Semantic model for sand production and erosion: An ISO 15926 use case

Integrated Operations in the High North – Joint Industry Project

IOHN

Integrated Operations in the High North (IOHN) 2011

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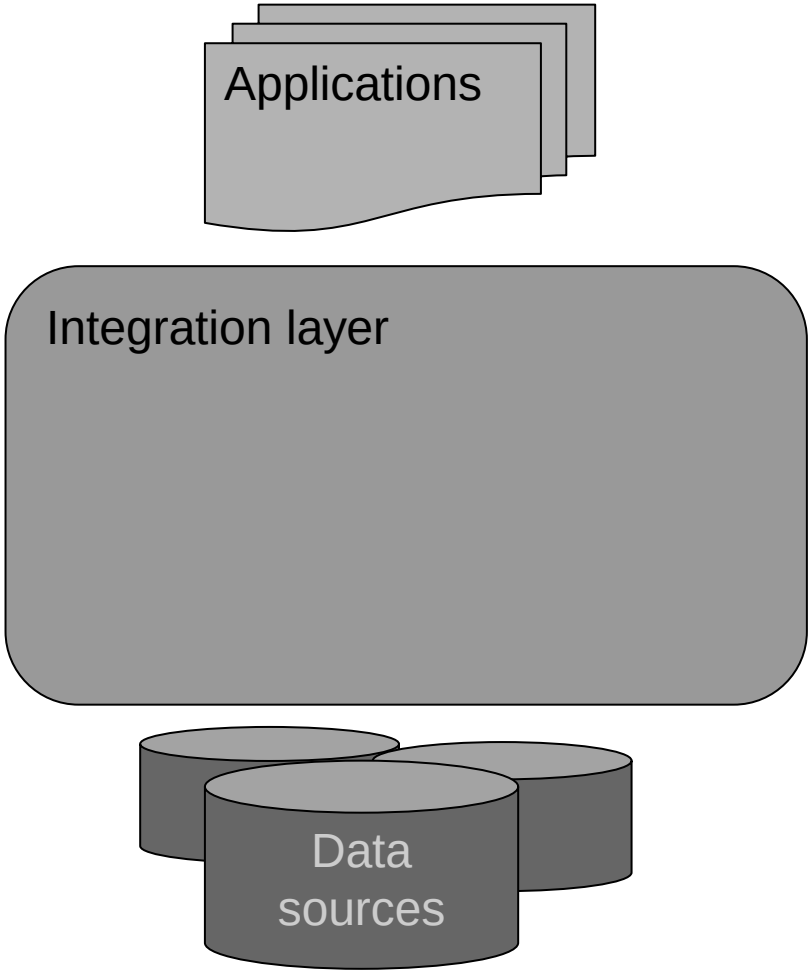
OVERVIEW

The varied information landscape

- Operators tend to prefer giving experts the choice of tools
- This leads to a proliferation of domain-specific tools that have not been designed for integration
- Standardization on core, common pieces of information promotes integration
  - Example: Well identification. One and the same well is typically represented in many different forms across the systems that collect information, from drilling to operations.

Architecture: Generic



- Route all information through an integration layer

What semantics?

- Build an ISO 15926 compliant integration model of an O&G plant
  - Build
  - Validate
  - Query

- The model is a common point of reference for linking data sources to applications (within the enterprise)
- The model enables integration and exchange with external entities

Standardization

- We should free enterprise data from proprietary applications and systems
- “Avoid spaghetti integration” – a common idea
- What’s different in IOHN is the emphasis on standardization
  - ISO 15926 ontologies
  - Linked Data publication of vocabularies
  - Integration with public registries
  - Open formats – private data
  - Formats that can be scrutinized, verified, (in)validated by external entities

ARCHITECTURE

IOHN prototype (act. 3 & 6)

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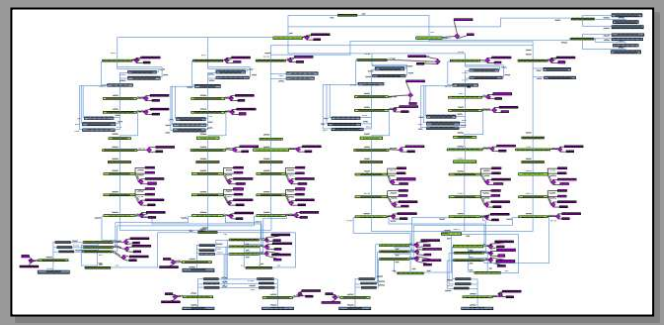
DNV Erosion Monitor

