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Semantic interoperability: A Goal for Marine Data Management

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Presentation Overview

- Introduction
- Development of Syntactic Interoperability
- GF3 and Semantic Interoperability
- How to Achieve Semantic Interoperability (Ideal World)
- Vocabulary Governance
- How to Achieve Semantic Interoperability (Real World)
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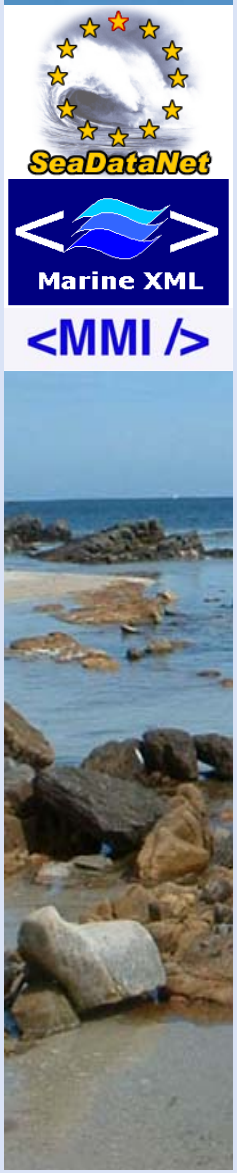
Introduction

- **Interoperability is the ability to share data from multiple sources as a common resource from a single tool**
- **Interoperability has four levels (Bishr, 1998)**
  - **System – protocols, hardware and operating systems**
  - **Syntactic/Structural – loading data into a common tool (reading each others' files)**
  - **Semantic – understanding of terms used in the data by both humans and machines**



Introduction

- **Interoperability has been the elusive Nirvana for oceanographic data management since IODE was established in 1961**
- **Modern Semantic Web knowledge management technologies are bringing this dream within reach**
- **But without a foundation of published well-defined, well-governed and versioned base vocabularies the technology will achieve nothing**

Syntactic Interoperability Development

- There was a time when data were exchanged primarily on 9-track magnetic tape
- These had different byte lengths, word lengths, character encodings and physical file constructions
- Listing a file took an expert 2-3 days
- After which, there was the format to decipher

Syntactic Interoperability Development

- Now standards have become established making life easier
  - The Excel spreadsheet is a universally accepted currency for biological and chemical oceanographic data exchange
  - NetCDF, particularly standardised variants like CF over protocols such as OpenDAP gives interoperable high volume data exchange
- Scientists without programming skills can visualise data from multiple sources in minutes
- But can they understand what it means?

GF3 and Semantic Interoperability

- GF3 was an oceanographic data exchange format developed by IODE in the 1980s
- It was primarily targeted at system, structural and syntactic interoperability issues, particularly 9-track tape harmonisation
- But it also addressed semantic interoperability through the introduction of code tables covering countries, platforms, instruments and especially measured phenomena

GF3 and Semantic Interoperability

- Code tables generally not taken up by science, but were adopted by the IODE data centre network
- A study of their use, and abuse, by this community can provide valuable lessons for those developing semantic interoperability today

GF3 and Semantic Interoperability

- **Content Governance**
  - **Initially the GF3 code tables had strong content governance through IODE GETADE**
  - **This fell apart when it was realised that effort put into development of vocabularies distributed by paper publication was wasted**
  - **Consequently, code tables became dated**
    - IOC Country codes last revised in 1981
    - A lot has happened in the world since then
- **Breakdown of content governance leads to a proliferation of local vocabularies**
- **Like finches on Galapagos, these all start the same, but then diversify**

GF3 and Semantic Interoperability

- GF3 code tables included no definitions of terms or the entity represented
- Words have different meanings to different people and even common words like ‘cruise’ gained multiple meanings
- Code (key) syntax was deemed important
  - Not scalable – there is a limit to how many meaningful combinations can be squeezed from 4 or even 8 bytes
  - Diverts attention onto labels and away from the real issue of meaning

GF3 and Semantic Interoperability

- **Vocabularies were used to ‘fix’ data models**
  - **One-to-one relationships turned into one-to-many by creating vocabulary entries that are themselves lists**
    - Examples from a ‘data type’ vocabulary
      - Moored profiling CTD + acoustic current meter
      - Turbulence/dissipation data
  - **Adding metadata elements by mixing entities**
    - Examples from the same ‘data type’ vocabulary introducing ‘platforms’
      - Multiple data types – aircraft
      - Multiple data types – ship
  - **Makes mapping much more difficult or even impossible**

Semantic Interoperability (Ideal World)

- **Comments directed at those building marine data systems without the millstone of legacy data**
  - **Take note of the work of others, learn their lessons and don't reinvent wheels**
  - **Avoid free text in metadata except for abstracts**
  - **Populate fixed fields from existing vocabularies wherever possible**
    - Spend time looking rather than inventing
    - Build any new lists in collaboration and establish governance
  - **Always allow for vocabulary development**
    - Use on-line declarations wherever possible
    - Don't implement local copies without synchronisation
  - **Ensure your metadata always accompanies your data**

Semantic Interoperability (Ideal World)

- **The guidance being given is to adopt vocabulary standards wherever possible**
- **This has been preached but not practiced in the past because**
  - **Interoperability was not top of some agendas**
    - Data hoarding preferred to data sharing
    - Interoperability difficulties provided an excuse not to share
  - **Local needs trumped community efforts**
    - Community development takes time and effort
    - Quick fixes needed at the coal face
  - **The standards never really delivered**
    - Vocabulary content lacked adequate governance
    - Vocabulary updates slow, confusing and unreliable

