MANAGING RISK

Progress and challenges in ISO 15926

Johan W. Klüwer, DNV
Arild Waaler, UiO

UNIVERSITY OF OSLO

Overview

- Part 1: From the point of view of logic
  - Main concepts from logic
  - Description logic knowledge bases
  - Templates
- Part 2: Implementation demo

Recap of some notions from logic

- Logical languages
  - formal expressions
  - inference rules
  - formal semantics
- The consequence relation
  - a relation between premises and conclusion:
    $\Gamma \vdash \varphi$
  - consistency: not $\Gamma \vdash$ contradiction
  - decidable vs undecidable vs tractable

Reasoning services for decidable languages

- Consistency checking
- Classification in ontology languages
  - important when formalization is not backed up by strong intuitions
- More advanced:
  - query languages
  - executable specifications
- Tradeoff expressivity vs complexity!!!
  - Use an as least expressive language as possible

The Description logic family

- Main idea: Decidable fragments of first-order logic suited for knowledge representation
- Expressive DLs: push the limit of decidability
  - Ex: OWL DL, OWL 2
- Lightweight DLs: push the limit of tractability
  - Ex: DL-Lite, EL
- Terminology vs instances
  - Query languages for instances

DL Knowledge Base

MANAGING RISK

- A DL Knowledge base consists of
  - a set of “terminological” axioms (the Tbox)
  - a set of “assertional” axioms (the Abox)
- Tbox axioms are of the form:

  f % gOf 4 gOu % vOu 4 v and u^N % u

  fOg concepts, u, v roles, u^N set of transitive roles
- Abox axioms are of the form:

  `:gO>`,´fiu

  x,y individual names, D a concept and R a role

UNIVERSITY OF OSLO

Example of reasoning

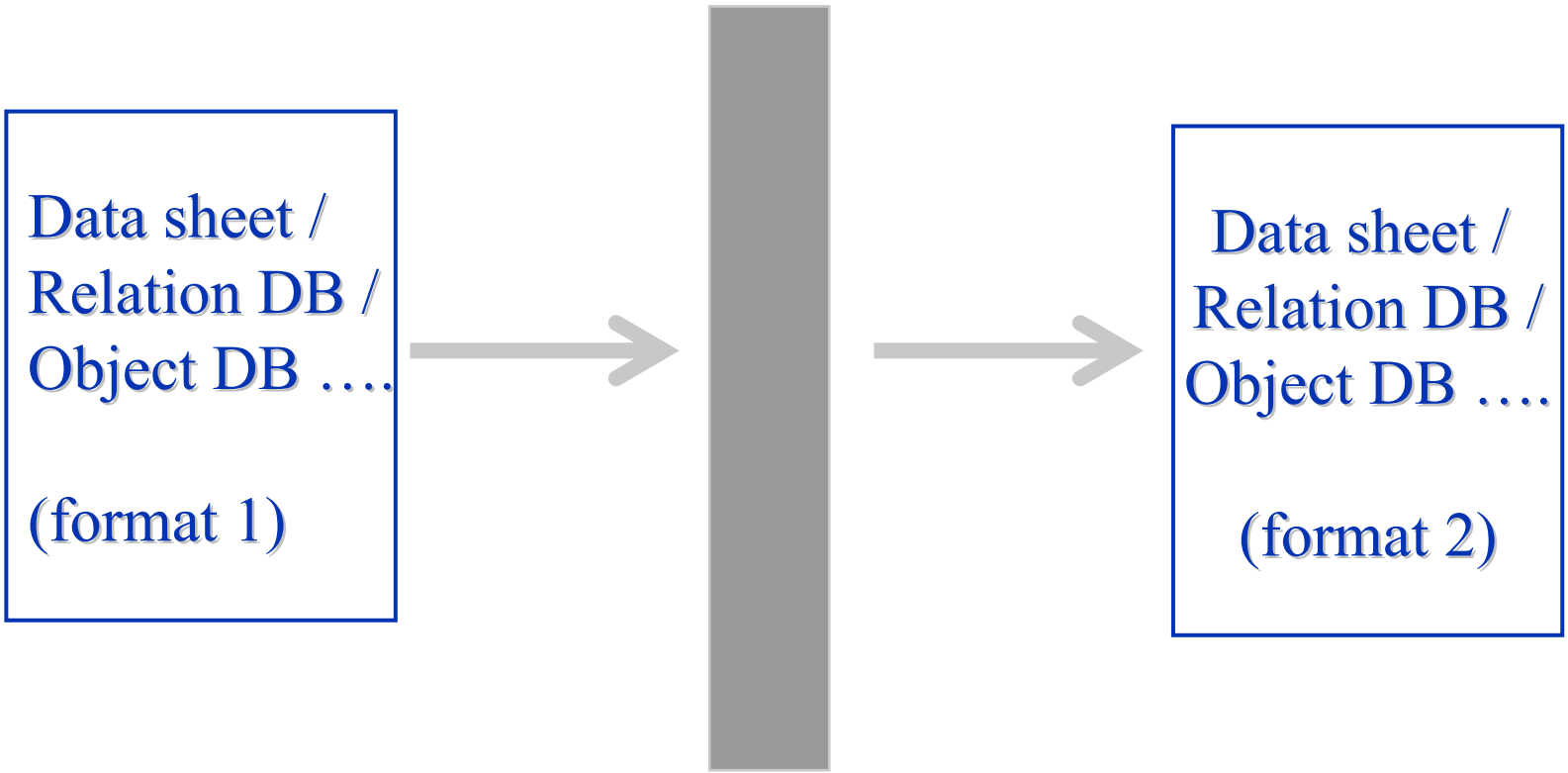
MANAGING RISK

- i „¶ǂ »» " ¶·»¶†¶<´]
  w ›fi· < 4 (d §"»„ƒ¤»r §fl"¤» » s ¶""fl§†"l· 'fi‰fi' ...ƒ†L
  ] Kd §"»„ƒ¤»r §fl"¤» ... s ¶""fl§†"l· 'fi‰fi' ...ƒ†L
  p ...t»fig fi# "·"fi¶·ƒtr §fl"¤» ‰ d §"»„ƒ¤»r §fl"¤»
  PhysicalObject ‰ s ¶""fl§†"l· 'fi‰fi' ...ƒ†
  s ›´"fiPƒtr §fl"¤»K•TL

- fi» «¶†¶¿ " »» ƒ»
  ] KP ...t»fig fi# "·"fi¶·ƒtr §fl"¤» ... PhysicalObject L
  ] d §"»„ƒ¤»r §fl"¤»K•T L

UNIVERSITY OF OSLO

ISO 15926: what for?



Data translation/exchange is difficult

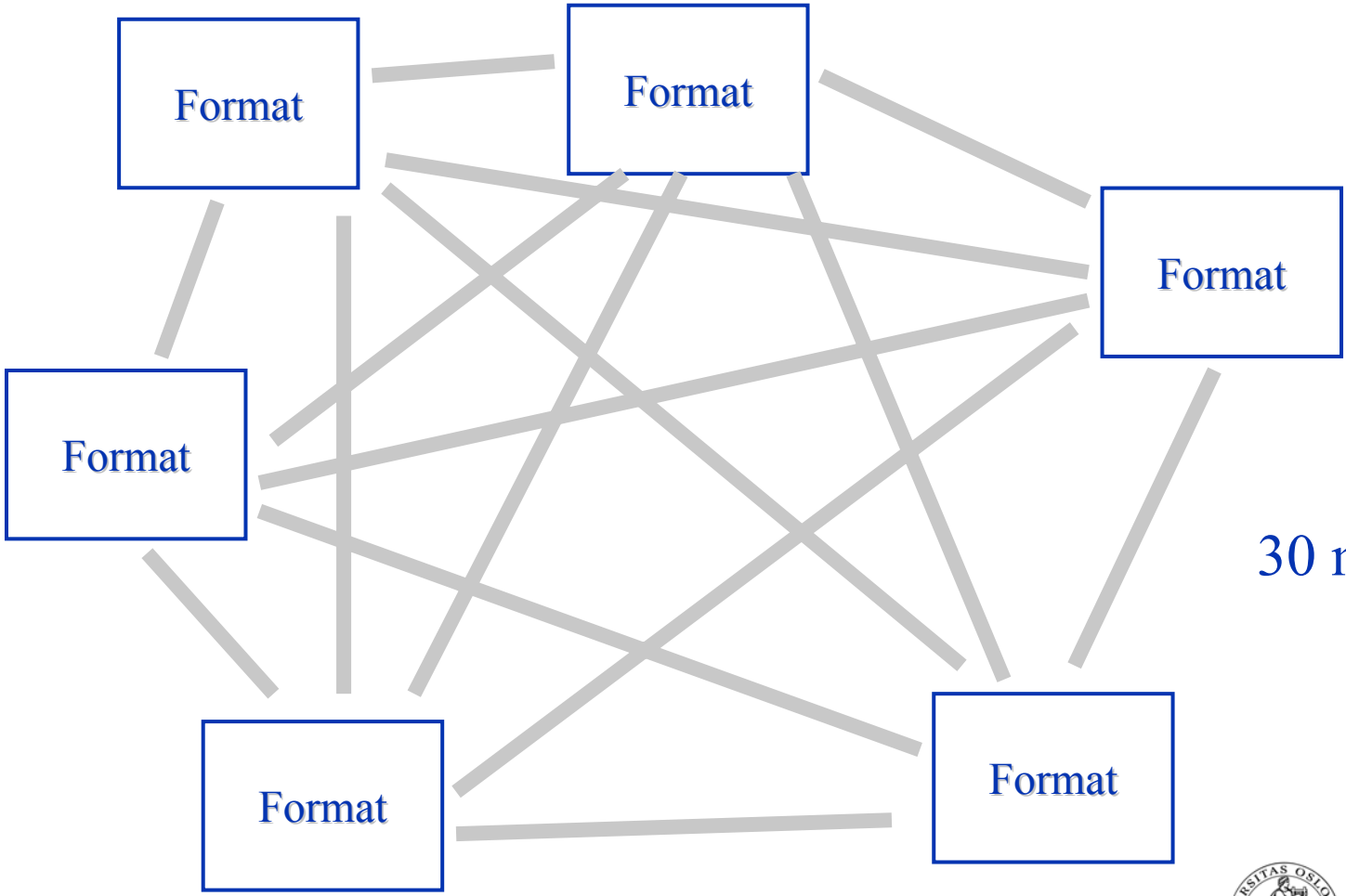
MANAGING RISK DNV

- There is often not a 1-1 relationship between items
- An item in one data sheet
  - may correspond to a combination of many items in another
  - may lack in another
- There may be complex information about classes
  - what if the data sheets have different classes?