ABB Insight

Epsis Decide

Integration layer



Public classifiers

Public identifiers

Ontologies

ISO
PCA
IOHN

Classes
Relations
Templates

Registries

NPD

Wells
Facilities
Fields

Enterprise | Internet

Siemens PIMAQ

Tieto Energy Components

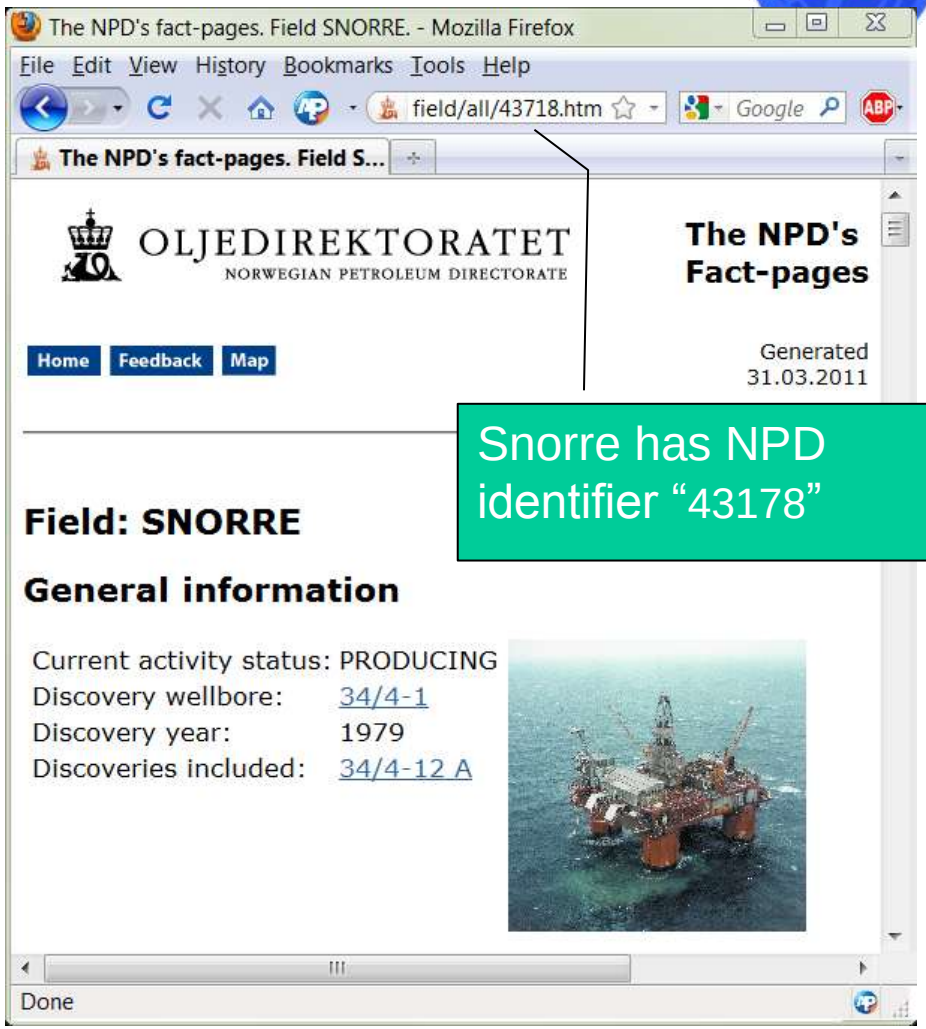
A hierarchy of ontologies

	Background ontology (basic classes and relations)	**Templates** (representation patterns)
ISO	Generic and core classes	Generic patterns (ISO 15926-7)
PCA	Core and industry classes	Industry patterns
IOHN	*Sand and erosion* classes	*Sand and erosion* patterns

Each layer extends the one above.

