Acronym: COMMON SENSE
Title: COST-EFFECTIVE SENSORS, INTEROPERABLE WITH INTERNATIONAL EXISTING OCEAN OBSERVING SYSTEMS, TO MEET EU POLICIES REQUIREMENTS
Grant agreement n° 614155

Deliverable 3.3
Sensor Data Processing and Conversion Tools, semantic framework and standard sensor web service
31-03-2016

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)

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<thead>
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<th>Dissemination Level</th>
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<td>PU Public</td>
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<td>PP Restricted to other programme participants (including the Commission Services)</td>
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<td>RE Restricted to a group specified by the consortium (including the Commission Services)</td>
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<td>CO Confidential, only for members of the consortium (including the Commission Services)</td>
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The COMMON SENSE project has received funding from the European Union’s Seventh Framework Program (Ocean 2013-2) under the grant agreement no 614155.
Acknowledgement

The work described in this report has been partially funded by the European Commission under the Seventh Framework Programme, Theme OCEANS 2013.2; Innovative multifunctional sensors for in-situ monitoring of marine environment and related maritime activities.
EXECUTIVE SUMMARY

Objectives
The objective of this report is to describe the prototype tools and web services developed to support the Common Sensor Web Platform (CSWP). This includes tools for extracting and transforming sensor data and metadata, and loading them into the CSWP database, and for extracting data and metadata from the latter into standard delivery formats (O&M and SensorML). It describes a prototype semantic framework for managing, linking, and querying sensor data and metadata semantics. It also describes a set of web services for accessing and viewing sensor data and metadata based on existing implementations of standard OGC and Sensor Web Enablement web service specifications.

Rationale
COMMON SENSE WP3 aims to design and implement the Common Sensor Web Platform for connecting, processing, storing, managing and sharing sensor data. It aims to convert data and metadata into standard delivery formats and also aims to develop a service based platform to provide access to the web service network through a sensor data access and visualisation web portal.

This report first outlines an updated architecture diagram for the Common Sensor Web Platform (CSWP). The main critical path has been the deployment of the sensor metadata and observation data access service. First a sensor is registered in the CSWP, where the platform administrator uploads a SensorML 2.0 document to the SOS 2.0 server via the platform gateway. Data from the Smart Sensor Unit is uploaded and stored on an FTP server in the NMEA data format. Thereafter, the data is harvested from the FTP into the platform gateway, processed and transformed into O&M 2.0, and pushed into the CSWP. While the 52North SOS software platform is mature, the main effort here is regarding marine community profiles for the SensorML standard and the O&M data exchange standard, and applying these profiles to COMMON SENSE sensor data. While the syntax of the current generation of these standards is mature, marine community profiles are not yet well established.

The sensor discovery service, ontology and semantic reasoning service is also not a mature topic, so this is very much a research topic requiring dedicated time. Sensor data discovery is the process of browsing and/or searching data and services documented in one or more catalogues with the intention to check whether relevant data or services already exist. Data and service discovery relies on metadata that document these existing resources. A Semantic Web Service (SWS) has been developed by University College Cork in previous research projects and is being adopted and adapted for use in the COMMON SENSE project. It is a high-level web interface for querying SKOS thesauri and vocabularies. This semantic framework is being coupled with Sensor Instance Registry (SIR) to support sensor data discovery. It is intended that the semantic framework will facilitate and improve sensor data discovery by:

- Supporting semantic references in sensor data and metadata,
- Supporting multi-facet data/service search and browsing,
- Exploiting semantic relationships between terms to improve keyword search,
- Supporting smart search based on the interpretation of user terms.
This will be achieved through the use of controlled vocabulary terms from ontologies for inclusion in SensorML and O&M. The semantic framework will allow multi-facet search and browsing of the available data and services. Proposed data discovery facets for COMMON SENSE sensor discovery are:

1. Theme/Discipline (parameter)
2. MSFP descriptors
3. Instrument
4. Platform/Platform Class

COMMON SENSE is building on existing vocabulary services, and in particular the SKOS concepts defined in NERC Vocabulary Server (NVS) which is used by SeaDataNet. Sample ontology content based on NVS has been tested for COMMON SENSE, replicating relevant NVS concepts and semantic relations. New content is being added to the COMMON SENSE SKOS Scheme as new sensors are registered for COMMON SENSE. During this process, additional concepts and semantic mappings to other semantic resources such as the Semantic Sensor Network will be considered while further researching and populating these ontologies.