UNIVERSITY OF OSLO

Direct translations: many mappings!

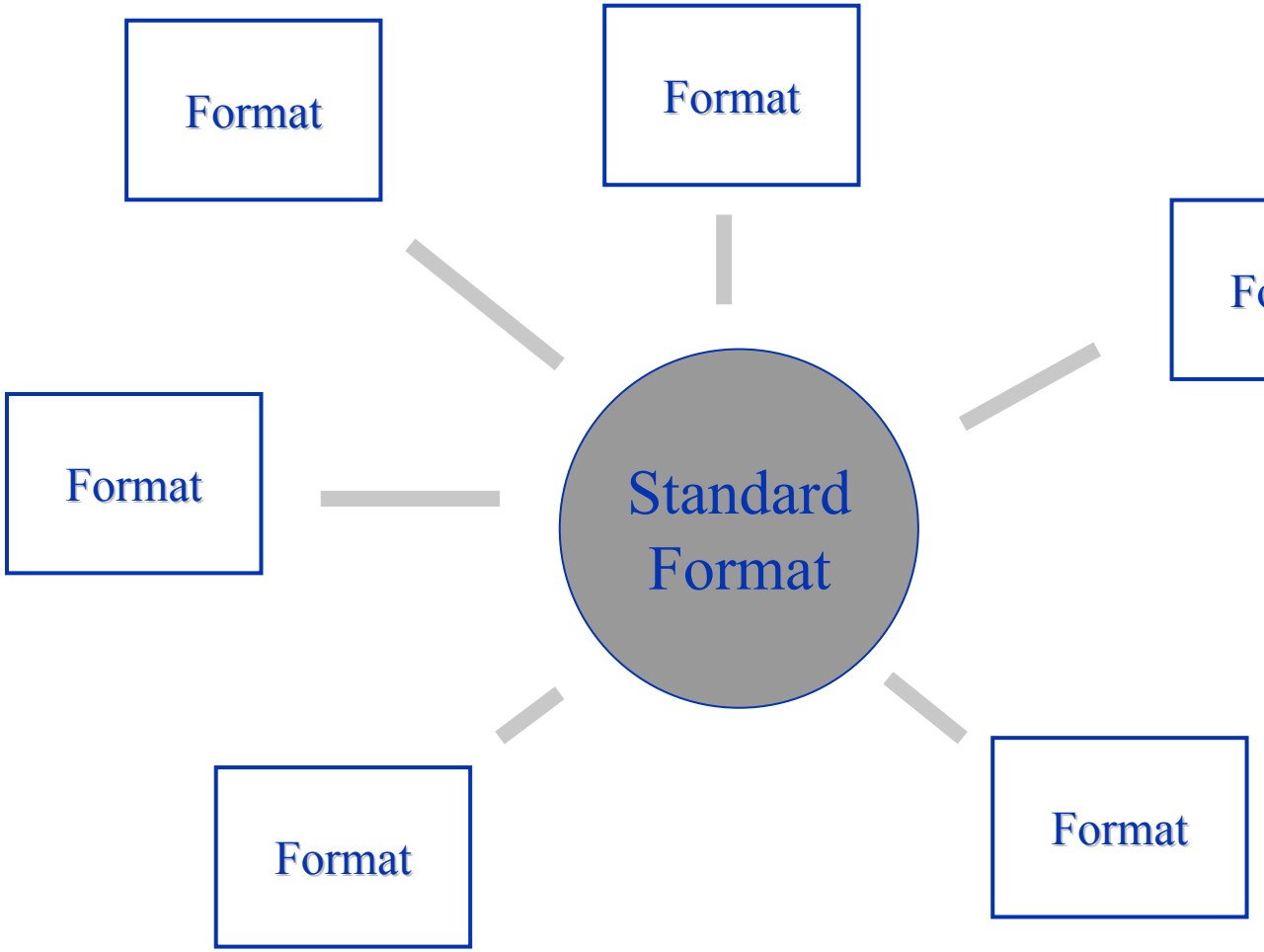
MANAGING RISK



30 mappings

Solution: Standardization

MANAGING RISK



12 mappings

UNIVERSITY OF OSLO

ISO 15926: generic and general

MANAGING RISK DNV

- It's difficult to design a general standard

  … much more difficult than a specific mapping!