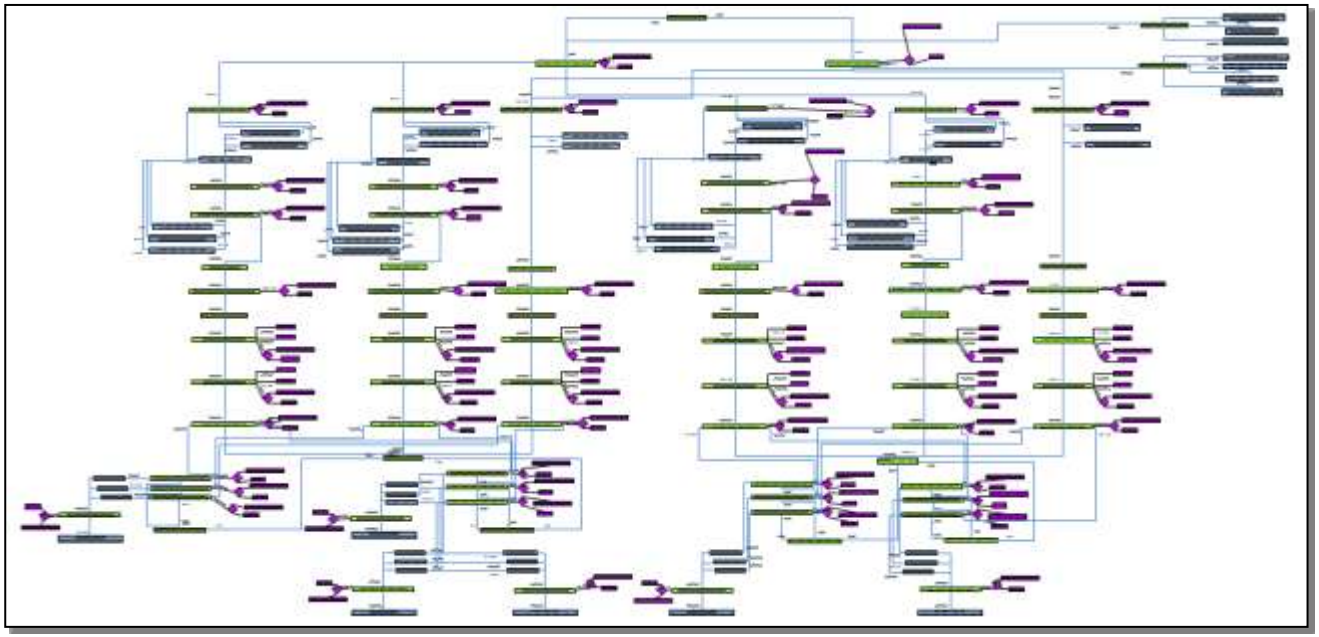
Use public identifiers whenever possible

- The Norwegian Petroleum Directorate (NPD) maintains a database that overlaps with the IOHN scope, assigning identifiers to
  - Fields
  - Plants
  - Wells
- Represent NPD identifiers as RDF Linked Data (prototype)



A platform with wells and sensors

- The plant model resides in the integration layer
- Common point of reference for applications and data sources