Vocabulary Governance

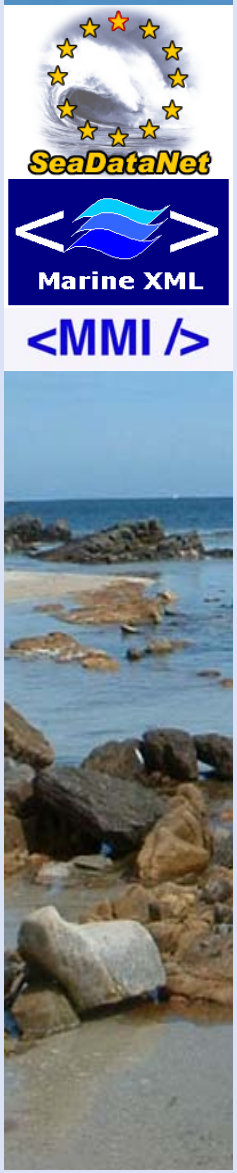
- **For vocabulary standards to be adopted we need content governance (the mechanism for making decisions on vocabulary change) that delivers:**
    - Change with no compromise in vocabulary standards or internal consistency
    - Change on a timescale that matches the needs of the scientific community
- **The CF community have come a long way towards achieving this for their Standard Names**
- **Work is beginning to establish an infrastructure for the development of vocabularies within the EU SeaDataNet project and the IOC data centre network**
- **NASA's SWEET project is developing a forum for discussing the management and development of environmental ontologies**

Vocabulary Governance

- **For vocabulary standards to be adopted we need technical governance (vocabulary storage, maintenance and serving) that delivers:**
    - Convenient access to up to date vocabularies
    - Clear, rigorous vocabulary versioning
    - Version history through audit trails
    - Maintenance that doesn't break user systems
    - Semantically neutral keys to represent entries
- **BODC has achieved this with the NERC DataGrid Vocabulary server**
- **ICES is coming along fast with the proposed upgrades to its RECO system**

Semantic Interoperability (Real World)

- In the real world we have legacy metadata populated using many similar, but significantly different vocabularies
- The only way to address semantic interoperability is by building maps between the terms of these vocabularies
- Drive and effective tooling to do this is being delivered by the Marine Metadata Interoperability Initiative (MMI)



Semantic Interoperability (Real World)

- MMI (http://marinemetadata.org)
  - MMI received first funding in 2004 to create advanced, interoperable community-based metadata practices
  - MMI has developed sophisticated tools based on Semantic Web technologies to support the vocabulary mapping process
  - MMI has just received a 3-year NSF grant to continue to develop semantic interoperability in the marine community

Semantic Interoperability (Real World)

- **The MMI approach to mapping**
  - **Vocabularies are syntactically harmonised into proto-ontologies using the Voc2OWL tool**
  - **Terms from vocabularies are mapped using the VINE tool resulting in an OWL ontology**
  - **Mapping is based on three relationships**
    - Broader than
    - Narrower than
    - Same as
  - **Gives greater semantic richness than the inferred 'equivalent' relationship used in mappings to date**

VINE – Vocabulary Integration Environment

cf-gcmd.owl

Click on a vocabulary to select it

all none **cf** gcmd

Search for: use REGEX

sea.*(surface|water).*temp

find

sea.*(surface|water).*temp
water temp -potential -freezing
water temp -potential
water temp

integral_of_sea_water_temperature_
ocean_integral_of_sea_water_tempe
product_of_eastward_sea_water_vel
product_of_northward_sea_water_ve

sea_surface_temperature
narrowerThan
Oceans--Ocean_Temperatur

sea_surface_temperature

label : sea_surface_temperature
standard_name : sea_surface_temperature
hasCanonical_Units : K
description : Sea surface temperature is usually abbreviated as "SST". It is the temperature of sea water near the surface (including the part under sea-ice, if any), and not the skin temperature, whose standard name is surface_temperature. For the temperature of sea water at a particular depth or layer, a data variable of sea_water_temperature with a vertical coordinate axis should be used.
type : Standard_Name

?P

Click on a vocabulary to select it

all none cf **gcmd**

Search for: use REGEX

water temp

find

All (Found: 3 Checked: 1)

Atmosphere--Atmospheric_Water_V
Hydrosphere--Water_Quality_Water_
Oceans--Ocean_Temperature--Wat

Oceans--Ocean_Temperature--Water_T
broaderThan
sea_surface_temperature

Oceans--Ocean_Temperature--Water_Temperature

label : Oceans > Ocean Temperature > Water Temperature
type : TOPIC--TERM--VARIABLE

Map | Mapping Results

Conclusions

- **Significant scientific benefits result from sharing distributed data and information resources**
- **Semantic interoperability work to date in oceanographic data management has given us:**
  - **A firm foundation of lessons learned from our past efforts**
  - **Technology and vocabulary infrastructure that now deliver the means to build new systems that are semantically interoperable**
  - **The challenge of liberating the vast information resource locked away in isolated stovepipe systems**

Conclusions

- **Meeting this challenge requires:**
  - **The technology, guidance and community building provided by MMI**
  - **The combined efforts of the oceanographic scientific community to build the Semantic Web resources that will deliver effective semantic interoperability to the benefit of all**

The End

Thank you for your attention

Questions?