- One has to design
  - a vocabulary for the standard
  - a method to map info to and from the standard
- Examples of tricky information:
  - presentation formats
  - range: the camera works from 0 to 55 deg Celsius
- In DL terms: ISO 15926 is a huge TBox

Templates

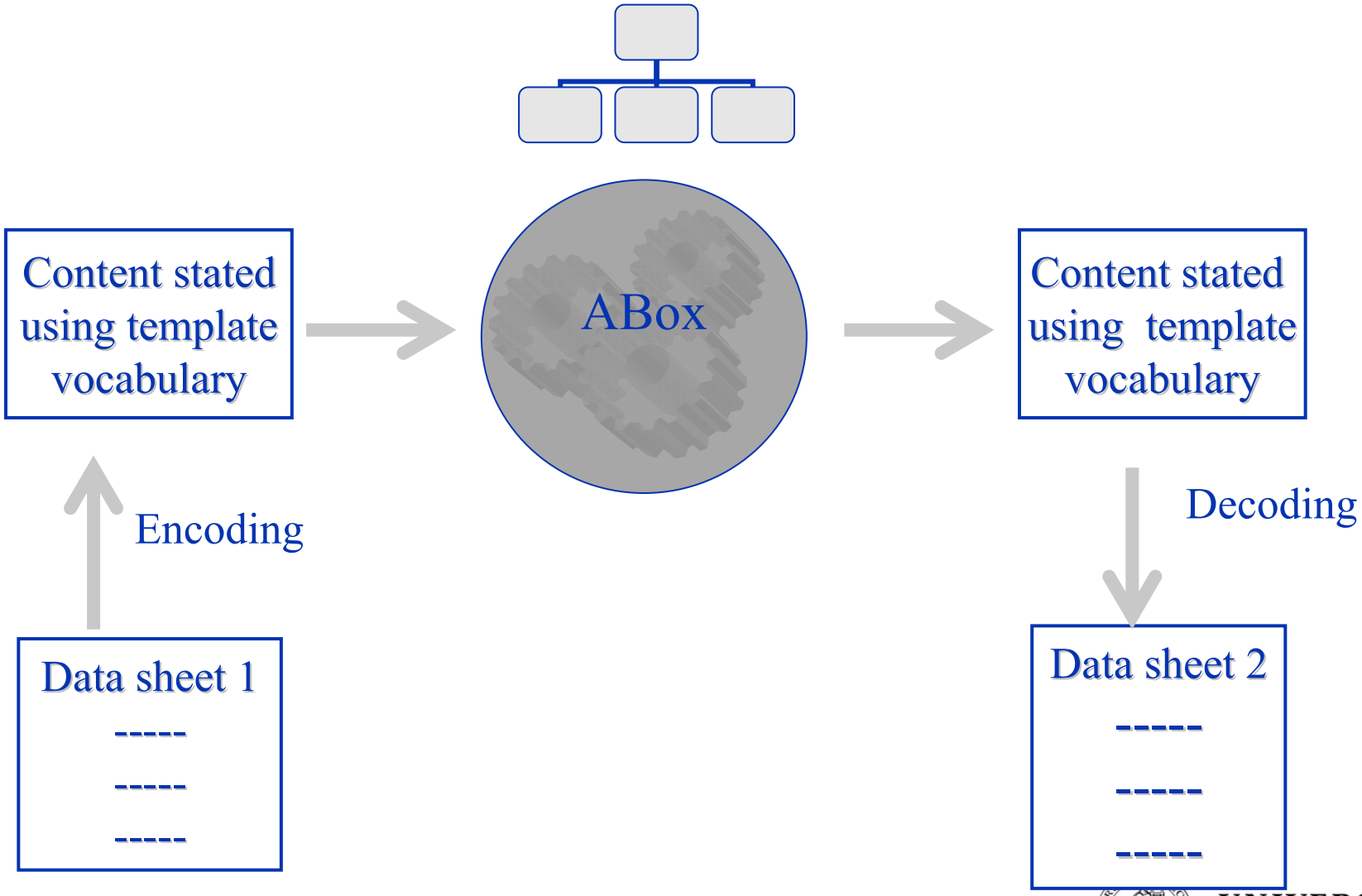
MANAGING RISK DNV

- Vocabulary external to ontology
  - designed to directly express data sheet information
- Templates translate instances into the ontology
  - thereby given meaning
  - hides details of encoding
- In DL terms: Templates specify the generation of an ABox in the language of the ontology

UNIVERSITY OF OSLO

Structure of the solution

MANAGING RISK



UNIVERSITY OF OSLO

ISO 15926: recent progress

MANAGING RISK DNV

- Migration to state of the art ontology languages
- Core part + reference library -> FOL / DL
- Templates expressed in FOL / DL
- Encoding in ontology languages
  - Coherent logic fragment
  - Research on hyper-tableaux!

UNIVERSITY OF OSLO

MANAGING RISK

ISO 15926 tools and formats

Using *templates* according to ISO 15926 Parts 7 and 8

UNIVERSITY OF OSLO

Template concepts: ISO 15926-7

MANAGING RISK

- ISO 15926 is all about creating a common language
- Concepts and terminologies are collected in Reference Data Libraries (RDL's)
- *Templates* are statement patterns using RDL terms
- ISO 15926 contains three parts dedicated to templates:
  - Part 7: Concepts and logic. Available in draft form
  - Part 8: Data formats. OWL prototype formats available.
  - Part 9: Web services. Prototype implementation available.

