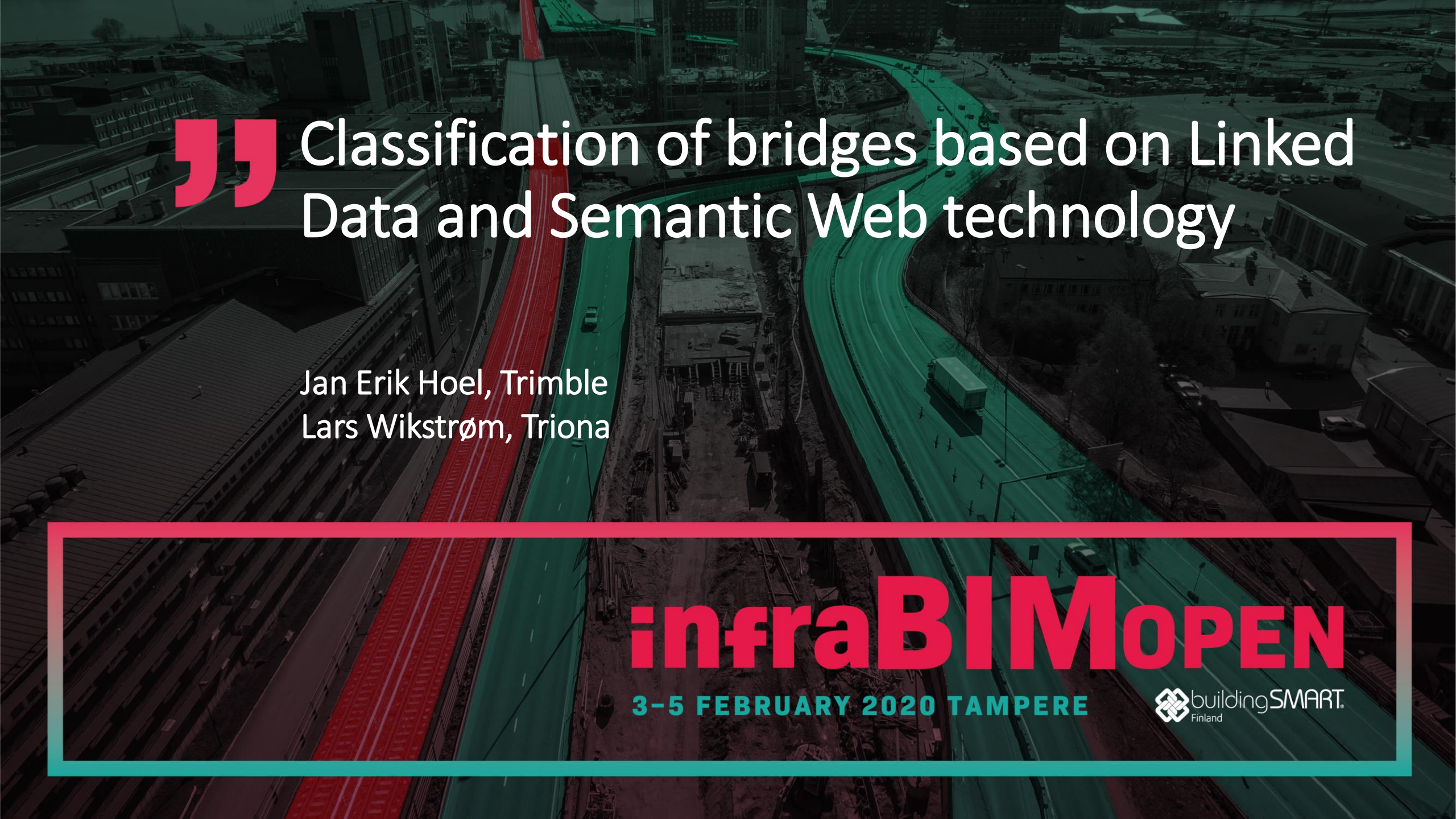
Classification of bridges based on Linked Data and Semantic Web technology

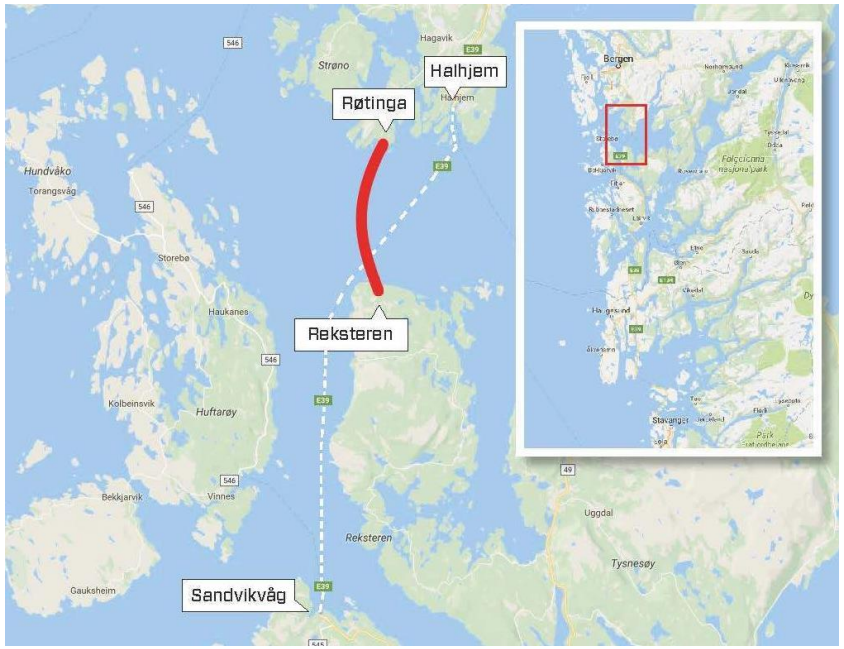
Jan Erik Hoel, Trimble
Lars Wikstrøm, Triona



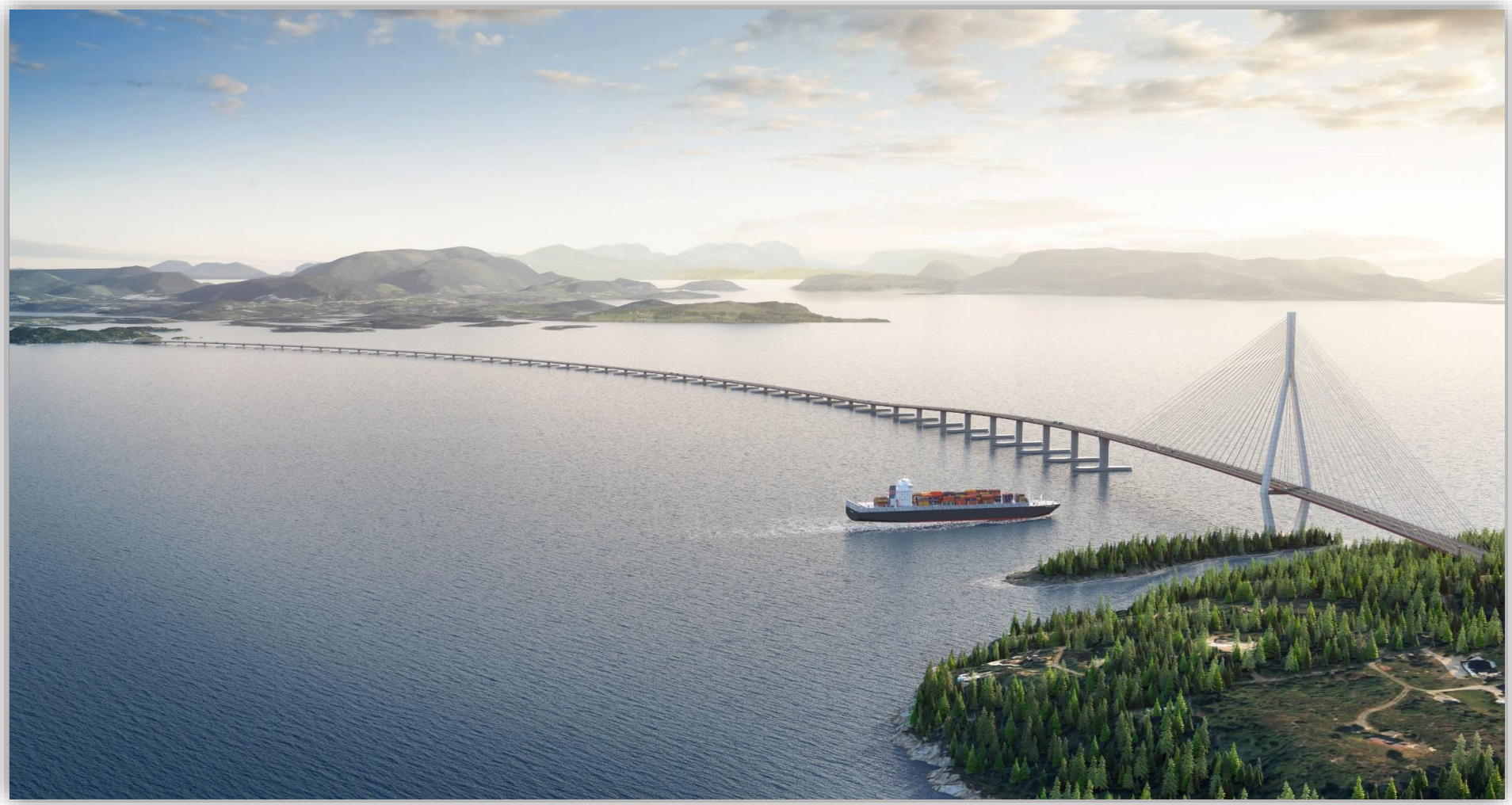
Agenda

- Presentation of the E39 Bjørnafjorden project
- Bjørnafjorden Open Live Centre (BOLC)
- The structure of the classification system V440
- Why use Linked Data/Semantic Web technology (LD/SW)
- Extremely brief introduction to LD/SW
- How V440 is modelled with LD/SW technology
- The way forward

E39 Bjørnafjorden project



E39 Bjørnafjorden project



Selected concept

E39 Bjørnafjorden project

Key values

- Chosen concept: Floating bridge with anchor cables, fixed at one side.
- Cable-stayed bridge at one side
- Total length: 5,5 km
- Fjord depth: 550 m
- About 110 000 ton steel
- About 35 pontoons
- Main span of the cable-stayed bridge: 450 m
- Bridge tower height: 215
- Free sailing clearance: 50 m
- Estimated cost: 17 billion NOK
- Municipality plan approved 2019
- Assumed start constuction 2024, finished 2028