Directly hand building ontologies using SKOS RDF/XML can be tedious. For COMMON SENSE we are simplifying the process by entering SKOS concepts and semantic relationships in Excel spreadsheets. Thereafter, we use an Extract, Transform, and Load (ETL) tool to convert Excel spreadsheets and load the content into the Semantic Web Service’s Jena TDB triple store in the backend.

An interactive web mapping client has also been deployed which enables a user to visualise data. It supports functionality such as panning, zooming, querying, animation, data overlay, data download, and role based access control to data products. In the backend, the web mapping server is implemented using GeoServer supporting the OGC Web Map Service (WMS) standard.

The glue behind the Common Sensor Web Platform is software data processing and conversion tools. In the gateway, Python scripts are used to convert NMEA data to O&M. For the user front-end, Python scripts are used in ingest sensor location data into GeoServer and generate sensor data plots.

Lastly, the various web services deployed to support the Common Sensor Web Platform are listed here:

<table>
<thead>
<tr>
<th>Service</th>
<th>Deployment URL</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOS</td>
<td><a href="http://commonsense.ucc.ie/sos">http://commonsense.ucc.ie/sos</a></td>
<td>52North SOS version 4.3.6.</td>
</tr>
<tr>
<td>SWS</td>
<td><a href="http://commonsense.ucc.ie/semantix/SWS">http://commonsense.ucc.ie/semantix/SWS</a></td>
<td>UCC Semantix 1.1</td>
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<td>SIR/OSS</td>
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<td>GeoNetwork 3.0.4</td>
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<tr>
<td>WMS</td>
<td><a href="http://commonsense.ucc.ie/geoserver">http://commonsense.ucc.ie/geoserver</a></td>
<td>GeoServer 2.8.3</td>
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<tr>
<td>Client</td>
<td><a href="http://commonsense.ucc.ie/client">http://commonsense.ucc.ie/client</a></td>
<td>UCC SmartAtlas framework</td>
</tr>
</tbody>
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1 INTRODUCTION

1.1 Background
The COMMON SENSE project aims to support the implementation of European Union marine policies such as the Marine Strategy Framework Directive (MSFD) and the Common Fisheries Policy (CFP). The project has been designed to directly respond to requests for integrated and effective data acquisition systems by developing innovative sensors that will contribute to our understanding of how the marine environment functions. It aims to develop and provide cost-effective and multi-functional innovative sensors to perform reliable in-situ measurements in the marine environment.

The core project research will focus on increasing the availability of standardised data on: eutrophication; concentrations of heavy metals; microplastic fraction within marine litter; underwater noise; and other parameters such as temperature and pressure. This will be facilitated through the development of a sensor web platform and smart sensor unit, the overall block diagram of the Common Sensor Web Platform is shown in Figure 1-1.

![Overall block diagram of Common Sensor Web Architecture](image)

*Figure 1-1. Overall block diagram of Common Sensor Web Architecture*

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This objective of this report is to describe the prototype tools and web services developed to support the Common Sensor Web Platform (CSWP). This includes tools for extracting and transforming sensor data and metadata, and loading them into the CSWP database, and for extracting data and metadata from the latter into standard delivery formats (O&M and SensorML). It describes a prototype semantic framework for managing, linking, and querying sensor data and metadata semantics. It also describes a set of web services for accessing and viewing sensor data and metadata based on existing implementations of standard OGC and Sensor Web Enablement web service specifications.

1.2 Organisation of this report
Chapter 2: Architecture - review
This chapter outlines an updated architecture diagram for the Common Sensor Web Platform.

Chapter 3: Semantic Framework
This chapter describes the Semantic Framework for the Common Sensor Web Platform, utilising the Semantic Web Service (SWS) and semantic concepts based on the NERC Vocabulary Server (NVS).

Chapter 4: Sensor Web Services
This chapter describes the various web services deployed for the Common Sensor Web Platform.

Chapter 5: Sensor data processing and conversion tools
The glue behind the Common Sensor Web Platform is software data processing and conversion tools, which are described in this chapter.

1.3 Terminology
This document uses several keywords that are defined as follows.

1.3.1 Semantic framework
In reality, there is no common definition for “semantic framework”. However, the term “semantic framework” as used in this report means: a collection of classes, libraries, application programming interfaces (APIs), or applications that can be used to build semantics-aware information systems that integrate, manage, handle or deliver semantic knowledge related to the information system’s data and services.