UNIVERSITY OF OSLO

Templates: Signatures and rules

MANAGING RISK DNV

- The *signature* of a template is comparable to a table definition
  - Give a set of roles
  - For each role, give a type
    - Data types – *string, integer, date*
    - Reference Data Library types – C

Order	Role name	Role type
1	Class	ClassOfIndividual
2	Restricted Property	ClassOfIndirectProperty
3	Scale	Scale
4	Upper Bound	ExpressReal
5	Lower Bound	ExpressReal

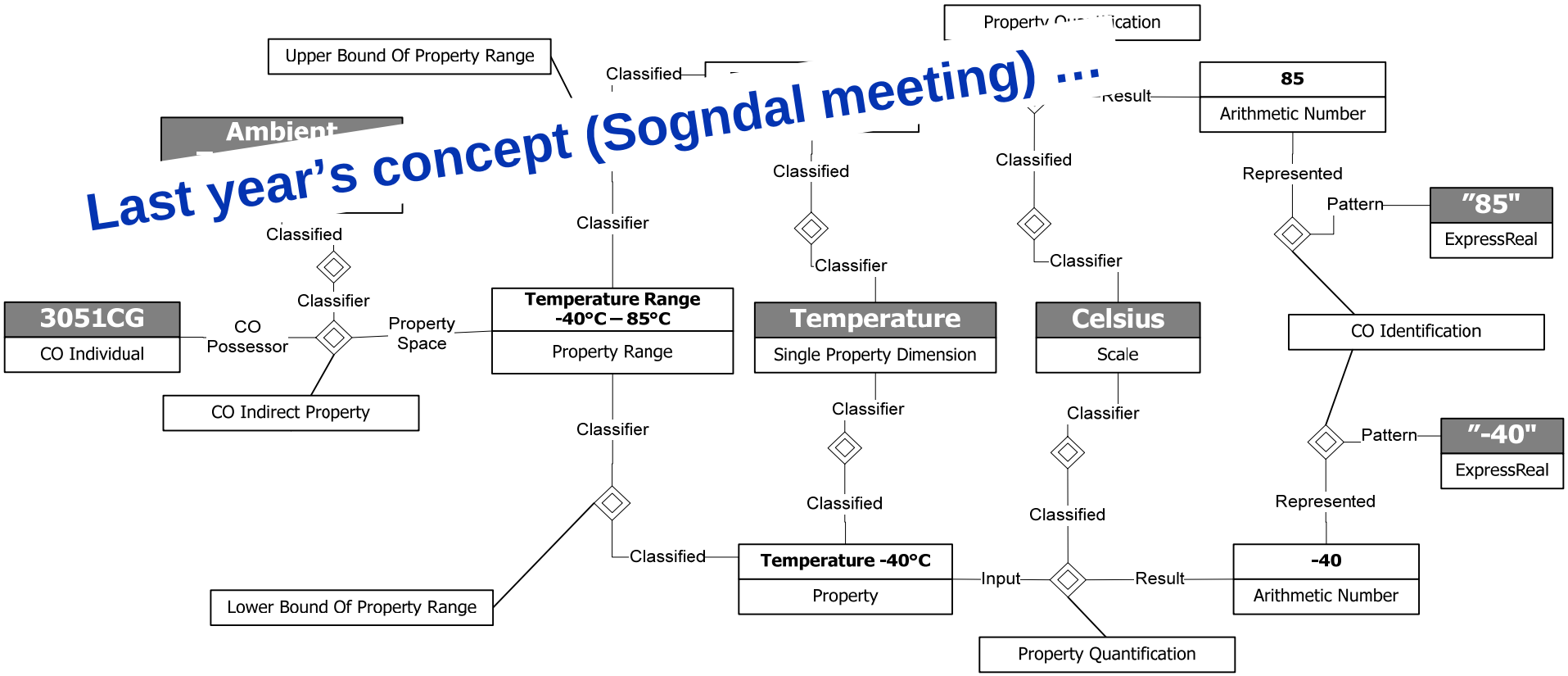
- Each “row” in a “template table” is a statement in the RDL language
  - Providing a simple interface for capturing specialist knowledge
  - Supporting a gradual introduction of semantics to traditional data stores

- A template *rule* defines the deep structure of statements
  - Semantic reasoning may be applied to check adequacy
  - Information exchange using templates can be formally validated
    - *Information validation is a main goal in the IOHN project*