Cost risks

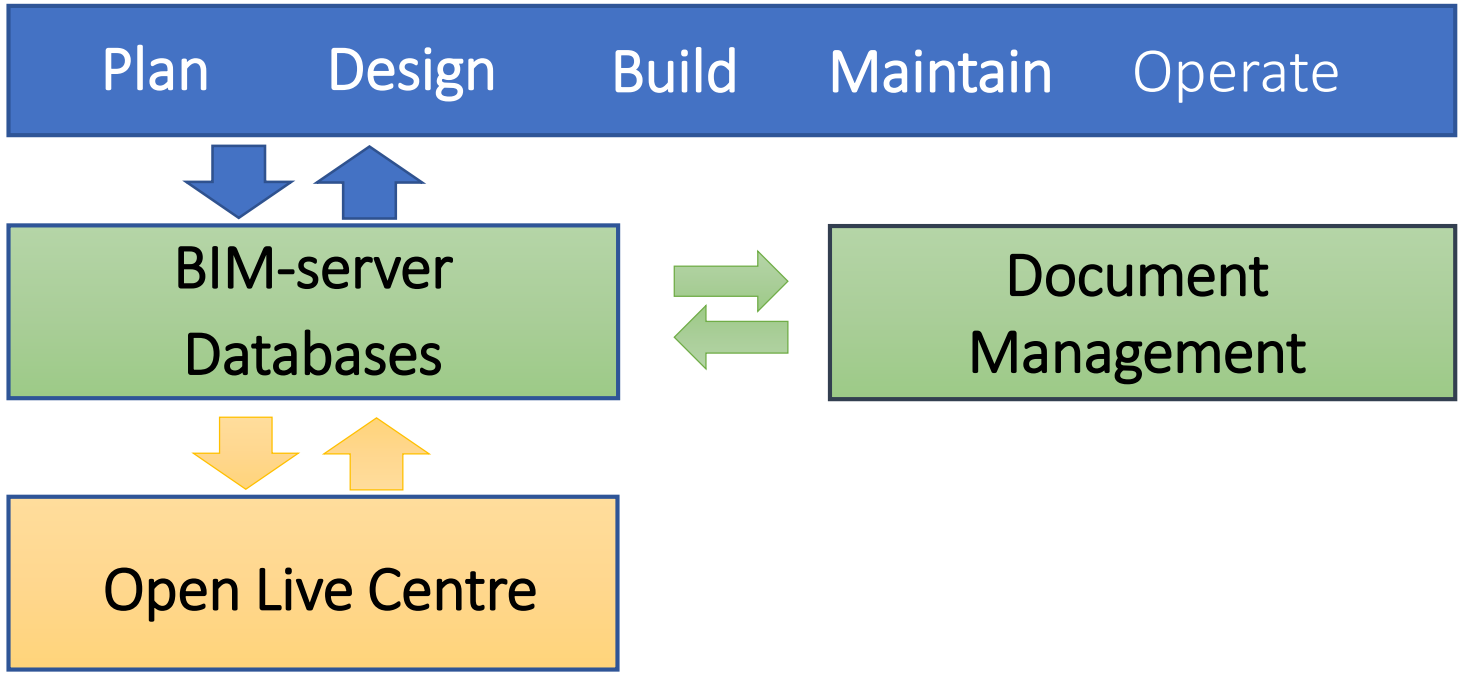
- Marked (steel)
- Logistics

E39 Bjørnafjorden project

Data management ambitions

- BIM-model: From CAD-layer based data to level 3 BIM-model
- Document management system:
  - Integrated with the BIM-model
  - Easy to search and find all relevant documentation
- Seamless data transfer from design and build models (PIM) to asset management models (AIM)
- Dashboard solution: Bjørnafjorden Open Live Centre (BOLC)

E39 Bjørnafjorden – Open Live Centre (BOLC)

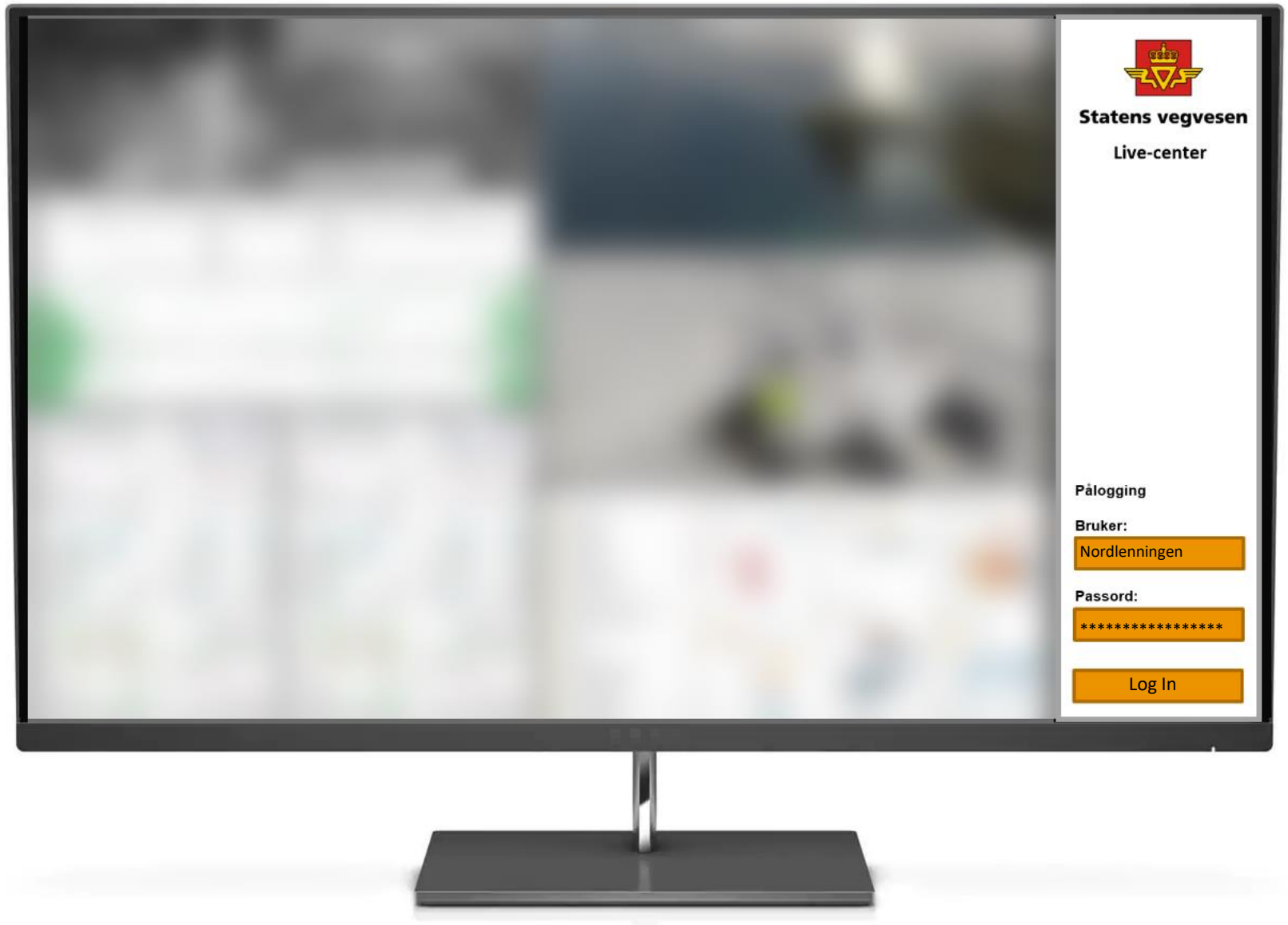


Project management tool for the E39 Bjørnafjorden project

E39 Bjørnafjorden – Open Live Centre (BOLC)

Functionality examples for Open Live Centre (BOLC):

- Extract and present data from the BIM-server
- Harvest and publish data from different sources, like:
  - Quantities
  - Collisions and constructability
  - Cost / Compensations
  - Status / Progress
  - Logistics
  - RFID-sensors/ QR-code readings
  - HR-data
  - Environmental data
  - Surveillance camera
  - Visualisation / Animation
  - Etc.


Statens vegvesen
Live-center
Pålogging
Bruker:
Nordlenningen
Passord:
Log In


Ferjefri E39 Bjørnafjorden
Statens vegvesen
Live-center
Pålogging:
Innlogget som:
Nordlenningen
Passord:
Log Ut

V440 - The Norwegian Road Authority’s manual for bridge registration

The main purpose of the manual is to provide guiding for the personnel who do the registration and condition-monitoring of the bridges on the main road network in Norway.

The manual contains registration process descriptions and rules for bridge document management.

In addition the manual provides a comprehensive list of definitions of bridge types and bridge parts, that is bride classification.

V440 - The Norwegian Road Authority's manual for bridge registration

Examples of bridge classification:

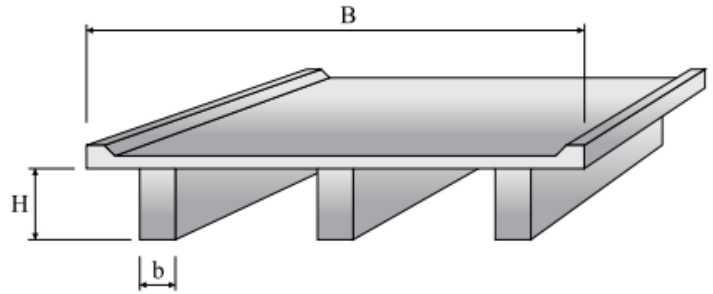
Bridge Categories:

Code	Description
1	Road bridge
2	Bridge embedded in the road superstructure
3	Pedestrian bridge
4	Ferry landing
6	Tunnel
7	Supportive structures
8	Railroad bridge
9	Other structures

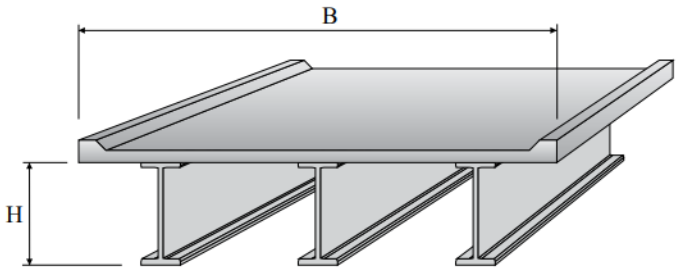
Examples of bridge classification:

Bridge Types:

Beam bridges:

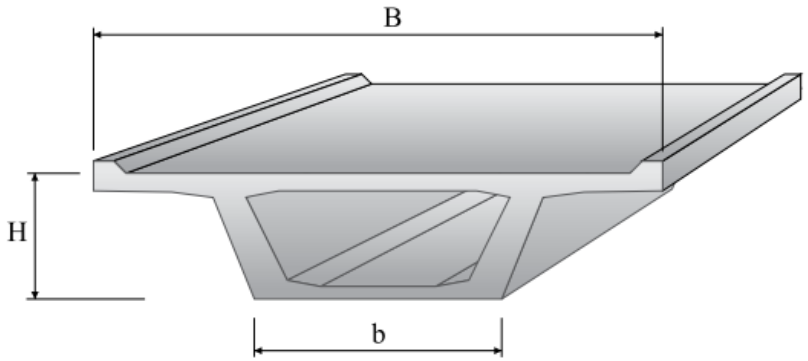


Concrete beam bridge

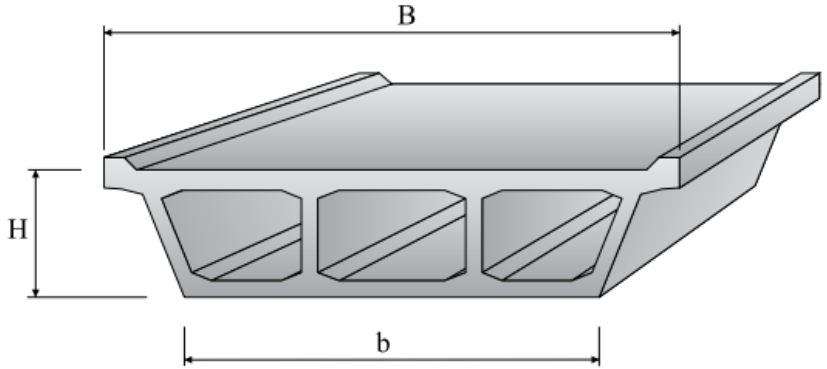


Steel beam bridge

Box bridges:



Box bridge

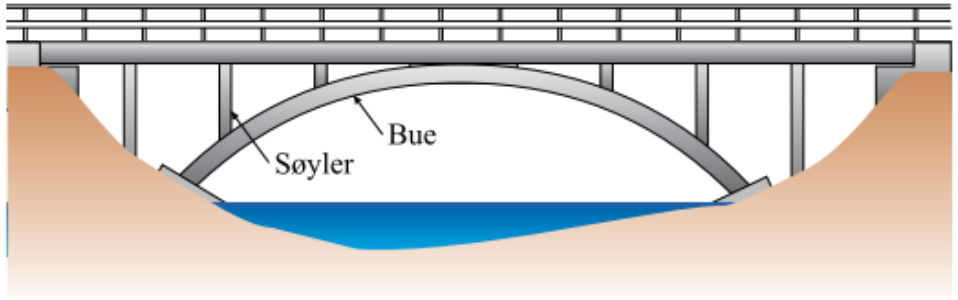


Multiple box bridge

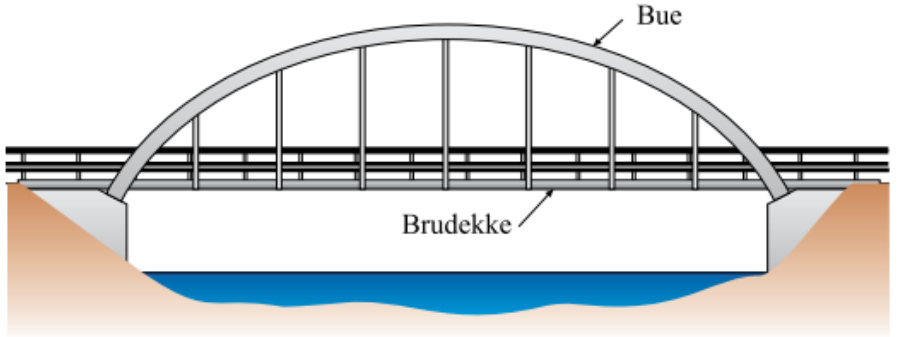
Examples of bridge classification:

Bridge Types:

Arc bridges:

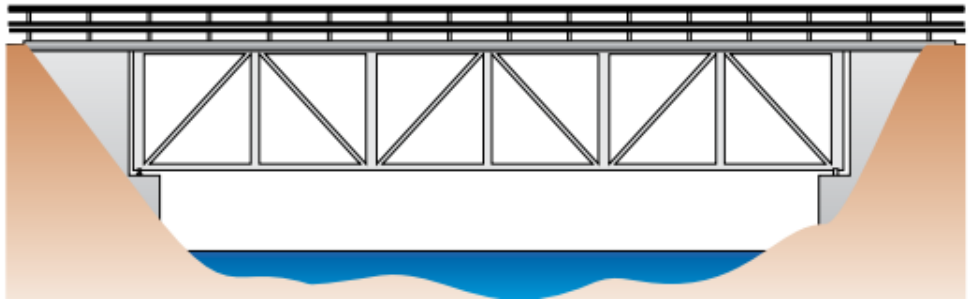


Arc bridge with upper carriageway

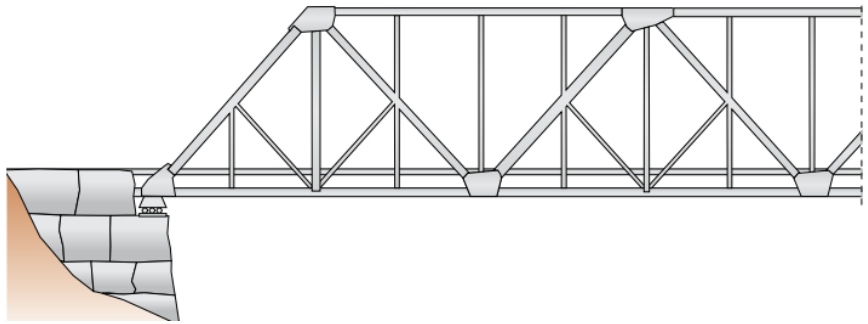


Arc bridge with lower carriageway

Truss bridges:



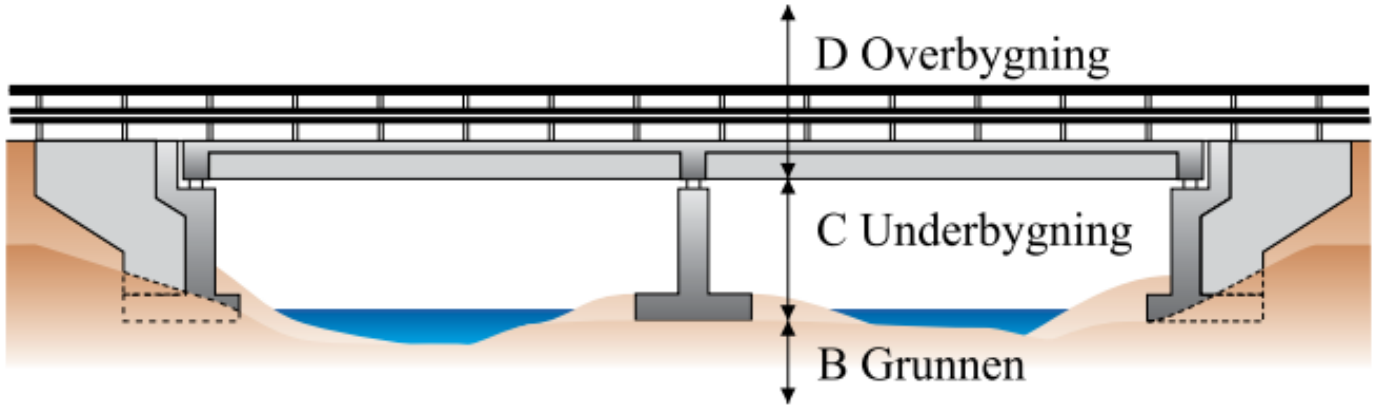
Truss bridge with upper carriageway

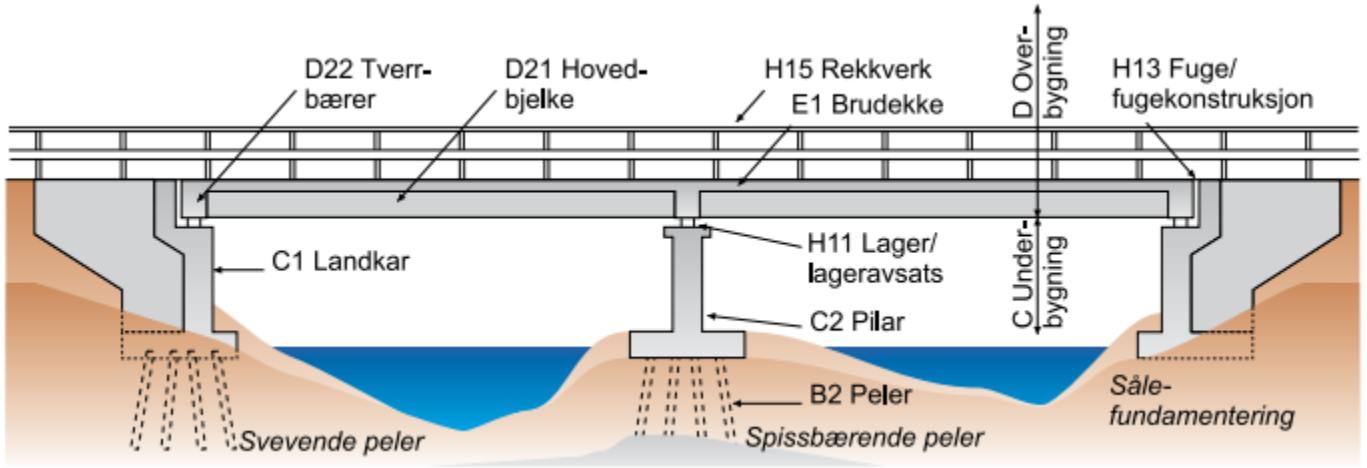


Truss bridge with lower carriageway

Examples of bridge classification:

Main Groups of Bridge Element Codes:

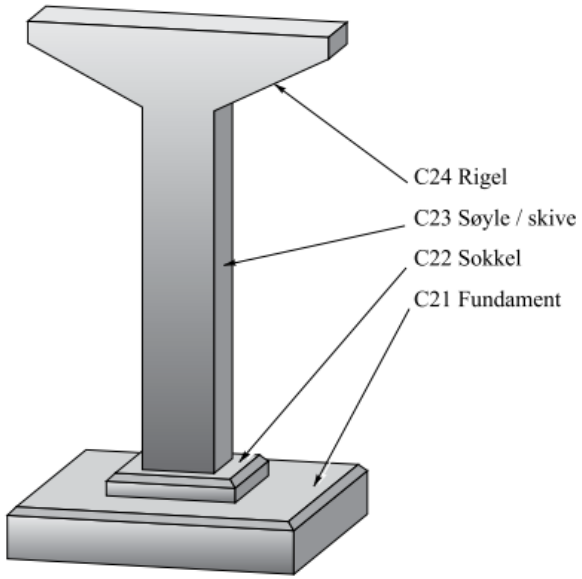


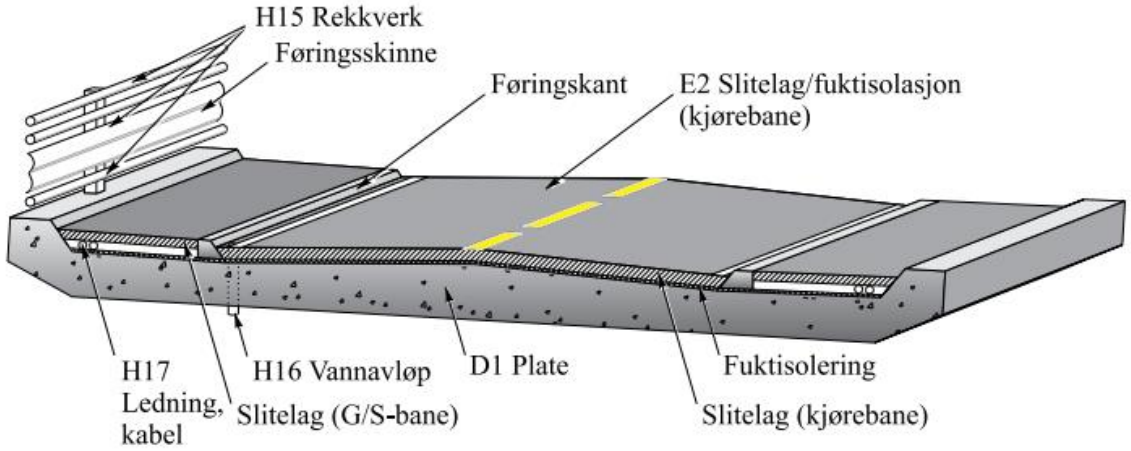


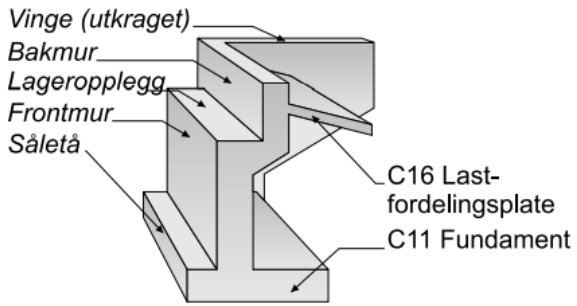
Code	Description
B	Ground
C	Substructure
D	Superstructure
E	Bridge Deck
F	Structure embedded in filling
H	Equipment

Examples of bridge classification:

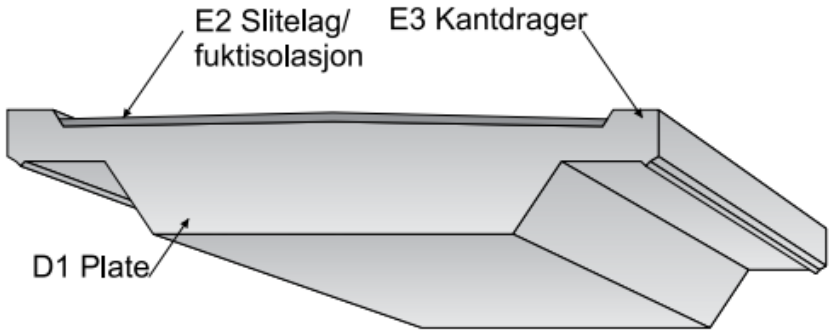
Detailed Bridge Element Codes:







C12 Vegg omfatter frontmur, bakmur, vinge og utkraget vinge



Why use Linked Data and Semantic Web (LD/SW) for BOLC

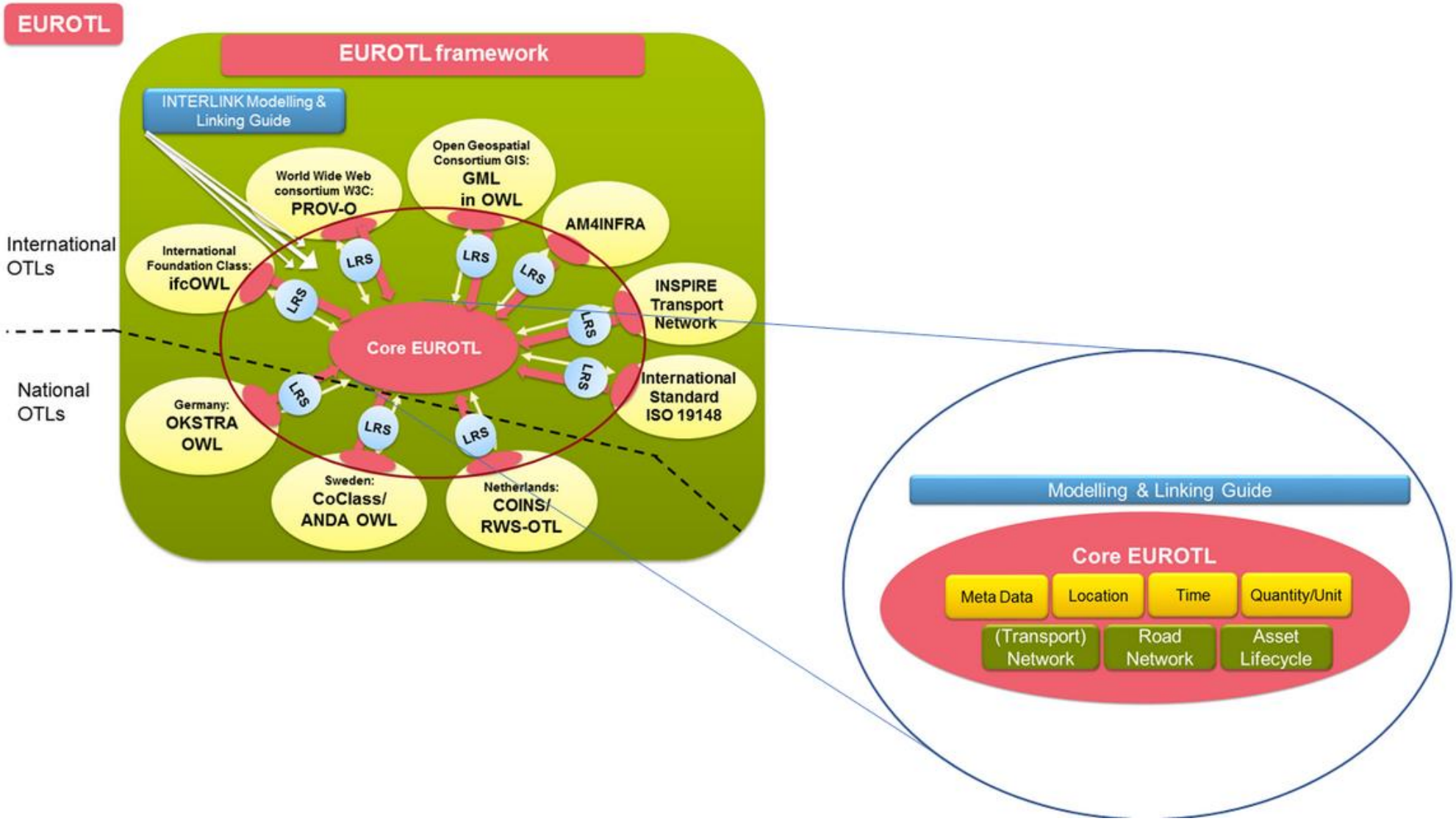
Why use LD/SW technology:

- BOLC is an integration project. An integration project needs a common data model to be able to interpret and accumulate data
- LD/SW is an extremely flexible technology for data modelling of different domains and combining these domains
- The LD/SW technology is mature based on a well-developed standardisation work from international bodies like World Wide Web Consortium (W3C) and ISO
- By using LD/SW technology as the back-bone of the integration architecture, we'll facilitate an extremely flexible integration solution.

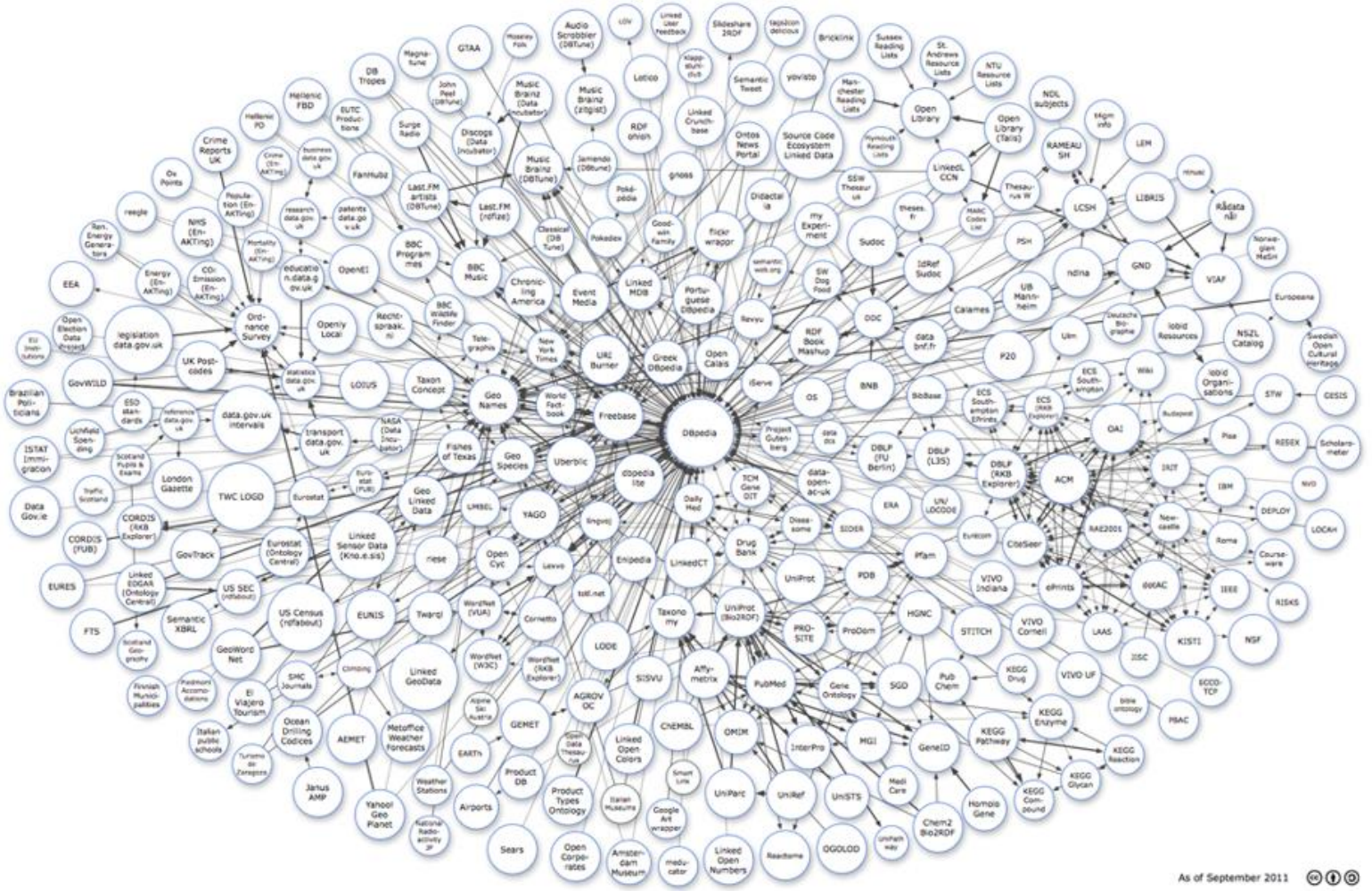
Why use V440 – Norwegian Bridge classification system :