1.3.2 SKOS
The Simple Knowledge Organization System (SKOS) is a common data model for knowledge organization systems such as thesauri, classification schemes, subject heading systems and taxonomies. The SKOS data model is formally defined as an OWL (Web Ontology Language) Full ontology. SKOS data are expressed as RDF (Resource Description Framework) triples, and may be encoded using any concrete RDF syntax (such as RDF/XML or Turtle) [SKOS].

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1.3.3 **SKOS Concept**

The fundamental element of the SKOS vocabulary is the concept. A SKOS concept can be viewed as an idea or notion; a unit of thought. The notion of a SKOS concept is useful when describing the conceptual or intellectual structure of a knowledge organization system [SKOS].

1.3.4 **SKOS Semantic Relations**

SKOS semantic relations are links between SKOS concepts, where the link is inherent in the meaning of the linked concepts. The properties skos:broader and skos:narrower are used to assert a direct hierarchical link between two SKOS concepts. The properties skos:broaderTransitive and skos:narrowerTransitive are used to assert transitive hierarchical links between two SKOS concepts. The property skos:related is used to assert an associative link between two SKOS concepts [SKOS].

1.3.5 **SKOS Concept Scheme**

A SKOS concept scheme can be viewed as an aggregation of one or more SKOS concepts. Semantic relationships (links) between those concepts may also be viewed as part of a concept scheme. This is useful to compile vocabularies, such as thesauri or classification schemes [SKOS].

1.3.6 **SKOS Concept Collections**

SKOS concept collections are labelled and/or ordered groups of SKOS concepts. Collections are useful where a group of concepts shares something in common, and it is convenient to group them under a common label [SKOS].
2 ARCHITECTURE - REVIEW

The COMMON SENSE deliverable report D3.1 “Common Sensor Web Platform Strategy and Architecture” provided analysis for the following use cases and services (the first being of highest priority):

1. Sensor metadata and observation data access service (SOS)
2. Sensor discovery service, ontology and semantic reasoning service (SIR, SOR/SWS, CSW)
3. Sensor eventing service (SES)
4. Sensor tasking service (SPS)
5. Sensor status service (SIR)

While all these use cases and services are not be required for COMMON SENSE, as documented in the state of the art review report COMMON SENSE D2.3 “Review of Sensor Web Middleware”, an architecture analysis of all the relevant SWE services was included in D3.1 in respect of fully analysing the current SWE framework and any potential update of requirements for COMMON SENSE. This was done in light of discussions with other FP7 “Oceans of Tomorrow” projects and any quick wins in terms of potential collaborations.

Priority 5 (sensor status service) and priority 4 (sensor tasking service) are still not required as originally outlined in COMMON SENSE D2.3. Priority 3 (sensor eventing service) is deferred until later in the project due the chosen 52North SES software not being a mature technology, thus, requiring extra dedicated time to research this topic. Instead emphasis and resources has been invested in priority 2 (sensor discovery service, ontology and semantic reasoning service) and priority 1 (sensor metadata and observation data access service). The sensor discovery service, ontology and semantic reasoning service is also not a mature topic, so this is very much a research topic requiring dedicated time. On the other hand, sensor metadata and observation data access service using the 52North SOS software platform is more mature. The main effort here is regarding marine community profiles for the SensorML sensor metadata standard and the Observations and Measurements (O&M) data exchange standard, and applying these profiles to COMMON SENSE sensor data. While the syntax of the current generation of these standards is mature, marine community profiles are not yet well established. The main critical path has been the deployment of the sensor metadata and observation data access service.

Figure 2-1 illustrates an updated architecture diagram. First a sensor is registered in the Common Sensor Web Platform, where the platform administrator uploads a SensorML 2.0 document to the SOS 2.0 server via the platform gateway. Each registered SensorML document has a unique identifier. Data from the Smart Sensor Unit (Figure 1-1) is uploaded and stored on an FTP server in the NMEA data format. Thereafter, the data is harvested from the FTP into the gateway, processed and transformed into O&M 2.0, and pushed into the Common Sensor Web Platform. The O&M document contains a reference to the previously registered SensorML using the same unique identifier.