UNIVERSITY OF OSLO

Model: Ambient Temperature Range

MANAGING RISK



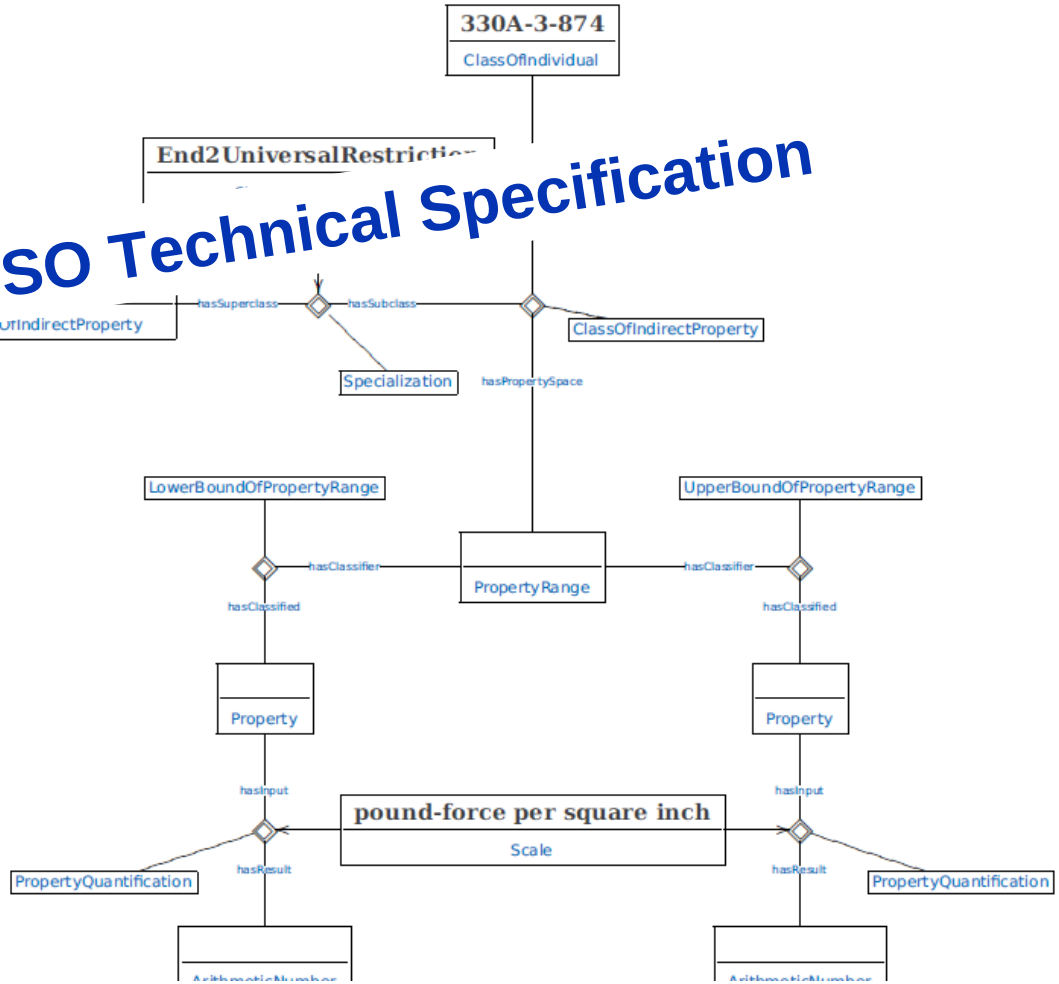
3051CG ambient temperature: -40°C – 85°C

UNIVERSITY OF OSLO

PropertyRangeMagnitudeRestrictionOf Class

MANAGING RISK

Now a draft ISO Technical Specification



UNIVERSITY OF OSLO

Reasoner tasks

MANAGING RISK DNV

- Satisfiability of templates
- Equivalence between templates
- Subsumption hierarchies (more/less general templates)
- Simplification (of signatures, rules)
- Explanation (why was my statement rejected?)

Last year's concept (Sogndal) …

- Challenge: To provide these not just for Part 2, but for templates as well.

UNIVERSITY OF OSLO

Template language

MANAGING RISK

5.2 Template Syntax and Semantics

5.2.1 Template Syntax

We now define logical templates, which capture the logical and rewriting behaviour of templates. Templates as defined in Clause 6 additionally have "[illegible]ures", which will not be discussed here, since they are of no relev[illegible] subclause.

Now in draft ISO Technical Specification

5.2.1.1 [illegible]

[illegible]st-order signature Σ_0 for a basic language (the predicate names of the part 2 axiomatisation).

A *logical template definition* over Σ is a formula of first order logic of the form

$$N(x, y, \ldots) \leftrightarrow \phi$$

where $N \notin \Sigma$ is a predicate symbol called the *name* of the template, $x, y, \ldots$ are pairwise different variables called the *formal arguments*, and ϕ is a $\wedge$-$\vee$-$\exists$-formula over symbols in

UNIVERSITY OF OSLO

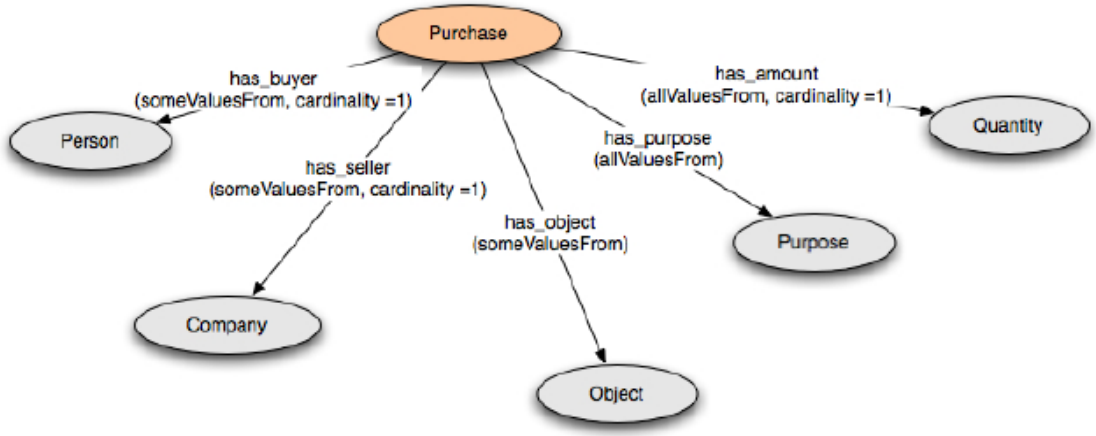
ISO 15926-8: Semantic Web friendly templates