- For integration projects, it is crucial to have a common understanding of the domains
- V440 provides a fully developed data model/ classification system for the main domain for this integration project
- V440 is relevant for Norwegian conditions
- V440 will be the "centre ontology" for the integration work, like the Core EUROTL on the next slide

Interlink - EUROTL

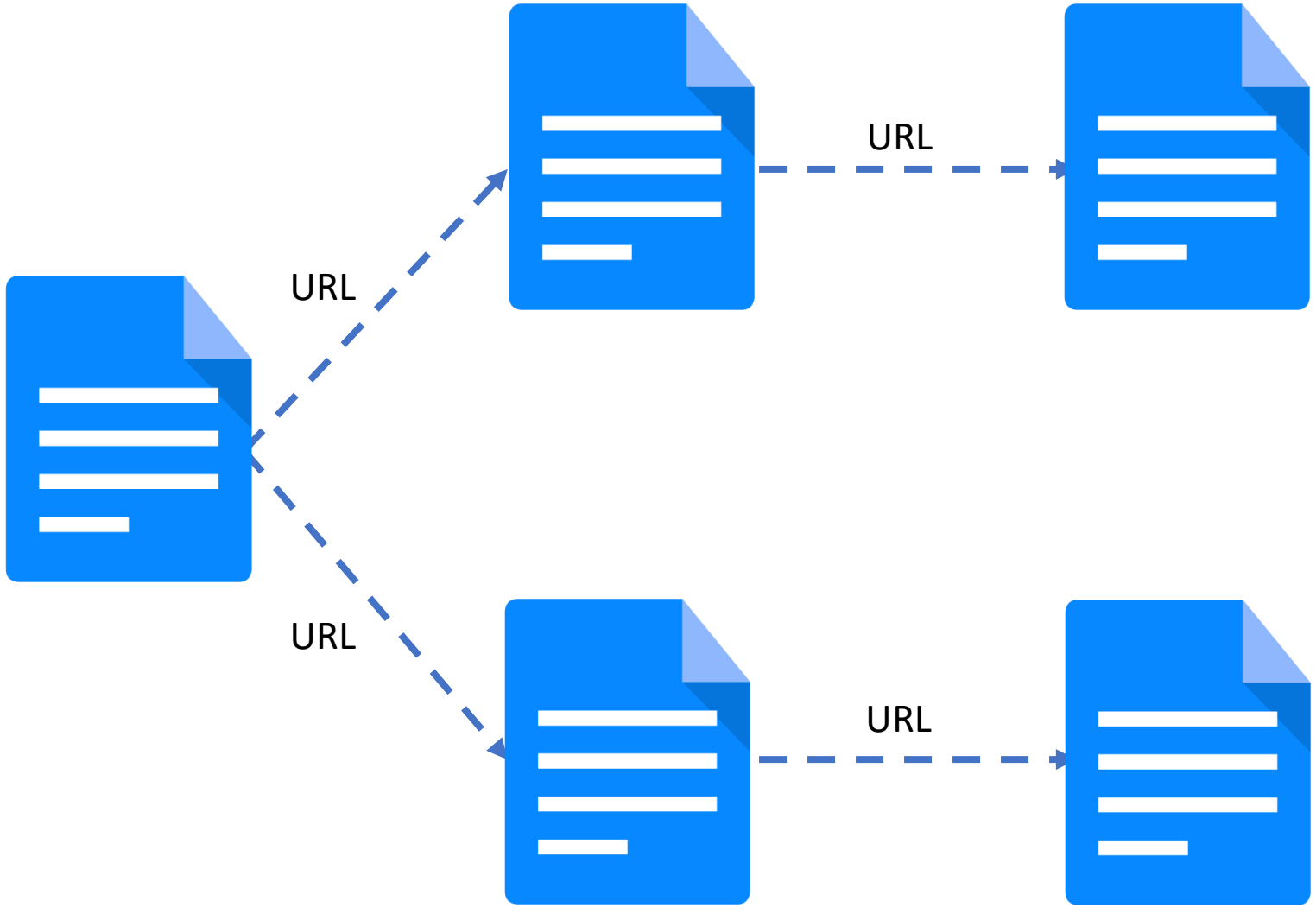


Linked Data & The Semantic Web – Crash course (5 mins)

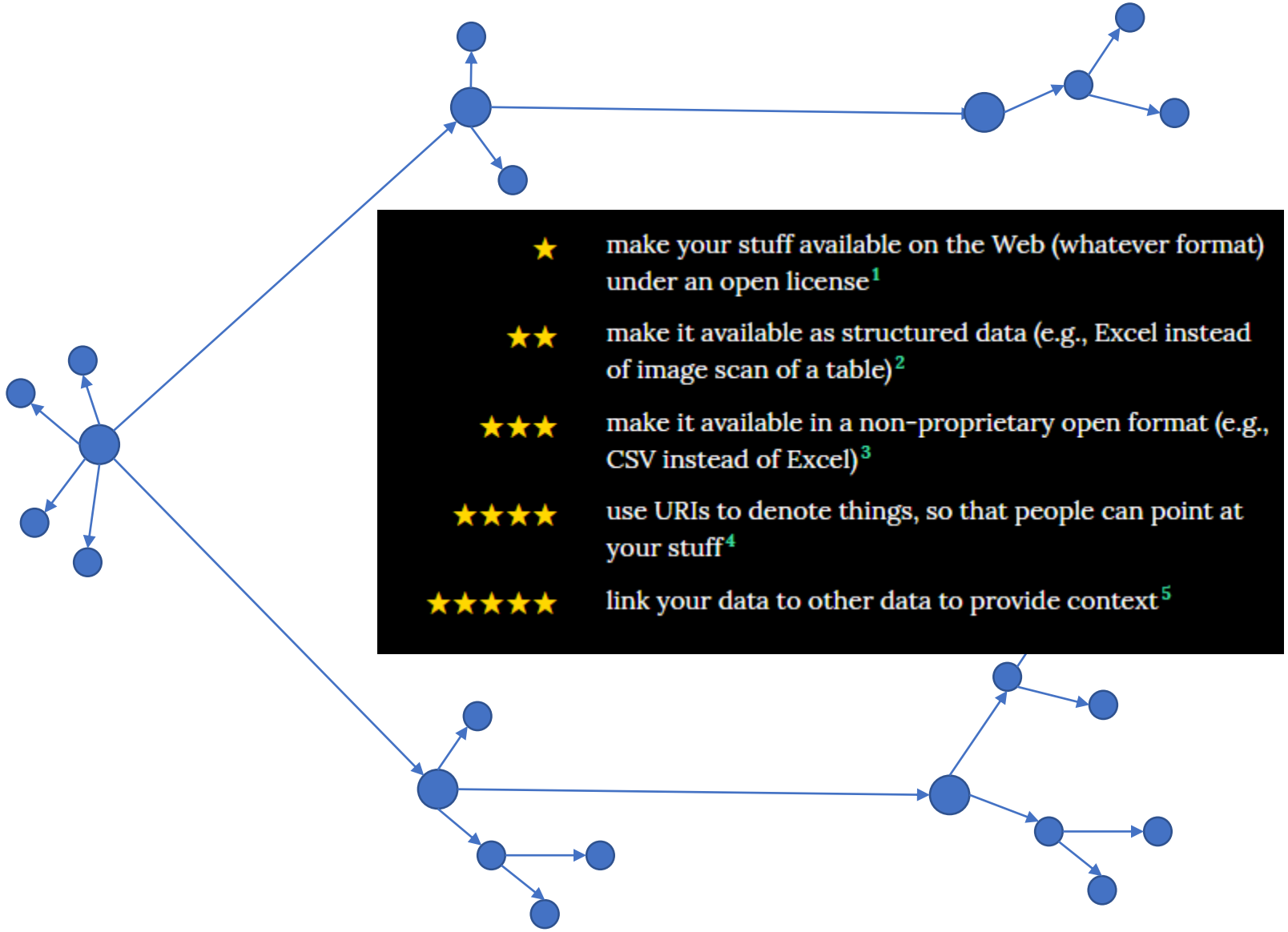


http://www.w3.org/standards/semanticweb/

Linked data – starting with the web (linked documents)
Physical machines abstracted away



Linked data - Semantic Web (Web of data)