The 52North implementation of SOS 2.0 supports both SensorML 2.0 and O&M 2.0. However, the 52North implementation of SIR only supports SensorML 1.0 and 1.0.1. SES support for O&M 2.0 is not well documented. As an interim solution, the gateway can transform SensorML 2.0 into SensorML...
1.0.1 for simplified use case demonstration. Ideally the SIR and SES should be upgraded directly to support SensorML 2.0 and O&M 2.0 as a long term solution. CSW 2.0.2 using the GeoNetwork implementation is mature, while the SWS is a research solution developed by University College Cork for semantic reasoning using ontologies.

Figure 2-1. Common Sensor Web Platform architecture
3 SEMANTIC FRAMEWORK

Sensor data discovery is the process of browsing and/or searching data and services documented in one or more catalogues with the intention to check whether relevant data or services already exist. Data and service discovery relies on metadata that document these existing resources. It is intended that the semantic framework will facilitate and improve sensor data discovery by:

- Supporting semantic references in sensor data and metadata,
- Supporting multi-facet data/service search and browsing,
- Exploiting semantic relationships between terms to improve keyword search,
- Supporting smart search based on the interpretation of user terms.

This will be achieved through the use of controlled vocabulary terms from ontologies for inclusion in SensorML and O&M. The semantic framework is being coupled with Sensor Instance Registry (SIR) to support sensor data discovery. The semantic framework will allow multi-facet search and browsing of the available data and services. As data search and browsing is based on metadata keywords, the most appropriate search and browsing facets are metadata keyword types.

3.1 Search Facets

COMMON SENSE data discovery facets are based on selected keyword types defined in the ISO 19115 metadata model and also keyword types used by SeaDataNet. These facets are proposed for COMMON SENSE sensor discovery:

1. Theme/Discipline (parameter)
2. MSFP descriptors
3. Instrument
4. Platform/Platform Class

These search facets are discussed in the following section in the context of ontologies.

3.2 Ontologies

COMMON SENSE is building on existing vocabulary services, and in particular the NERC Vocabulary Server (NVS) which is used by SeaDataNet. We are using these NVS Collections:

<table>
<thead>
<tr>
<th>NVS Collection Code</th>
<th>Title</th>
</tr>
</thead>
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<tr>
<td>L19</td>
<td>SeaDataNet keyword types</td>
</tr>
<tr>
<td>P08</td>
<td>SeaDataNet Parameter Disciplines</td>
</tr>
<tr>
<td>P03</td>
<td>SeaDataNet Agreed Parameter Groups</td>
</tr>
<tr>
<td>P02</td>
<td>SeaDataNet Parameter Discovery Vocabulary</td>
</tr>
<tr>
<td>P01</td>
<td>BODC Parameter Usage Vocabulary</td>
</tr>
<tr>
<td>P06</td>
<td>BODC data storage units</td>
</tr>
<tr>
<td>L05</td>
<td>SeaDataNet device categories</td>
</tr>
</tbody>
</table>
Within O&M and SensorML we will use low level usage vocabularies, such as P01 (BODC Parameter Usage Vocabulary), P06: BODC data storage units, P05 (SeaDataNet device categories), L22 (SeaVoX Device Catalogue). The user-oriented sensor search client will use higher level discovery vocabularies such as P02 (SeaDataNet Parameter Discovery Vocabulary), P08 (SeaDataNet Parameter Disciplines), C45 (Marine Strategy Framework Directive descriptors), etc.

The NVS provides SKOS concept collections, and semantic relationships between concepts within and between these collections. Some of these NVS concept collections are very large. It is necessary for COMMON SENSE to create custom SKOS schemes, built from a subset of the NVS concept collections, to better support the demonstration of semantic smart search within the COMMON SENSE project.

The semantic knowledge of an ontology resides in the semantic relationships between concepts and the inference rules rather than in the concepts themselves. These semantic relationships can be processed by a machine automatically and allow a computer to generate new knowledge from a set of predefined concepts, rules and relationships. Exploiting these semantic relationships allows the semantic framework, and consequently the information system, to improve the quality and completeness of its responses to user queries.