MANAGING RISK DNV

- In order to put ISO 15926 into practical use, we need transport formats
- *Part 8* provides an RDF/OWL ontology for template signatures
- The implementation draws on a widely used "n-ary relations" RDF pattern

13 Templates in RDF

For the representation of template (signatures) and template (signature) instances in RDF/OWL, we adopt a representation described in W3C's Working Group Note *Defining N-ary Relations on the Semantic Web*, 2006, *Use Case 3*. An example given in that Note is that of a *Purchase*, which involves a buyer, a seller, an object, a purpose, and an amount, all modelled as shown in this illustration:[1]

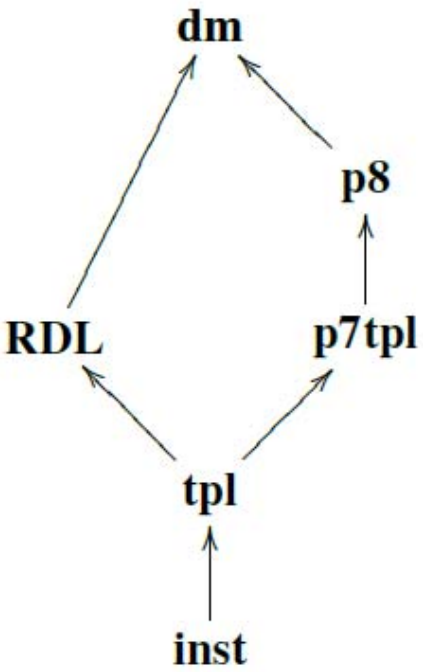


UNIVERSITY OF OSLO

ISO 15926-8 as a set of dependent OWL ontologies

MANAGING RISK

- Pattern of dependencies between resources



Prefix	content
dm	Data Model (Part 2)
RDL	Customer Reference Data Library
p8	Template ontology (Part 8)
p7tpl	Initial Set Templates (Part 7)
tpl	Customer Templates
inst	Customer data

UNIVERSITY OF OSLO

Example (iRING): Piping network system parts

MANAGING RISK

- Basis: The generic template *Classified Assembly of Individual*
- Domain specific: The “piping” template *Piping Network System has Segment*

Developing template rules: Expand and check

MANAGING RISK

- *Template Expander*
  - A freely available tool for developing template definitions
    https://www.posccaesar.org/svn/pub/TemplateExpander/applet/template-expander.html
  - Expand concrete template statements to see what they amount to
  - Converting to (e.g.) RDF allows for visualization
  - The ISO 15926-7 ”initial set of templates” is available

Developing template rules: Reasoning services

MANAGING RISK

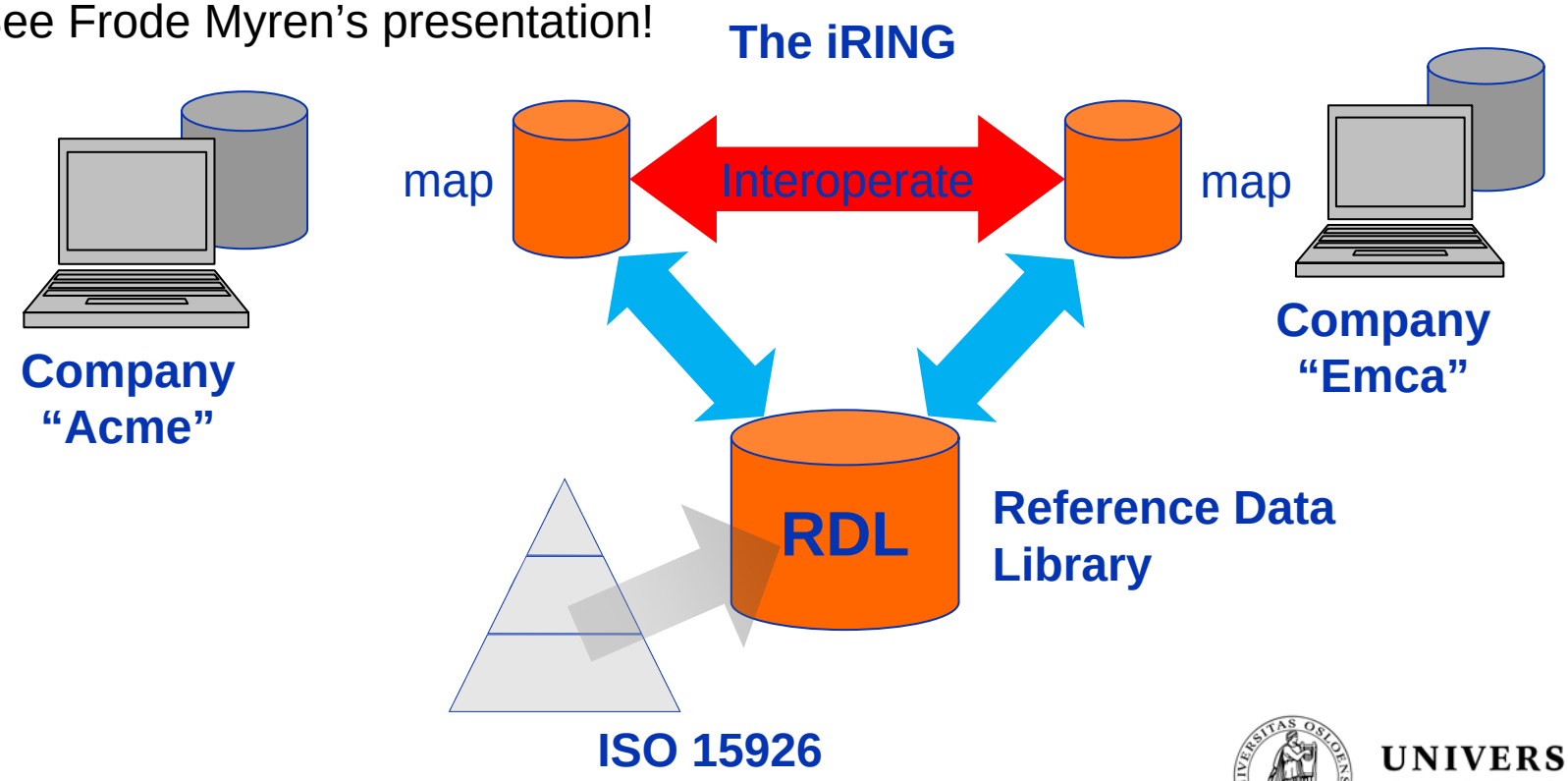
- A template definition is not just a macro, but a logical axiom
- Template Expander syntax is that of the Prover9 generic First order logic prover
- The Initial set of ISO 15926-7 is auto-loaded as a starting point

