <gml:posList dimension="2">45.67 88.56 55.56 89.44</gml:posList>
  </gml:LineString>
  ```

- **Sensor Model Language (SensorML)**

  - SensorML is an [XML schema](http://www.w3.org/XML/Schema) for defining the geometric, dynamic, and observational characteristics of a sensor.

  - The primary focus of SensorML is to define [processes and processing components](http://www.opengis.net/def) associated with the measurement and post-measurement transformation of observations such as actuators, spatial transforms, and data processes, to name a few.

  - SensorML can, but generally does not, provide a detailed description of the hardware design of a sensor. Rather it is a general schema for describing functional models of the sensor.
The purposes of SensorML are to:

- Provide general *sensor information* in support of data discovery
- Support the *processing and analysis* of the sensor measurements
- Support the *geolocation* of the measured data.
- Provide *performance characteristics* (e.g. accuracy, threshold, etc.).
- Archive *fundamental properties* and assumptions regarding sensor.
Information Models and Schema

- Sensor Model Language (SensorML)

```
<sensorml:
  <sml:Sensor>
    <sml:identification>
      <sml:identifier>http://www.w3.org/2001/XMLSchema</sml:identifier>
      <sml:version>1.0</sml:version>
      <sml:encoding>UTF-8</sml:encoding>
    </sml:identification>
    <sml:inputs />
    <sml:outputs />
    <sml:position>  
      <sml:Point> 
        <sml:coordinates>37.56 50</sml:coordinates>
      </sml:Point> 
    </sml:position> 
    <sml:location>  
      <sml:Geolocation> 
        <sml:latitude>37.56</sml:latitude> 
        <sml:longitude>50</sml:longitude> 
      </sml:Geolocation> 
    </sml:location> 
    <sml:status> 
      <sml:statusType>active</sml:statusType> 
    </sml:status> 
    <sml:instance> 
      <sml:instanceType>sensorml:SensorML</sml:instanceType> 
    </sml:instance> 
  </sml:Sensor> 
</sensorml>
```

Information Models and Schema

- TransducerML
  - Transducer Markup Language (TML or TransducerML) aims at standardizing a way to exchange raw or preprocessed sensor data. TML facilitates the interoperability and fusion of transducer data. Here a transducer is either a receiver (i.e. sensor) or a transmitter.
  - TML exchanges both data and metadata in the same or separate packages.
  - Data: is formatted in a natural transducer format.
  - Metadata: describes everything an engineer needs to know about the data, such as: data content and structure, transducer characteristics, transducer geometry model, transducer interrelationships. Time sensitive metadata is treated as sensor data.

- TML is a sensor data exchange language that allows for the fusion of heterogeneous sensor data at levels not presently achievable (i.e. upstream data).
- TML can be used to communicate data from remote and/or in situ sensors (Vision, audio, IR, Sonar, magnetic, GPS, odometry, climate, environmental, position, temperature, force, sound, etc.).
- TML is a domain independent language (i.e. can be used for any application that requires the exchange of sensor data, e.g. environmental, image or signals surveillance and reconnaissance, medical imaging, factory automation, etc),
Information Models and Schema

- **TransducerML**

  - TML is Sensor Agnostic
    - Metadata is Common for all Type Sensors
    - Enables a “Common Sensor Processor”
  
  - TML is Application Domain Agnostic

- TML is Sensor Agnostic
  - Metadata is Common for all Type Sensors
  
- TML is Application Domain Agnostic
  - Enables Data for Fusion

Ref. [8]
Information Models and Schema

- **TransducerML**

![Diagram of Information Models and Schema](image)

**Best at the Sensor**

- Transducer System
  - Transducer
  - TML S/W
  - Computer

**OK downstream**

- Transducer
  - Proprietary
  - Computer
  - TML S/W
  - Computer

Ref. [8]
Information Models and Schema

- TransducerML: How it works?