COMMON SENSE is building customised SKOS schemes to support semantic reasoning. However, the COMMON SENSE SKOS schemes are not completely tied to the NVS. Additional concepts and semantic mappings to other semantic resources such as the Semantic Sensor Network (SSN) will be considered while further researching and populating these ontologies. Simple illustrative examples of the concept scheme hierarchy are illustrated in the following sections:

### 3.2.1 Theme/Discipline (parameter) example

This example illustrates a concept scheme hierarchy for salinity from a CTD instrument for the Theme/Discipline (parameter) search facet.

L19: parameter (http://vocab.nerc.ac.uk/collection/L19/current/SDNKG03/)
→ L19: discipline (http://vocab.nerc.ac.uk/collection/L19/current/)
→ P08: Physical oceanography (http://vocab.nerc.ac.uk/collection/P08/current/DS03/)
→ P08: Water column temperature and salinity (http://vocab.nerc.ac.uk/collection/P08/current/DS03/)
→ P03: Water column temperature and salinity (http://vocab.nerc.ac.uk/collection/P03/current/D025/)
→ P02: Salinity of the water column (http://vocab.nerc.ac.uk/collection/P02/current/PSAL/)
→ P01: Practical salinity of the water body by CTD and computation using UNESCO 1983 algorithm (http://vocab.nerc.ac.uk/collection/P01/current/PSALST01/)
In the example, if the user searches for “Physical oceanography” from the P08 collection, then the semantic framework engine will infer that a SensorML document tagged with “Practical salinity of the water body by CTD and computation using UNESCO 1983 algorithm” from the P01 collection will be a search result match.

### 3.2.2 MSFP descriptors

This example illustrates a concept scheme hierarchy for salinity from a CTD instrument for the MSFP descriptors search facet.

C45: Biological diversity maintained (http://vocab.nerc.ac.uk/collection/C45/current/D1/)
→ C46: Habitat condition (http://vocab.nerc.ac.uk/collection/C46/current/C1_6/)
→ C47: Physical, hydrological and chemical conditions (http://vocab.nerc.ac.uk/collection/C47/current/IN1_6_3/)
→ P02: Salinity of the water column (http://vocab.nerc.ac.uk/collection/P02/current/PSAL/)
→ P01: Practical salinity of the water body by CTD and computation using UNESCO 1983 algorithm (http://vocab.nerc.ac.uk/collection/P01/current/PSALST01/)

In the example, if the user searches for “Habitat condition” from the C46 collection, then the semantic framework engine will infer that a SensorML document tagged with “Practical salinity of the water body by CTD and computation using UNESCO 1983 algorithm” from the P01 collection will be a search result match.

### 3.2.3 Instrument

This example illustrates a concept scheme hierarchy for a CTD for the instrument search facet.

L19: instrument (http://vocab.nerc.ac.uk/collection/L19/current/SDNKG01/)
→ L05: CTD (http://vocab.nerc.ac.uk/collection/L05/current/130/)
→ L22: Idronaut Ocean Seven 320 CTD (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0213/)

In the example, if the user searches for “CTD” from the L05 collection, then the semantic framework engine will infer that a SensorML document tagged with “Idronaut Ocean Seven 320 CTD” from the L22 collection will be a search result match.

### 3.2.4 Platform/Platform Class

This example illustrates a concept scheme hierarchy for a ship for the platform/platform class search facet.

→ L19: platform_class (http://vocab.nerc.ac.uk/collection/L19/current/SDNKG05/)
→ L06: ship (http://vocab.nerc.ac.uk/collection/L06/current/30/)
In the example, if the user searches for “ship” from the L06 collection, then the semantic framework engine will directly infer that a SensorML document tagged with “ship” from the L06 collection will be a search result match.

### 3.3 Semantic Web Service (SWS)

A Semantic Web Service (SWS) has been developed by University College Cork in previous research projects and is being adopted and adapted for use in the COMMON SENSE project. It is a high-level web interface for querying SKOS thesauri and vocabularies. It delivers content in standard RDF/XML or JSON-LD formats. The SKOS thesauri and vocabularies are stored in a Jena TDB triple store. ([http://semantix.ucc.ie/](http://semantix.ucc.ie/)).

The SWS supports the following operations, which provide a service API infrastructure for supporting semantic based discovery of sensors:

1. **GetCapabilities**
   - Retrieves service metadata, including supported operations, response formats, available concept schemes, and their supported languages.

2. **GetConceptSchemes**
   - Lists available concept schemes with their annotations (labels, definitions, etc.).

3. **GetConceptScheme**
   - Returns a concept scheme definition given its URI. The response includes the concept scheme’s annotations.