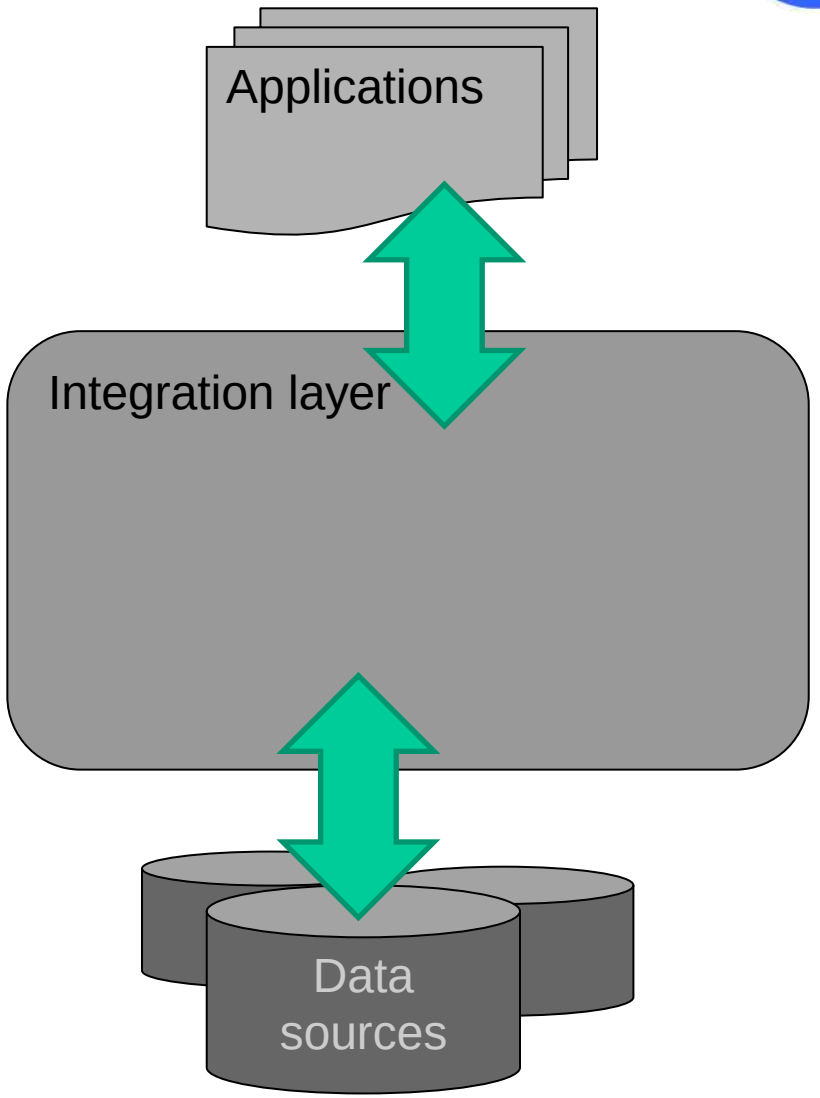
- All entities are classified using public ontologies
- Official registry identifiers name main plant parts

Relevance to: *Owner/Operators*

- Vendor independence
- Improved information quality
- Ease integration across disciplines, departments, and vendors
- Transparency
- Consolidation of information resources

Relevance to: *Vendors*

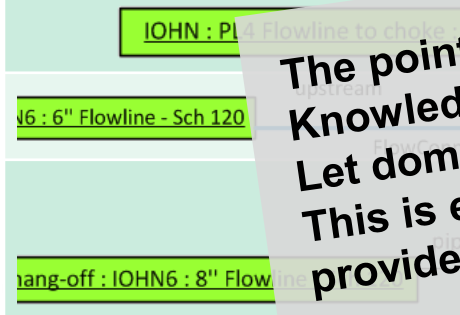
- If enterprises implement integrated information architectures, vendors need to provide standards compliant solutions
- Shorten development and deployment times
- Standards compliance gives a competitive edge!



BUILD, VALIDATE, QUERY

From diagram to ISO 15926 statements

- The platform model is a UML object diagram
- Translate the graphics into ISO 15926 template instances

Object in diagram	ISO 15926
	Classification of individual
	Binary template statement
	N-ary template statement

The point of using a Visio drawing is:
Knowledge capture in practice.
Let domain experts use what they like –
This is essential for getting them to provide input

Save as XML from Visio

Translate into ISO 15926-8 RDF/OWL using XQuery

Browsing the integration model

- The model resides in an RDF triple store
- Access from SPARQL endpoint
- Linked Data interface:
  - HTML for human consumption
  - RDF for computers