```
<tml>
  <system>
    <systemClock>...period, count accy</systemClock>
    <transducers>...transducer models...</transducers>
    <process>...process models...</process>
    <relations>...transducer relationships...</relations>
  </system>
  <prodDataDesc>...ID mapping, parsing, encoding and sequencing...</prodDataDesc>
<tml>
```

TML describes the transducer data (Common Transducer Model)

Ref. [8]
Information Models and Schema

- TransducerML: Static/Dynamic Data
  - Dynamic data

```
<tml>
    <data ref="t001" clk="3F63B6432674">...transducer data...</data>
    <data ref="t001" clk="3F63B64326A1">...transducer data...</data>
    <data ref="t002" clk="3F63B6432701">... transducer data ...</data>
    <data ref="t001" clk="3F63B6432723">... transducer data ...</data>
    <data ref="t003" clk="3F63B643273C">... transducer data ...</data>
    <data ref="t006" clk="3F63B6432788">... transducer data ...</data>
    <data ref="t001" clk="3F63B64327E9">... transducer data ...</data>
    <data ref="t001" clk="3F63B6432810">... transducer data ...</data>
    <data ref="t001" clk="3F63B6432856">... transducer data ...</data>
    <data ref="t008" clk="3F63B6432850">... transducer data ...</data>
</tml>
```

TML transports the transducer data

Ref. [8]

---

Information Models and Schema

- TransducerML: Example

![Diagram of TML node and processes]

- Digital Camera
- GPS
- IMU
- Compass

- JPEG Compress
- IMAGE SIZE
- Base64
- TML Node

- Produces Base64
- Produces JPEG Video clusters
- Produces IMAGE_SIZE clusters
- Produces GPS clusters
- Produces IMU clusters
- Produces Compass clusters
Information Models and Schema

- TransducerML: Example

```
<data clk='28118774' ref='IMU'>22.8,1.1,3.4</data>  <!-- IMU: true heading, pitch roll-->
<data clk='28118792' ref='COMPASS'>21.1</data>  <!-- COMPASS: mag heading-->
<data clk='28118795' ref='GPS'>516866,-4702126,4264297.2005-08-26T16:31:49Z</data>  <!-- GPS: X, Y, Z, Time-->
<data clk='28118800' ref='IMAGE_SIZE'>49388</data>
<data clk='28118899' ref='CAM'>... base64 JPEG video...</data>
<data clk='28119227' ref='COMPASS'>22.5 0.2 -1.2</data>
```

The data entity contains data multiplexed from all of the sensor contained within a system.

The data entity will contain a stream of sensor data transported in small sensor chunks called clusters.

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Web Services

- **Sensor Observation Service (SOS)**

  The goal of SOS is to provide access to observations from sensors and sensor systems in a standard way that is consistent for all sensor systems including remote, in-situ, fixed and mobile sensors.
### Web Services

**Sensor Observation Service (SOS)**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetCapabilities</td>
<td>Enables a client to retrieve metadata about the capabilities of a SOS.</td>
</tr>
<tr>
<td>DescribeSensor</td>
<td>Allows a client to obtain detailed metadata about the sensors and platforms exposed by the SOS service.</td>
</tr>
<tr>
<td>GetObservation</td>
<td>Operation to query a sensor system to retrieve archived or real-time observation data.</td>
</tr>
<tr>
<td>RegisterSensor</td>
<td>Allows a client to register a new sensor system with a SOS.</td>
</tr>
<tr>
<td>InsertObservation</td>
<td>Allows a client to insert a new observation for a registered sensor system.</td>
</tr>
</tbody>
</table>

Ref. [9]

**Sensor Alert Service (SAS)**

- SAS is a web service that allows a sensor to be monitored for an “alarming condition”, e.g. temperature exceeds a given value.
- It enables data node to publish alerts and subscribe to alerts from other nodes.
- SAS is a basic publish/subscribe system with asynchronous notification.
- A user may subscribe to receive alerts.