Basic concepts

RDF

Resource Description Framework

RDFS – One level up

Resource Description Framework Schema

SPARQL

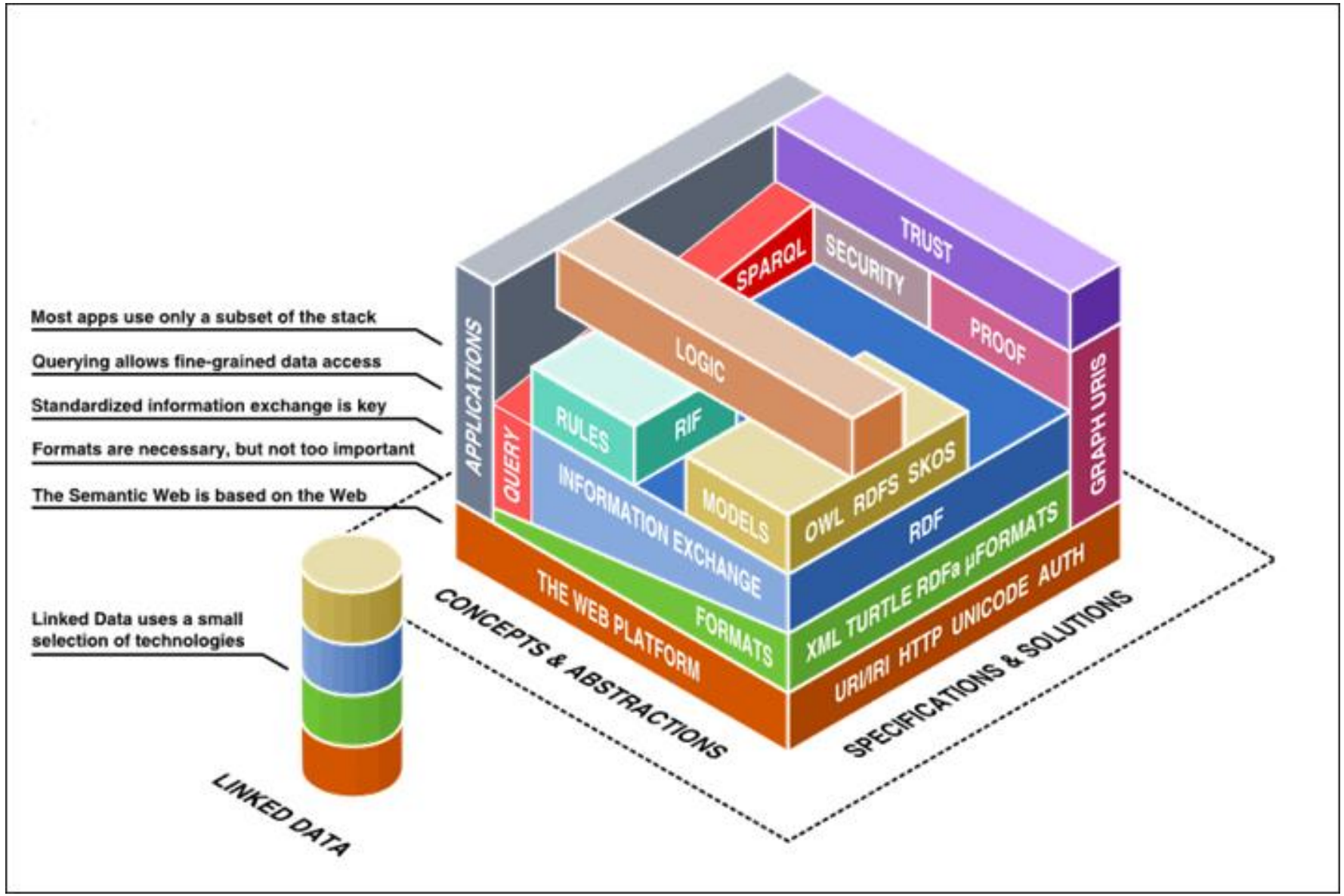
SPARQL Protocol and RDF Query Language

GeoSparQL

Ontologies

OWL == Web Ontology Language

Technology Stack – Web technology

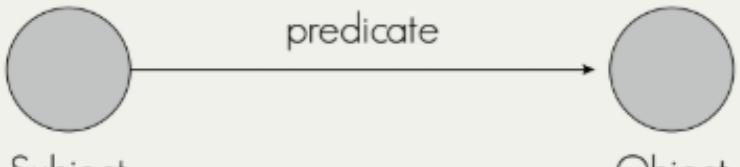


Basic Concepts

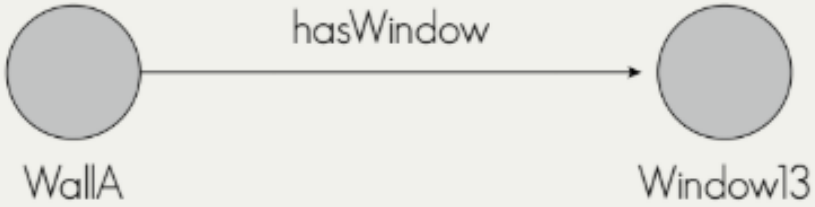
RDF – Resource Description Framework

RDF

Resource Description Framework

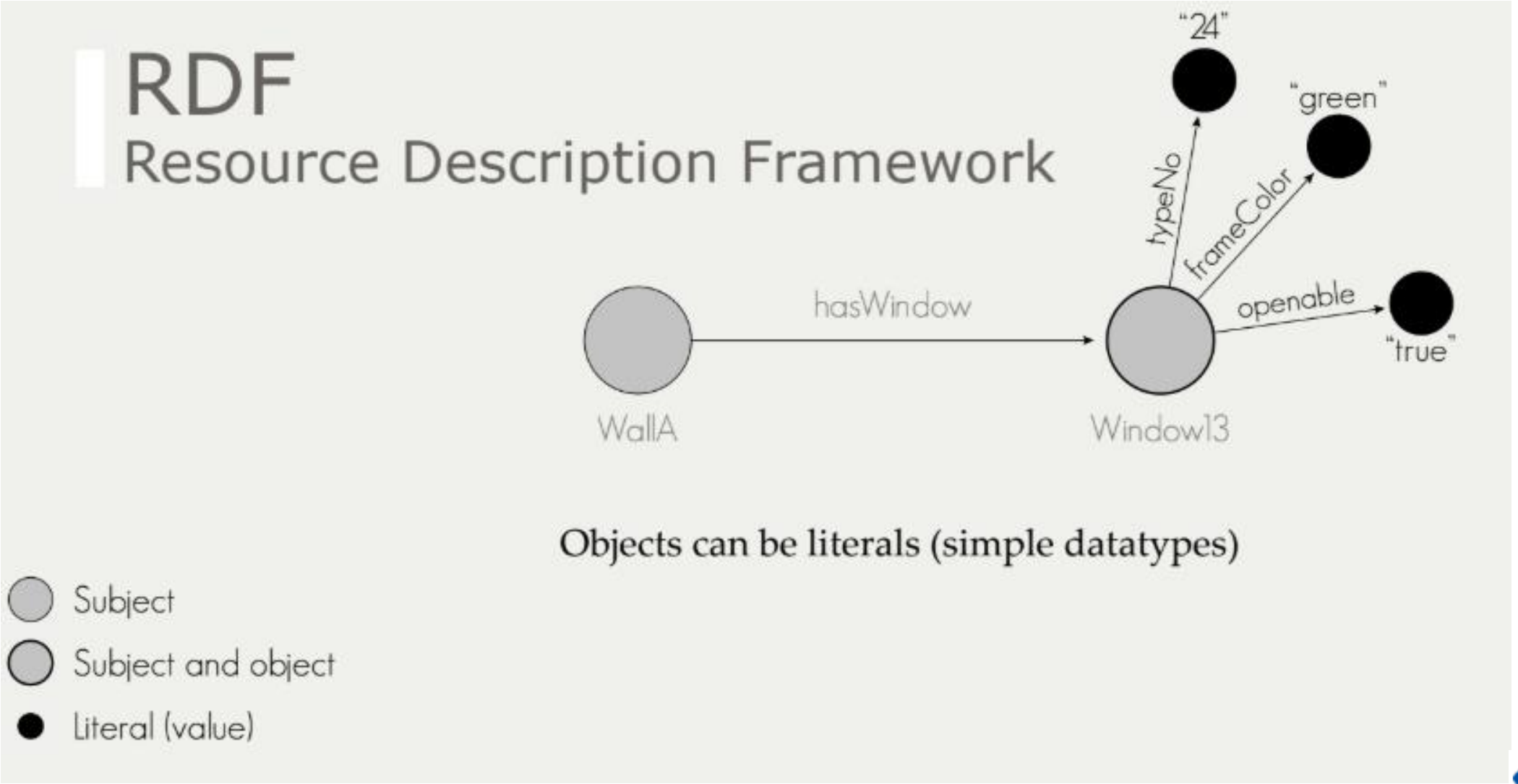


A triple



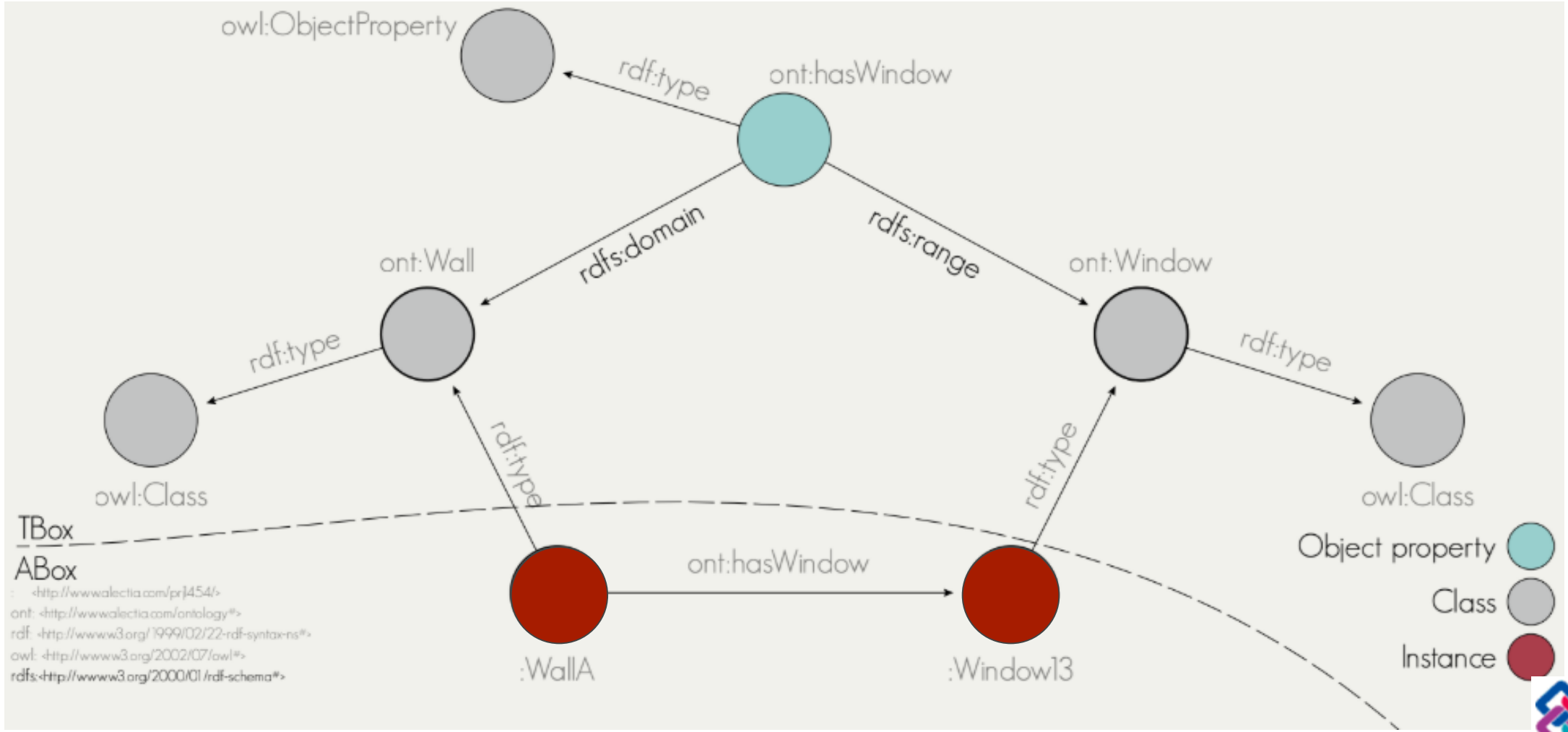
A triple

Basic Concepts



Basic Concepts

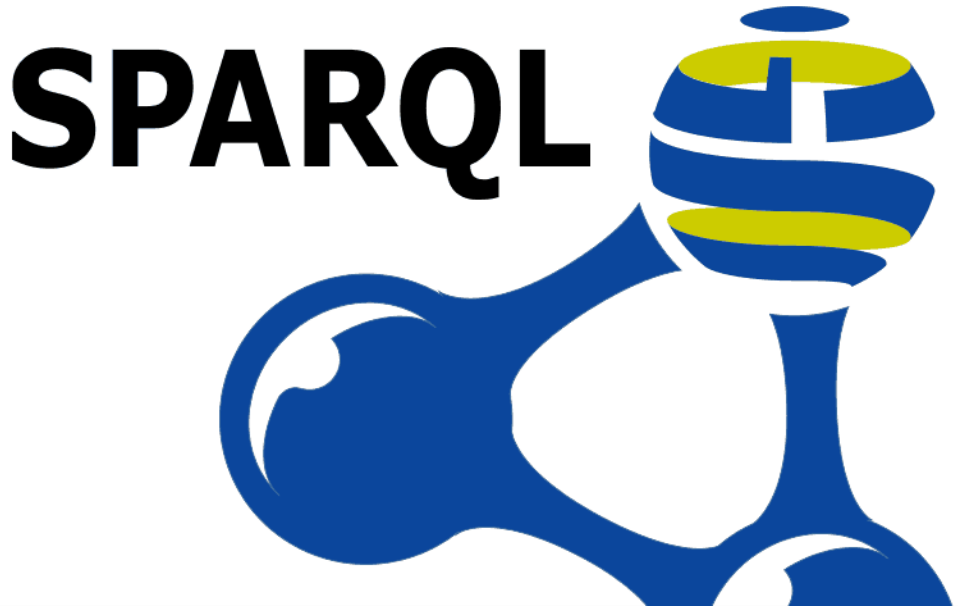
RDFS – RDF Schema



Basic Concepts

SPARQL – Querying the semantic web

```
SELECT ?wall ? Window
WHERE {
        ?wall rdf:type ont:Wall .
        ?wall ont:hasWindow ?window .
}
```



Basic Concepts

OWL – Ontologies (RDFS++)

- Web Ontology Language
- OWL includes RDFS plus much more:
  - *E.g. Class "Mother" is the intersection of classes "Parent" and "Woman"*
  - *E.g. My class "Wall" is equivalent to the class "IfcWall"*
  - *E.g. System-A:BridgeA is the same as System-X:BridgeX*
  - OWL gives you a much larger vocabulary to play with
    =>It makes it easy to say anything you might want to say about your data
    =>OWL allows you to easily express the relationships between different ontologies using a standard annotation framework.
- Semantic reasoning
  - Inferring new triples (knowledge) from existing triples
  - E.g. This individual belongs to "Parent" and "Woman" => Must be a "Mother"

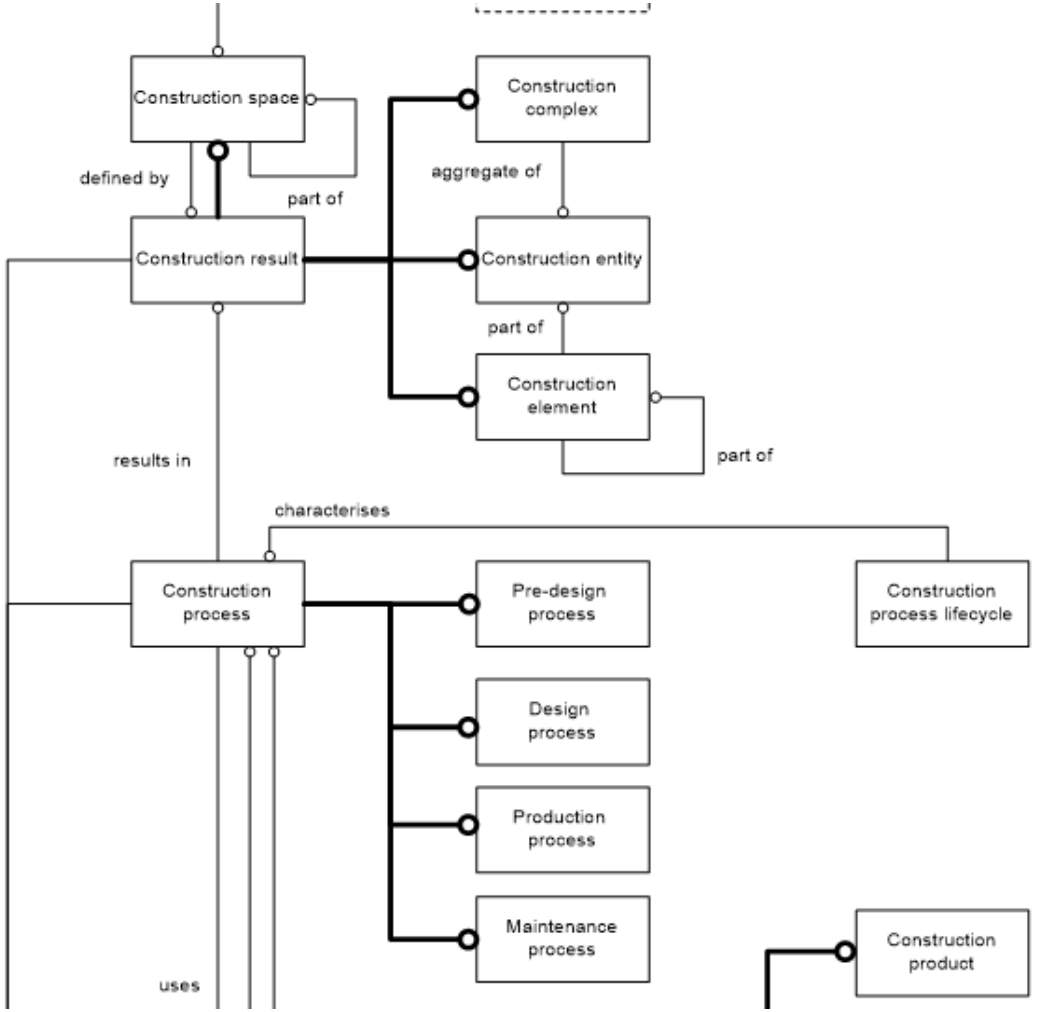