4. **SearchConceptSchemes**
   - Returns the definition(s) of one or more concept scheme(s) matching a specified free-text keyword.

5. **GetConceptSchemeContent**
   - Returns the content of a given concept scheme (identified by its URI), including its collections and concepts.

6. **GetCollections**
   - Lists available concept collections with their annotations. Collections may be filtered by one or more concept schemes.

7. **GetCollection**
   - Returns a collection definition identified by its URI. The response includes the collection’s annotations.

8. **SearchCollections**
   - Returns the definition(s) of one or more collection(s) matching a specified free-text keyword.
9. **GetCollectionMembers**
   Returns the content of a given collection (identified by its URI), including member collections and concepts.

10. **GetConcepts**
    Returns the definitions of the concepts belonging to a specified concept scheme and/or collection.

11. **GetConcept**
    Returns a concept definition given its URI. The response includes the concept’s annotations.

12. **SearchConcepts**
    A search operation that returns the concepts that textually match a given keyword.

13. **GetRelatedConcepts**
    Returns the concepts related to one or many given concept(s) using one or many given SKOS relationship(s) (e.g., skos:narrower, skos:broader, skos:related, etc.), both from direct assertions and by entailment.

14. **GetDirectNarrowerConcepts**
    Returns the concepts that are immediately narrower (skos:narrowerTransitive) than a given concept.

15. **GetDirectBroaderConcepts**
    Returns the concepts that are immediately broader (skos:broaderTransitive) than a given concept.

16. **GetTopConcepts**
    Returns the concepts that have explicitly been asserted as top concepts of a specified concept scheme.

17. **GetBroadestConcepts**
    Returns the top-level concepts of a specified concept scheme.

18. **GetConceptHierarchy**
    This operation is suitable for small thesauri, and is useful for ontology browsers. It returns the hierarchy of the concepts within a given concept scheme and/or collection.

19. **InterpretKeyword**
    Returns the concepts that semantically match a given keyword, within a specified concept scheme and or collection.

20. **CheckRelation**
    Checks whether two specified concepts are related via a specified SKOS relationship.
3.4 **Ontology population into Semantic Web Service (SWS)**

Directly hand building ontologies using SKOS RDF/XML can be tedious. For COMMON SENSE we are simplifying the process by entering SKOS concepts and semantic relationships in Excel spreadsheets. Thereafter, we use an Extract, Transform, and Load (ETL) tool to convert Excel spreadsheets and load the content into the Semantic Web Service’s Jena TDB triple store in the backend.

COMMON SENSE is building on existing vocabulary services, and in particular the SKOS concepts defined in NERC Vocabulary Server (NVS) which is used by SeaDataNet. Sample ontology content based on NVS has been tested for COMMON SENSE, replicating relevant NVS concepts and semantic relations. New content is being added to the COMMON SENSE SKOS Scheme as new sensors are registered for COMMON SENSE. During this process, additional concepts and semantic mappings to other semantic resources such as the Semantic Sensor Network will be considered while further researching and populating these ontologies.
4 SENSOR WEB SERVICES

4.1 Web services hosting environment
The COMMON SENSE web services are deployed on a virtual server hosted at University College Cork. The virtual server is currently running Ubuntu Linux 14.04 LTS (Long Term Support). The following baseline software is also installed and configured to support various web services:

- Java JDK 7 (OpenJDK 1.70_95) - Ubuntu package management
- Apache 2 HTTP Server (2.4.7) - Ubuntu package management
- Postgresql (9.3.11) - Ubuntu package management
- Postgis (2.1.2) - Ubuntu package management
- Apache Tomcat (8.33) – Direct download

For security and bug maintenance, the above software is routinely updated as new versions become available. This is done through the Ubuntu apt packaging tool or via direct download as appropriate.

4.2 Sensor Observation Service - SOS
The 52North implementation of SOS is installed and accessible at http://commonsense.ucc.ie/sos. We are using the latest stable release, currently 52North SOS version 4.3.6.

The Apache 2 HTTP Server was configured to reverse proxy to the Apache Tomcat backend using the AJP13 protocol. While the actual Apache Tomcat instance is running on port 18080 on the virtual server (http://commonsense.ucc.ie:18080/sos), the reverse proxy makes this web service available on the standard HTTP port 80 via the Apache 2 HTTP Server (http://commonsense.ucc.ie/sos). In some private networks, a non-standard port such as 18080 may be blocked by a firewall, thus preventing users from accessing the website within that network.