**Web Services**

- **Sensor Alert Service (SAS)**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetCapabilities</td>
<td>Enables a client to retrieve metadata about the capabilities of a SAS.</td>
</tr>
<tr>
<td>Advertise</td>
<td>Allows a client to advertise what kind of data could be published.</td>
</tr>
<tr>
<td>RenewAdvertisement</td>
<td>Allow a client to renew a previous advertisement.</td>
</tr>
<tr>
<td>CancelAdvertisement</td>
<td>Allows a client to cancel a previously registered advertisement offering.</td>
</tr>
<tr>
<td>Subscribe</td>
<td>Allows a client to subscribe to an alert that has been advertised by the SAS.</td>
</tr>
<tr>
<td>RenewSubscription</td>
<td>Allow a client to renew a subscription that has expired.</td>
</tr>
<tr>
<td>CancelSubscription</td>
<td>Allows a client to cancel a subscription</td>
</tr>
</tbody>
</table>

Ref. [9]

## Web Services

- **Sensor Planning Service (SPS)**

SPS enables an interoperable service by which a client can determine collection feasibility for a **desired set of collection requests** for one or more sensors/platforms, or a client may **submit collection requests** directly to these sensors/platforms.
**Web Services**

- **Web Notification Service**
  
  WNS manages message dialogue between client and Web service(s) for long duration (asynchronous) processes.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetCapabilities</td>
<td>Enables a client to retrieve metadata about the capabilities of a WNS.</td>
</tr>
<tr>
<td>Register</td>
<td>Register a user (or a group of users) to receive notifications.</td>
</tr>
<tr>
<td>UnRegister</td>
<td>Un-register a user (or a group of users)</td>
</tr>
<tr>
<td>DoNotification</td>
<td>Initiate the notification of a user</td>
</tr>
<tr>
<td>GetWSDL</td>
<td>Retrieve a WSDL description of the service interface</td>
</tr>
<tr>
<td>UpdateSingleUserReg</td>
<td>Update the settings of a registered user.</td>
</tr>
<tr>
<td>UpdateMultiUserReg</td>
<td>Update the settings of a registered group of users.</td>
</tr>
<tr>
<td>GetMessage</td>
<td>Allows a client to retrieve a message stored by the WNS, i.e. information of failed messages.</td>
</tr>
</tbody>
</table>

Ref. [9]

**Web Services**

- **Sensor Registries**

  OGC Catalog Service for the Web (CSW)

Ref. [10]
Web Services

- More Services

Geo Decision Support Services GeoDSS

Activity 1: Schema Tailoring & Maintenance.

Activity 2: Define and Implement Data Aggregation Service.

Activity 3: Symbology Management & Feature Portrayal Service.

Activity 4: GeoVideo Service.
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SWE Applications

• OGC OWS-3
• GEOSS
• INSPIRE
• SANY
• OPENIOOS
• SensorBay
• SunSPOTs
• GITEWS
• PulseNet
• WaterOneFlow
SWE Applications

- OGC OWS-3

OGC Web Services, Phase 3 (OWS-3) is an Interoperability Initiative that advanced OGC technology in the following areas:

- Common Architecture
- OGC Location Services (OpenLS)
- Sensor Web Enablement (SWE)
- Geo-Decision Support Services (GeoDSS)
- Geo-Digital Rights Management (GeoDRM)
- The IEEE 1451™ and OASIS Common alerting Protocol (CAP) standards were used in OWS-3.

SWE Applications

- GEOSS

- the Group on Earth Observations (a grouping of 76 national governments and other international organizations) aims to integrate existing observation networks into a Global Earth Observation System of Systems (GEOSS) to achieve comprehensive, coordinated and sustained observation of the Earth system.
GEOSS has the objective to continuously monitor the state of the earth in order to increase knowledge and understanding of our planet and its processes.

Timely delivery of earth observation data is a key aspect in identifying potential natural and human threats, such as tornados, tsunamis, wild fires, or algae blooms.

Data from in-situ or remote sensing devices form the basis for analyzing gradual processes, such as increasing drought, water shortages, or rising sea levels.