Use cases

- Make structure explicit and readable/understandable by machines/applications
  - RDF, RDFS, OWL
- Referenceable from other standards/formats such as IFC & *GML
  - Through the use of de-referenceable URI:s
- Easily ”mappable” to other structures
  - Through ”Linking Rule Sets”, i.e. ontologies of their own right, specifying schema level relationships
- Available through standard Web API:s
  - http GET, SPARQL endpoint
- For free:
  - Exchange format for both schema and data (XML, Json, Turtle, …)

Inspiration from ISO 12006-2

Building construction — Organization of information about construction works — Part 2: Framework for classification

- Construction complex
  - aggregate of *construction entities* serving at least one user activity or function
- Construction entity
  - an independent unit of the *built environment* with a characteristic spatial structure, serving at least one user activity or function
- Construction Entity part
  - constituent of a *construction entity*
- Construction element
  - constituent of a *construction entity* with a characteristic technical function, form or position
- Construction process
  - process which uses *construction resources* to achieve *construction results*



Use of CEN/TC442 Semantic Modelling and Linking Standard - Including the basicsemantics ontology

CEN/TC 442

Date: 2019-09-27

prEN XXXXX: XXXX

Secretariat: XXX

Building Information Modelling (BIM) —

Semantic Modelling and Linking Standard (SMLS) —

for data integration (delivery & sharing) in the built environment

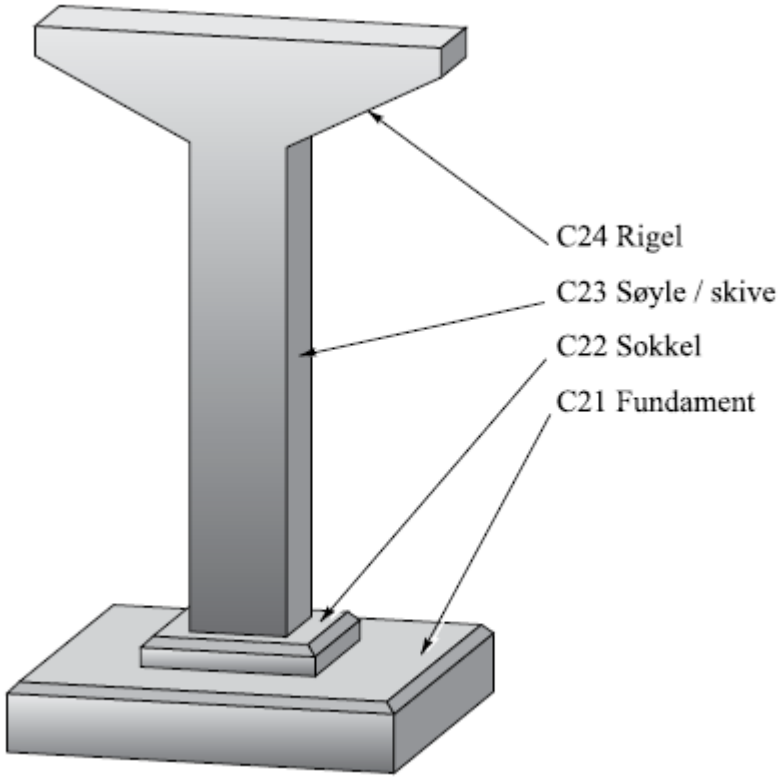
ICS:

Basic concepts used in RDF, RDFS and OWL

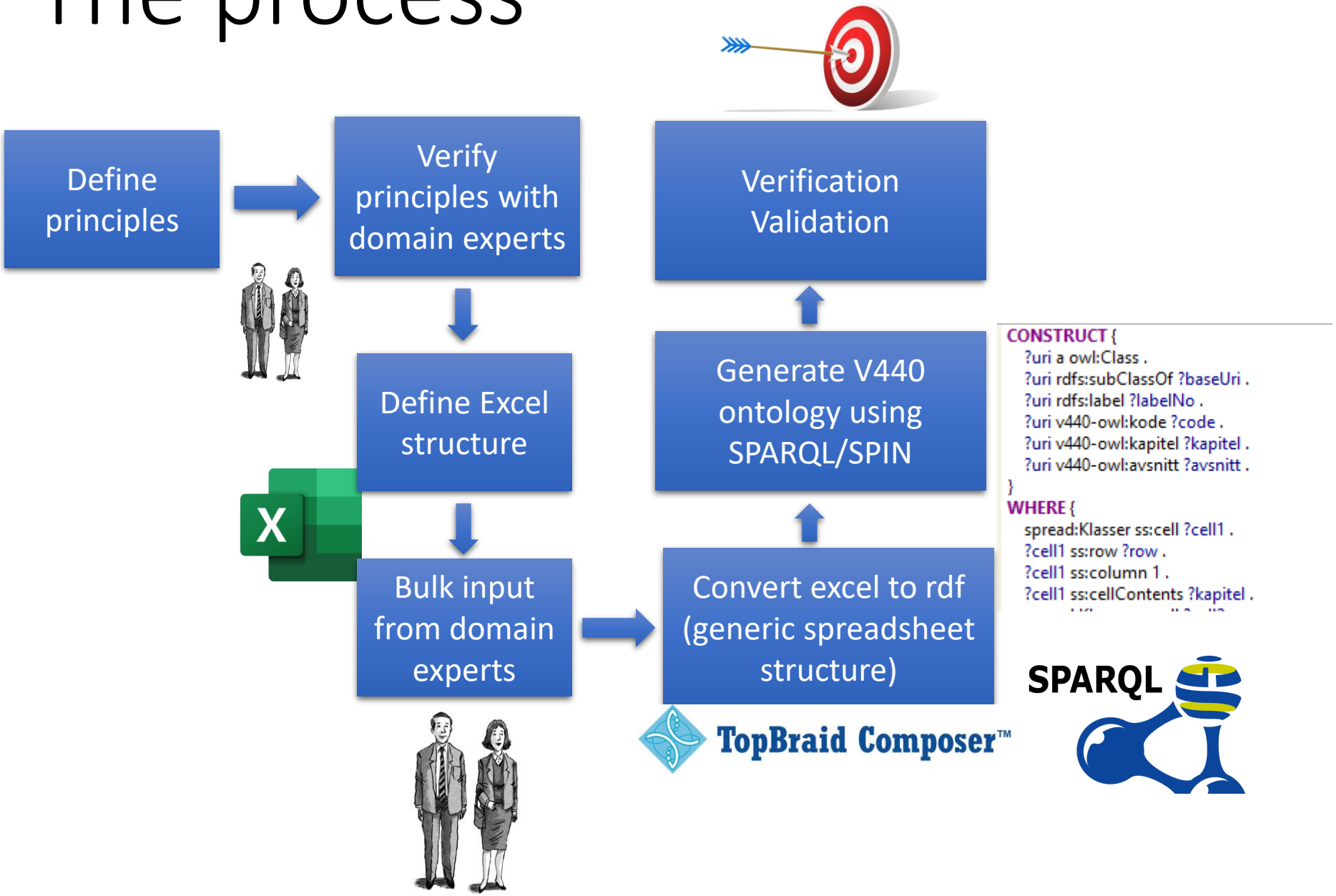
- URI:s identify each concept
- Define the concepts using owl:Class
- Define relationships between classes using
  - rdfs:subClassOf (for the taxonomy)
  - basicsemantics:hasPart (for the meronomy with restrictions)
  - And other owl:ObjectProperty if needed
- Define the properties using owl:DatatypeProperty
- Connect properties and classes with restrictions (cardinality, type)
  - rdfs:domain, rdfs:range and/or owl:Restriction
- Define Annotation using owl:AnnotationProperty
  - E.g. capture the ”Codes” used in V440

A challenge

- The handbook defines a hierarchical structure of classes/codes, but
  - It is not always strict with regards to the nature of the hierarchy
  - E.g. taxonomies vs meronomies
- rdfs/owl needs to support reasoning and to be ”semantically strict”
  - A class is a set
  - rdfs:subClassOf specifies a subset (used for taxonomies)
- Example: Pillar
  - In V440 there is no clear difference beteen
    - The relationship between BuildingElement vs Pillar (is-a)
    - And the relationship between Pillar and Foundation (has-a)



The process


Define principles
Verify principles with domain experts
Define Excel structure
Bulk input from domain experts
Convert excel to rdf (generic spreadsheet structure)
Generate V440 ontology using SPARQL/SPIN
Verification Validation
CONSTRUCT {
?uri a owl:Class .
?uri rdfs:subClassOf ?baseUri .
?uri rdfs:label ?labelNo .
?uri v440-owl:kode ?code .
?uri v440-owl:kapitel ?kapitel .
?uri v440-owl:avsnitt ?avsnitt .
}
WHERE {
spread:Klasser ss:cell ?cell1 .
?cell1 ss:row ?row .
?cell1 ss:column 1 .
?cell1 ss:cellContents ?kapitel .
TopBraid Composer™
SPARQL

Ontology

Construction entity

- v440:Byggverk
  - v440:Annet
  - v440:Bru_i_fylling
  - v440:Ferjeleie
  - v440:G_S_Bru
  - v440:Jernbanebru
  - v440:Stottekonstruksjon
  - v440:Tunnel_vegoverbygg
  - v440:Vegbru

composition

Properties

- Enumeration (21)
  - AdministrativeKoder_V2 (3)
  - Statisk_system_V6_2 (9)
  - Status_V5_2 (2)
  - Typekoder_V8 (7)
    - Diverse_typekoder_V8_8
    - Grunn_og_underbygning_V8_1 (5)
    - Konstruksjoner_i_fylling_V8_3
    - Konstruksjonsmaterialer_V8_6
    - Overbyggning_og_brudekke_V8_2 (2)
    - Overflatebehandling_V8_7
    - Spesielt_kaiutstyr_V8_5
    - Utstyr_V8_4

- v440:Byggverksdel
  - v440:Andre_byggverk
  - v440:Bjelkebru_BH1
  - v440:Buebru_og_hvelvbru
  - v440:Fagverksbru_sprengverksbru_og_hengverksbru
  - v440:Hengebru_skrastagbru_flytebru_og_nedtrykket_rorbru
  - v440:Kai_bevegelig_bru_og_andre_brutyper
  - v440:Kassebru
  - v440:Kulvert_bjelkeramme_ror_og_hvelv_i_fylling
  - v440:Platebru_bjelkeplatebru_og_ribbeplatebru

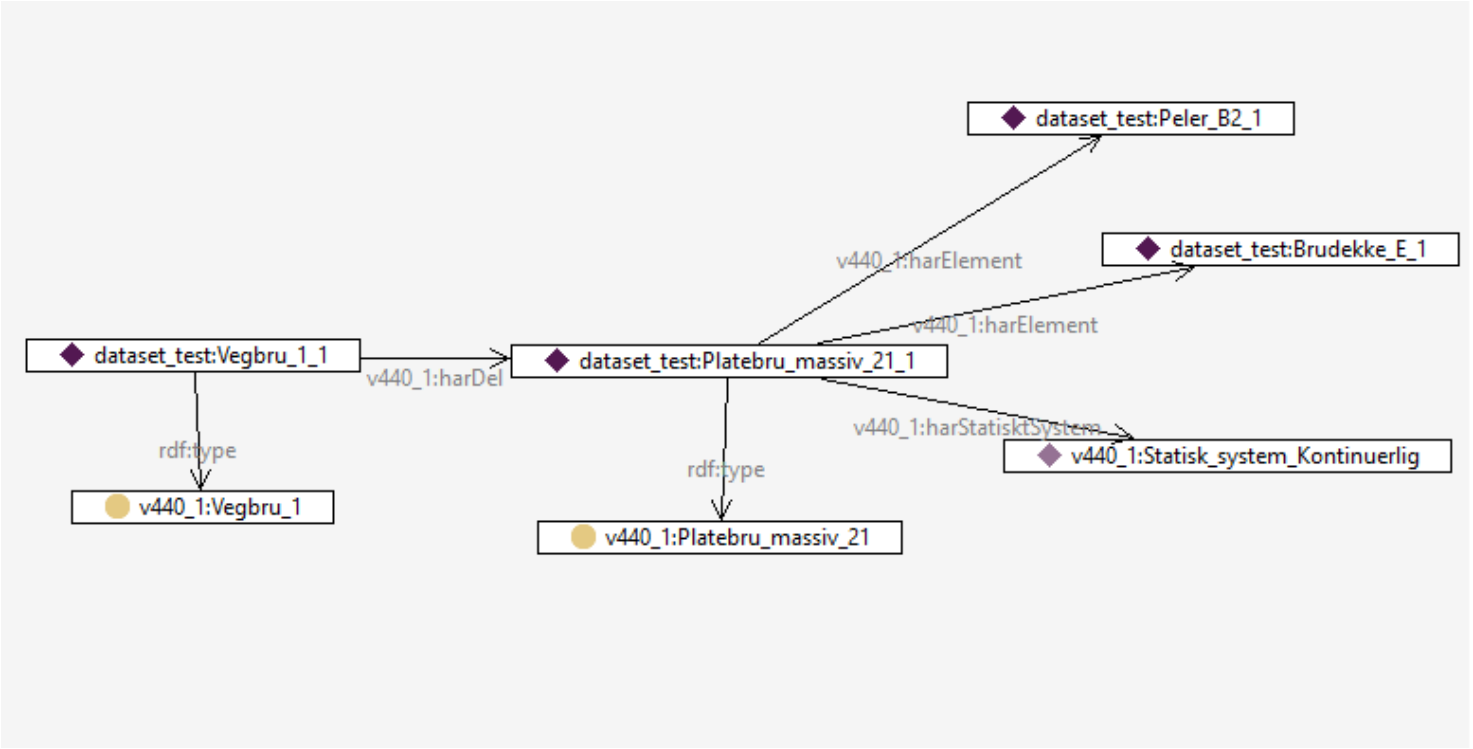
composition

- v440:Byggverkselement
  - v440:AnnetElement
  - v440:Brudekke_Slitelag
  - v440:Grunnen
  - v440:Konstruksjoner_i_fylling
  - v440:Overbygning
  - v440:Spesielle_installasjoner
  - v440:Spesielt_kaiutstyr
  - v440:Stottekonstruksjon
  - v440:Underbygning
  - v440:Utstyr

Construction entity part

Construction element

Example dataset



- dataset_test:Brudekke_E_1
  rdf:type v440_1:Brudekke_E ;
  .
  dataset_test:Peler_B2_1
  rdf:type v440_1:Peler_B2 ;
  .
  dataset_test:Platebru_massiv_21_1
  rdf:type v440_1:Platebru_massiv_21 ;
  v440_1:harElement dataset_test:Brudekke_E_1 ;
  v440_1:harElement dataset_test:Peler_B2_1 ;
  v440_1:harStatisktSystem v440_1:Statisk_system_Kontinuerlig ;
  .
  dataset_test:Vegbru_1_1
  rdf:type v440_1:Vegbru_1 ;
  v440_1:harDel dataset_test:Platebru_massiv_21_1 ;

The way forward

- An ontology (OTL) for V440 will be finished and published before March 2020
- Further work on Linked Data Sets (LDS) to other relevant OTLs (IFC e.g.) will probably start in the spring 2020
- The public tender for implementation of BOLC will be issued in Q1 2020
- Software vendors will be invited to an “interoperate” from mid-April to the end of June 2020
  - The purpose is to prototype the integration of LD/SW technology and the V440 OTL in relevant software products
  - Will be arranged as facilitated workshops with independent work sessions in between
- Information about this project, the LD/SW technology and the developed ontologies will be given to the industry in breakfast meetings, newsletters, seminars etc.
  It is important to get the industry engaged.