Before installation, a PostgreSQL user and a dedicated PostgreSQL database for the SOS are created. PostGIS, a spatial database extender for PostgreSQL, is installed into this database. For installation, a 52North SOS WAR (Web application ARchive) deployment file is required. A precompiled SOS WAR file can be downloaded from http://52north.org/downloads/category/3-sos. Alternatively, the source code can be downloaded from https://github.com/52North/sos. This is useful if you need to compile and debug the code. Once the Java WAR file (Web application ARchive) is ready for installation, it is just a matter of copying it into the Apache Tomcat webapps folder.

The final steps for installation are done via a web browser, where the installation administrator configures the database connections details and other configuration settings. Figure 4-1 is an example configuration form.
The COMMON SENSE project has received funding from the European Union’s Seventh Framework Program (Ocean 2013-2) under the grant agreement no 614155.

4.3 Semantic Web Service - SWS

The SWS server is installed and its API is accessible at http://commonsense.ucc.ie/semantix/SWS. The deployable Java WAR file was downloaded from http://semantix.ucc.ie and copied into the Apache Tomcat webapps folder. Similar to the SOS web service, we configured the Apache 2 HTTP Server to provide an AJP reverse proxy over the standard port 80. The main SWS configuration step was to set the directory to the Jena TDB triple store. The building of the triple store was built using an Extract, Transform, and Load (ETL) tool to convert semantic content entered in Excel spreadsheets as described in Section 3.4. An example SWS request which lists available SKOS Concept Schemes for COMMON SENSE in XML format is shown in Figure 4-2.
The COMMON SENSE project has received funding from the European Union’s Seventh Framework Program (Ocean 2013-2) under the grant agreement no 614155.
Open Sensor Search

Open Sensor Search is an open platform for discovery and management of sensor metadata. This is the landing page for the service.

APIs
The entry point into the API: /api
The endpoint for the Sensor Instance Registry (SIR): /sir

Current Statistics
- sensors, phenomena, and services.

Figure 4.3. Open Sensor Search

4.5 Catalogue Service for the Web - CSW

The GeoNetwork implementation of the CSW standard is installed and accessible at http://commonsense.ucc.ie/geonetwork. We are using the latest stable release, currently GeoNetwork version 3.0.4.

Before installation, a PostgreSQL user and a dedicated PostgreSQL database for GeoNetwork are created. PostGIS is also installed into this database. GeoNetwork was then installed via an executable jar, where a dedicated servlet container is installed (Jetty). We configured this Jetty server to run on 12080 and configure the Apache 2 HTTP Server to provide a HTTP reverse proxy over the standard port 80 for HTTP. Final configuration steps such as database connection details are manually added to GeoNetwork configuration files.

A metadata record, using the ISO 19115/19139 standards describing the deployed SOS server (section 4.2), has been added to the GeoNetwork (Figure 4-4). This record can be accessed through the CSW standard, promoting interoperability. For example CSW is required by the INSPIRE Directive to support data service discovery.
The COMMON SENSE project has received funding from the European Union’s Seventh Framework Program (Ocean 2013-2) under the grant agreement no 614155.

4.6 Sensor Event Service - SES

SES is not a priority to install as described in Chapter 2 requiring extra dedicated time to research this topic. Instead emphasis and resources has been invested in the previous web services. This will be reviewed after the main priority objectives have been met.
4.7 Client

A demo client has been setup at [http://commonsense.ucc.ie/client](http://commonsense.ucc.ie/client). This client is based on an existing web GIS mapping framework developed at University College Cork ([http://smartatlas.ucc.ie/](http://smartatlas.ucc.ie/)). It is an interactive web mapping viewer which enables a user to visualise data. It supports functionality such as panning, zooming, querying, animation, data overlay, data download, and role based access control to data products.

In the backend, the web mapping server is implemented using GeoServer. The latest stable GeoServer (version 2.8.3) was installed ([http://commonsense.ucc.ie/geoserver](http://commonsense.ucc.ie/geoserver)). GeoServer supports the OGC Web Map Service (WMS) standard, which is also used by the INSPIRE Directive. Maps rendered by GeoServer show sensor observation locations, while we use Google Charts to visualise sensor outputs as plots. We use conversion scripts developed in the Python programing language, which are described in the next Chapter. Links to the O&M data, SensorML metadata, and a link to the visualisation plots are included as attributes for querying by the user in the viewer. Finally, the sensor search client tool using the SIR and SWS web services is currently under development.