SWE Applications

- Infrastructure for Spatial Information in Europe

Data Resources

<table>
<thead>
<tr>
<th>National and Sub-national SDI</th>
<th>European Data</th>
<th>Local data</th>
</tr>
</thead>
<tbody>
<tr>
<td>National and Sub-national SDI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INSPIRE Specifications

- Discovery Service
- Technical Integration harmonisation
- Harmonised Data policy
- Collaborative agreements

Users

- Government & Administrations
- Utility & Public Services
- Commercial & Professional Users
- Research
- NGOs and not-for-profit orgs
- Citizens

http://inspire.jrc.ec.europa.eu/
SWE Applications

- Sensors Anywhere (SANY)
  - Unified and generic data fusion methodology
  - Generic development and re-use of fusion technology
  - Generic standards related to data fusion services implementations
  - Generic and formalized information fusion framework
SWE Applications

• OPENIOOS

![OPENIOOS diagram](image1)

The Sensor Bay project used Compusult’s Web Enterprise Suite SWES to set up a SWE compliant sensor network in remarkably short time and budget.

• SensorBay

![SensorBay diagram](image2)

http://www.sensorbay.ca
SWE Applications

- Sensor Web in SunSPOTs

**Dimensions**
- 41 x 23 x 70 mm
- 54 grams

**Sun SPOT Processor Board**
- 180 MHz 32 bit ARM920T core - 512K RAM/4M Flash
- 2.4 GHz IEEE 802.15.4 radio with integrated antenna
- USB interface
- 3.7V rechargeable 720 mAh lithium-ion battery
- 32 uA deep sleep mode

**General Purpose Sensor Board**
- 2G/6G 3-axis accelerometer
- Temperature sensor
- Light sensor
- 8 tri-color LEDs
- 6 analog inputs
- 2 momentary switches
- 5 general purpose I/O pins and 4 high current output pins

SunSPOTs provides a tool for rapidly prototyping sensor-based applications, and for testing and verifying algorithms on a small scale prior to deploying them in industrial operation. This tool can be exploited to reduce costs by evaluating novel algorithms a priori before adapting them to real-world problems.

**Applications:** detection and warning systems, environmental monitoring, automotive engineering, warehouse/container management, logistics, monitoring of buildings, home automation, weather forecasting, medical monitoring of patients and diagnosis, and agriculture and farming.
SWE Applications

• Sensor Web in SunSPOTs

Indoor Environmental Quality Measurement

Based on SunSPOT sensor technology, this project develops an indoor environmental quality application.

Each sensor station is composed of two main components:

(i) an external sensor which can measure electromagnetic pollution, air pressure, humidity, air temperature, brightness, noise or carbon dioxide, and

(ii) a SunSPOT module which is responsible for pre-processing acquired sensor data and propagating them through the sensor network.

The base station managing this sensor network is an OGC-compliant Sensor Web application.

It allows for administration of the sensors, and reading and processing of sensor data; for example, users can visualize and interact with current sensor values on a graphical, Web-based interface. In particular, the Sensor Model Language (SensorML), Observation & Measurements (O&M), and Sensor Observations Service (SOS) specifications are adopted.
SWE Applications

• Sensor Web in SunSPOTs

  Indoor Environmental Quality Measurement

  Communication between the sensor and the base station can occur in both push and pull modes and in a regular or on-demand fashion, where the values are communicated over the meshed wireless sensor network.

  All configurations can be defined by the user during run-time. In addition, a user can employ a sensor value reader device (essentially another SunSPOT) in order to get data from a specific sensor by physically moving into the communication range of that sensor and querying the accordant data.

  http://www.salzburgresearch.at/

SWE Applications

• GITEWS

  German Indonesian Tsunami Early Warning System

  The German organization 52North provides a complete set of SWE services under GPL license.

  35 Million Euro project

  www.gitews.org/
SWE Applications

- **PulseNet:**

  In its first year, PULSENet was successfully field tested under a real-life use case scenario that fused data from four unattended ground sensors, two tracking cameras, 1,800 NOAA weather stations and NASA’s EO-1 satellite.

PULSENet clients in multiple Web locations can task heterogeneous sensors and sensor systems

SWE Applications

- **WaterOneFlow**

  WaterOneFlow Web services will provide a standard mechanism for flow of hydrologic data between hydrologic data servers (databases) and users

Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI)

http://www.cuahsi.org/
References