UNIVERSITY OF OSLO

Using templates: Data transfer

MANAGING RISK

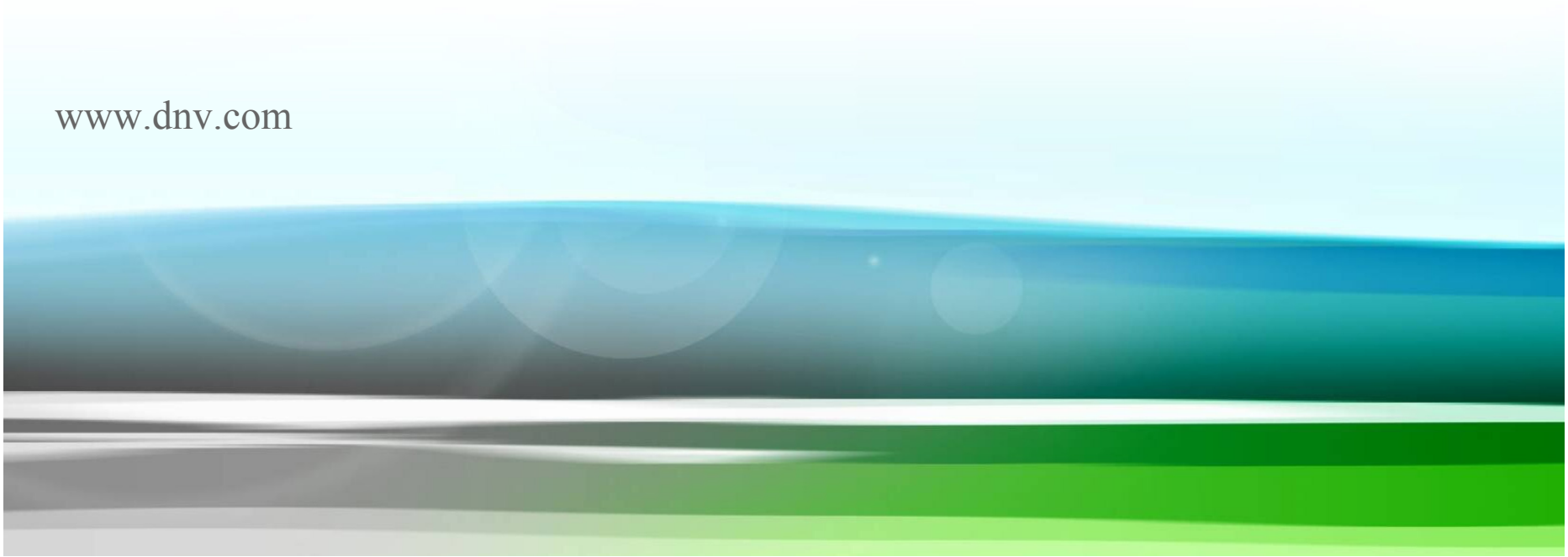
- The iRING initiative prototypes ISO 15926-9: Web services
- Demonstration will be given at ISA EXPO, Houston, October 6–8
- Target of *ISO 15926 adapters* for IOHN information architecture
  - See Frode Myren's presentation!



UNIVERSITY OF OSLO

Safeguarding life, property and the environment

www.dnv.com



MANAGING RISK