Figures 4-5 to 4-7 illustrates the current version of the COMMON SENSE demo client with sample data from two CTD locations. First the locations of the two casts are illustrated. Next the user opens the attribute table for one of the locations. This includes links to the O&M data, SensorML metadata, and a link to plots. The final figure illustrates a sea water temperature plot from a CTD instrument.

![Web mapping: location of two CTD casts](image)

Figure 4-5. Web mapping: location of two CTD casts

The COMMON SENSE project has received funding from the European Union’s Seventh Framework Program (Ocean 2013-2) under the grant agreement no 614155.
Figure 4-6. Geo-location attribute table, includes links to O&M data, SensorML metadata, and plots

Figure 4-7. Online plot, pre-generated from O&M

The COMMON SENSE project has received funding from the European Union’s Seventh Framework Program (Ocean 2013-2) under the grant agreement no 614155.
5 SENSOR DATA PROCESSING AND CONVERSION TOOLS

This chapter describes software data processing and conversion tools. Tools are broken into these areas:

1. Gateway: backend processing
2. Client: user application processing

5.1 Gateway: backend processing
As described in Chapter 2, data from the Smart Sensor Unit (Figure 1-1) is uploaded and stored on an FTP server in the NMEA data format. Thereafter, data is harvested from the FTP into the gateway, processed and transformed into O&M 2.0, and pushed into the Common Sensor Web Platform.

The first iteration of the processing tool developed in Python has used sample CTD data in CSV format. The tool converts the data into O&M 2.0, and successfully uploads the O&M data document to the SOS server. As more test data becomes available, the script is extensible by adding a new data handler per instrument type based on customised O&M templates.

5.2 Client: user application processing
As described in Section 4.7, the client visualises the location of sensor observations, and plots the sensor results. In terms of the data flow pipeline, sensor geo-location data are ingested into GeoServer, sourced from a SOS O&M data request. To support near real time products, the Python programming language is used to automate and manage this ingestion process. For the first demo iteration, sensor location data is converted into a Shapefile format using a script and the GDAL ogr2ogr utility program. It is planned to move from Shapefile to a PostgreSQL/PostGIS database. Once data is registered in GeoServer, we define how data are to be styled and rendered. While GeoServer will render sensor locations, we need a plotting tool to visualise sensor outputs. For the first demo iteration, sensor O&M data is converted into a Google Charts web page using a Python script. Links to the O&M data, SensorML metadata, and a link to the visualisation plots are included as attributes in the Shapefile for querying by the user in the client viewer.
6 REFERENCES

7 ACRONYMS

AJP13  Apache Jserv Protocol version 1.3
API    Application programming interface
CFP   Common Fisheries Policy
CSV   Comma Separated Values
CSW   Catalogue Service for the Web
CSWP  Common Sensor Web Platform
CTD   Conductivity, Temperature, Depth
ETL   Extract, Transform and Load
FTP   File Transfer Protocol
GDAL  Geospatial Data Abstraction Library
HTTP  Hypertext Transfer Protocol
INSPIRE  Infrastructure for Spatial Information in the European Community
ISO   International Organization for Standardization
JDK   Java Development Kit
JSON  JavaScript Object Notation
JSON-LD JSON for Linking Data
LTS   Long Term Support
NVS   NERC Vocabulary Server
O&M   Observations and Measurements
OGC   Open Geospatial Consortium
OSS   Open Sensor Search
OWL   Web Ontology Language
NMEA  National Marine Electronics Association
RDF   Resource Description Framework
SensorML Sensor Model Language
SES   Sensor Event Service
SIR   Sensor Instance Registry
SKOS  Simple Knowledge Organization System
SOR   Sensor Observable Registry
SOS   Sensor Observation
SPS   Sensor Planning Service
<table>
<thead>
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<tr>
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<td>Sensor Web Enablement</td>
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<td>SWS</td>
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<tr>
<td>TDB</td>
<td>A component of Jena for RDF storage and query (triple store)</td>
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<td>URI</td>
<td>Uniform Resource Identifier</td>
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<td>XML</td>
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