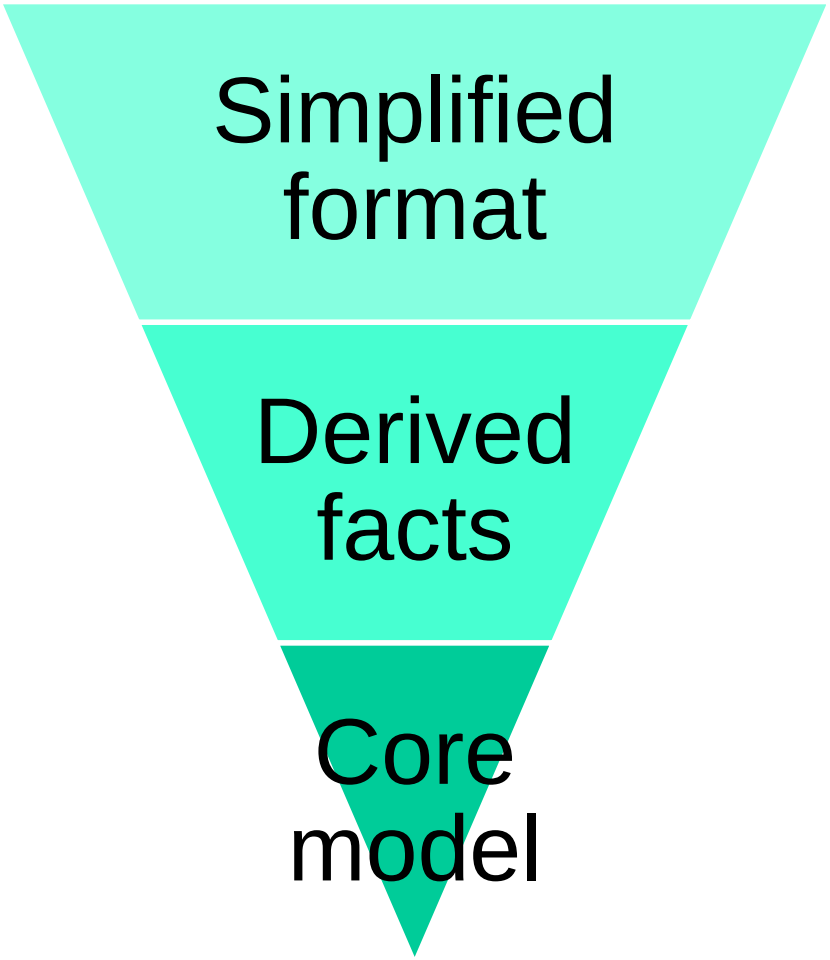
Querying the integration model

- The query language is SPARQL
- Internet access to RDF endpoint
- Seamless integration with NPD, PCA and other Linked Data sources
- All content is available in ISO 15926-8 format
- Simpler queries using derived facts

Querying the model: Pipelines

- "Retrieve the production and test pipelines."
  - A query that uses *derived* part/whole facts about pipelines and pipe sections
- This kind of query could support automated configuration of sand/erosion application analyses
- Other queries:
  - What is the radius of curvature of …
  - Which pipe section is connected to …

Derived content for convenience



Ad-hoc RDF for convenient queries

ISO 15926-8 template statements

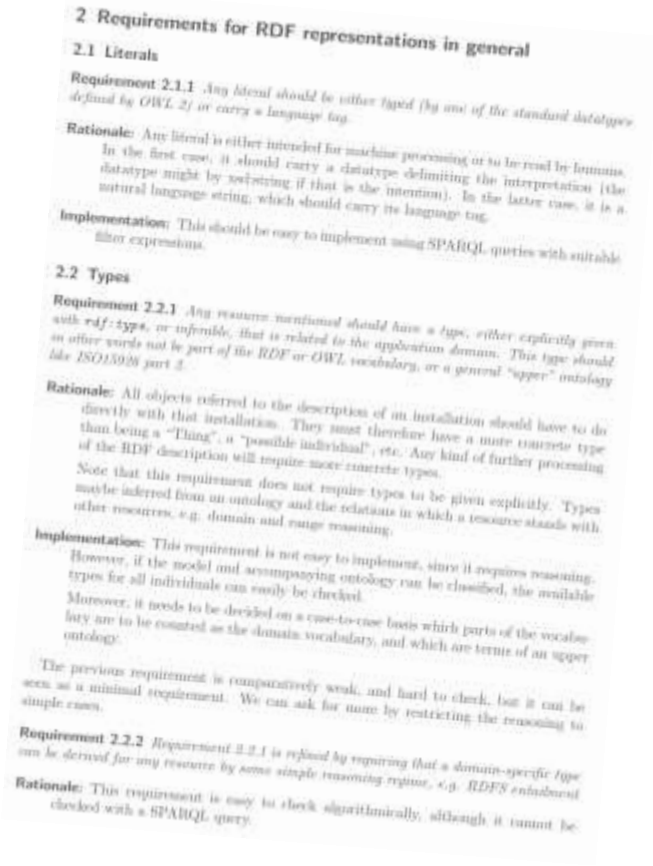
Federated query

- Federated data gives us new content “for free”
- Example: Geographical coordinates are provided by the NPD registry
  - “Retrieve all wells on the platform, with geographical position data”
    - IOHN Well → NPD Wellbore
- Other NPD data made accessible by way of resource sharing:
  - When was the well drilled?
  - Is the well in operation?
  - Who is the current operator?
  - …

Validating plant models

Any integration model needs to satisfy certain constraints

- RDF generic requirements
  - Consistency
  - Every individual is classified
  - No anonymous individuals
- ISO 15926-8 requirements
  - Only well-formed statements
  - Don't redefine authoritative vocabulary
- O&G requirements
  - Use domain vocabulary
- *Mainly for the* core *model*



2 Requirements for RDF representations in general

2.1 Literals

Requirement 2.1.1 *Any literal should be either typed (by one of the standard datatypes defined by OWL 2) or carry a language tag.*

Rationale: Any literal is either intended for machine processing or to be read by humans. In the first case, it should carry a datatype delimiting the interpretation (the datatype might be *xsd:string* if that is the intention). In the latter case, it is a natural language string, which should carry its language tag.

Implementation: This should be easy to implement using SPARQL queries with suitable filter expressions.

2.2 Types

Requirement 2.2.1 *Any resource mentioned should have a type, either explicitly given with* `rdf:type`*, or inferable, that is related to the application domain. This type should in other words not be part of the RDF or OWL vocabulary, or a general "upper" ontology like ISO15926 part 2.*

Rationale: All objects referred to the description of an installation should have to do directly with that installation. They must therefore have a more concrete type than being a "Thing", a "possible individual", etc. Any kind of further processing of the RDF description will require more concrete types.

Note that this requirement does not require types to be given explicitly. Types may be inferred from an ontology and the relations in which a resource stands with other resources, e.g. domain and range reasoning.

Implementation: This requirement is not easy to implement, since it requires reasoning. However, if the model and accompanying ontology can be classified, the available types for all individuals can easily be checked.

Moreover, it needs to be decided on a case-to-case basis which parts of the vocabulary are to be counted as the domain vocabulary, and which are terms of an upper ontology.

The previous requirement is computationally weak, and hard to check, but it can be seen as a minimal requirement. We can ask for more by restricting the reasoning to simple cases.

Requirement 2.2.2 *Requirement 2.2.1 is refined by requiring that a domain-specific type can be derived for any resource by some simple reasoning regime, e.g. RDFS entailment.*

Rationale: This requirement is easy to check algorithmically, although it cannot be checked with a SPARQL query.

Validating the model

- The central role of the integration model means high quality is a requirement
- Some faults can be automatically detected
- Validation feedback simplifies corrections

- Some validity checks can be expressed in SPARQL
- A web service for ISO 15926-8 process plant models

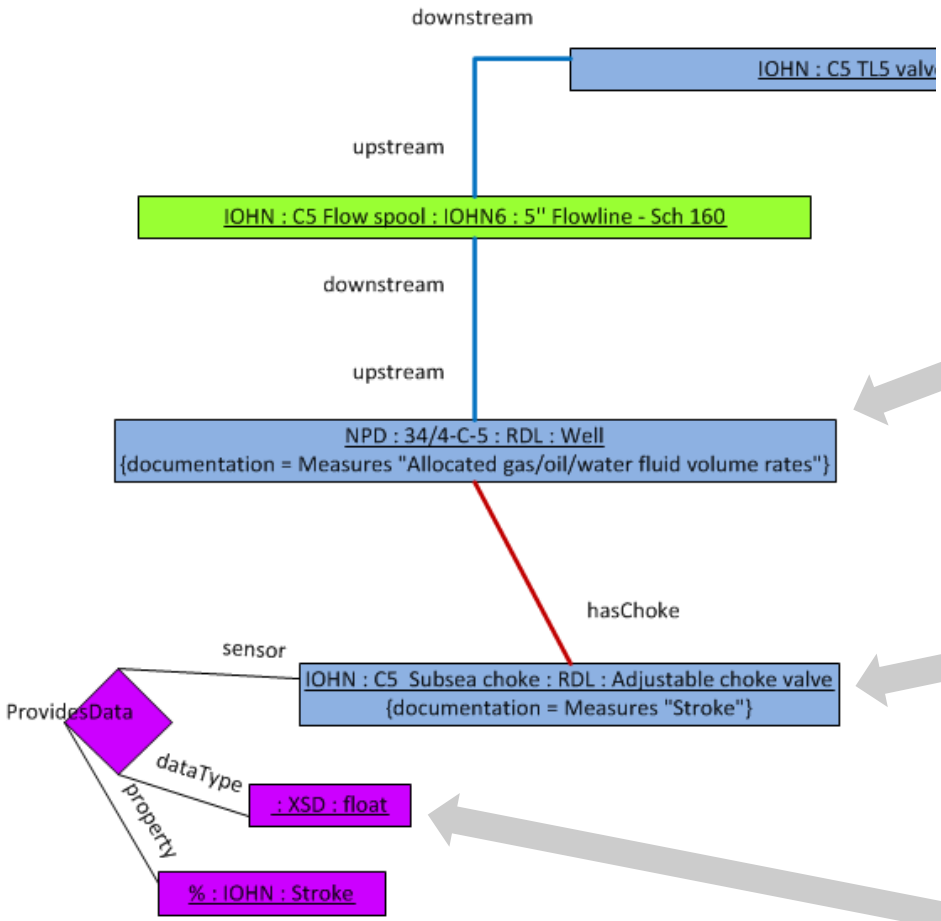
- Also applicable to handover

DATA ACCESS

Next step: Data access

- Use the plant model to provide data to applications
  - Install on an RDF integration platform (Cambridge Semantics server)
  - Connect sensor resources to SQL database views
  - Provide data to applications by means of Web Services

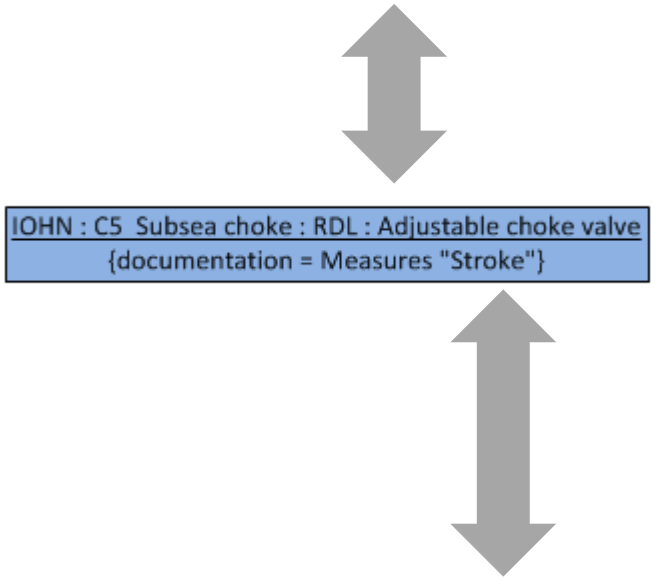
Sensors as data sources



- Q: What wells are there on *NPD:MyPlatform*?
- A: …, …, *NPD:C5*, …, …
- Q: What is the *PCA:Adjustable choke valve* on *NPD:C4?*
- A: *IOHN:C5 Subsea choke.*
- Q: What data is available for *IOHN:C5 Subsea choke*?
- A: *IOHN:Stroke,* in *%* as *xsd:float*.

Retrieving data

Applications refer to model elements when they query web services for data



Sensor data in source databases are linked to sensors in the model

- Q: What is the *IOHN:Stroke* on *IOHN:C5 Subsea choke* for each day of last week?
- A: The following instances of *IOHN:ChokeOpeningByDayInPercent.*

Choke	Day	Opening %
IOHN:C5 Ss. Chk.	Monday	40.0
IOHN:C5 Ss. Chk.	Tuesday	43.0
IOHN:C5 Ss. Chk.	Wednesday	39.0
…	…	…

The query result is a set of template statements according to ISO 15926-8.

CONCLUSION

ISO 15926 in the IOHN prototype

- To represent plant topology
  (minimal for the sand and erosion case)
- To describe sensors as data sources
- To express query result sets

IOHN: Representing project data using ISO 15926.

Templates according to ISO 15926-8 are applied throughout. The templates are defined using the PCA RDL with IOHN sand/erosion extensions.

Questions?

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