There is more to life than SQL!

Veronika Heimsbakk

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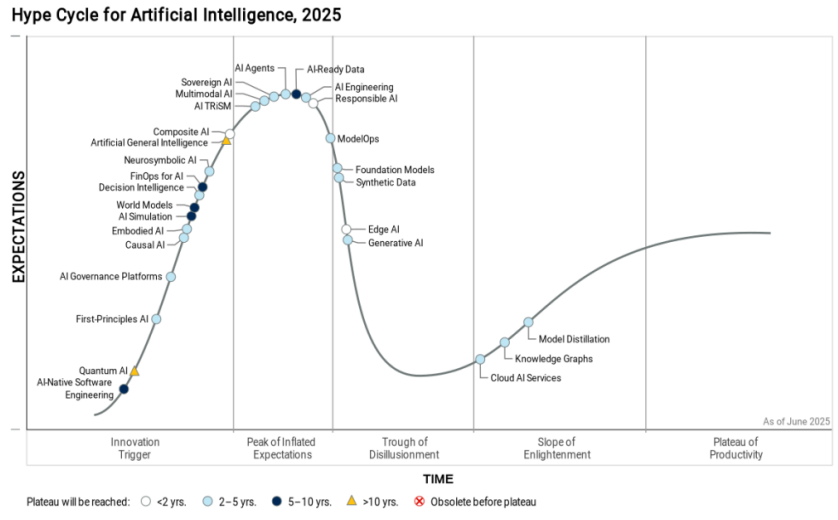
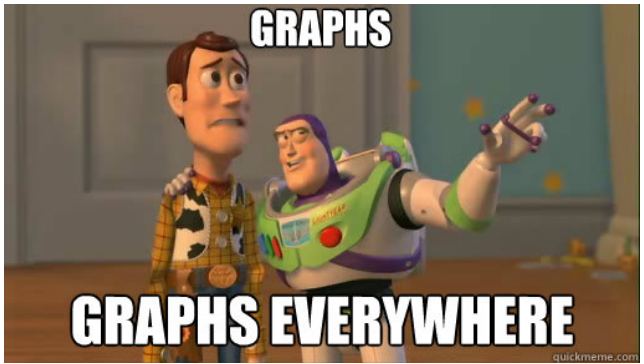
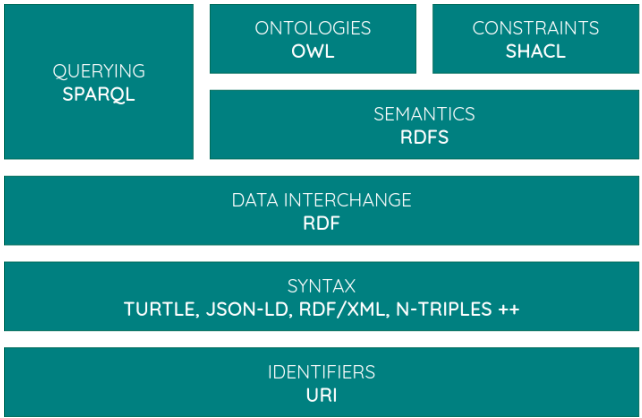
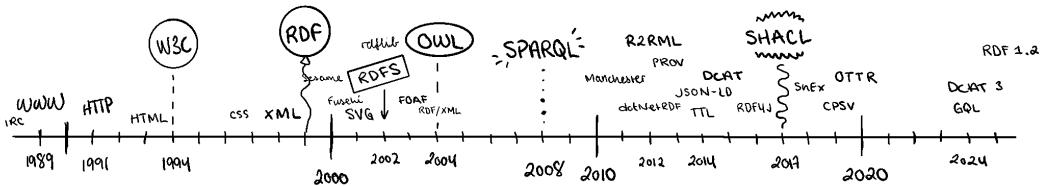
Agenda

RDF
DATA
ONTOLOGIES
MAPPING
SPARQL


Hype Cycle for Artificial Intelligence, 2025
EXPECTATIONS
AI Agents
AI-Ready Data
Sovereign AI
Multimodal AI
AI TRiSM
AI Engineering
Responsible AI
Composite AI
Artificial General Intelligence
ModelOps
Neurosymbolic AI
FinOps for AI
Decision Intelligence
Foundation Models
Synthetic Data
World Models
AI Simulation
Embodied AI
Causal AI
Edge AI
Generative AI
AI Governance Platforms
First-Principles AI
Model Distillation
Knowledge Graphs
Quantum AI
AI-Native Software Engineering
Cloud AI Services
As of June 2025
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
TIME
Plateau will be reached: <2 yrs. 2–5 yrs. 5–10 yrs. >10 yrs. Obsolete before plateau
Gartner


GRAPHS
GRAPHS EVERYWHERE
quickmeme.com


QUERYING
SPARQL
ONTOLOGIES
OWL
CONSTRAINTS
SHACL
SEMANTICS
RDFS
DATA INTERCHANGE
RDF
SYNTAX
TURTLE, JSON-LD, RDF/XML, N-TRIPLES ++
IDENTIFIERS
URI


WWW
IRC
HTTP
HTML
W3C
CSS
XML
RDF
Sesame
RDFS
Fusion
SVG
FOAF
RDF/XML
rdflib
OWL
SPARQL
R2RML
PROV
Manchester
JSON-LD
ckanNetRDF
TTL
DCAT
RDFlib
SHACL
SHEX
CPSV
OTTR
RDF 1.2
DCAT 3
GQL
1989
1991
1994
2000
2002
2004
2008
2010
2012
2014
2017
2020
2024

RDF

Think of data as a **directed graph**, and that all ***things*** has a relation to other things.

Terminology

Think of data as a directed graph, and that all things has a relation to other things.

- An open standard for representing data as graphs.

- Data described as **triples**.
- A triple is also called a **fact** or a **statement**.
- The elements of a triple are also called **resources**.

```
subject predicate object
```

- Use **Uniform Resource Identifiers** (URI) as global, unique identifiers.

URI

- **Only** a **name**. Does not need to link to anything, URI not URL.

```
scheme:[//[user:password@]host[:port]][/]path[?query][#fragment]
```

Example
`http://data.eksempel.no/Kraftverk`

URI	
Namespace	**Resource name**
`http://data.eksempel.no/`	`Kraftverk`

Triple

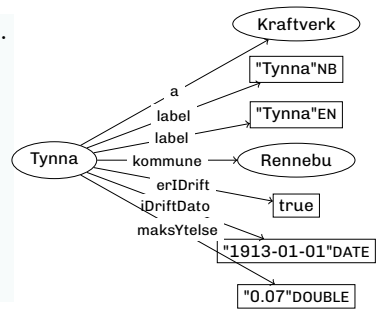
```
http://data.eksempel.no/Tynna
  http://www.w3.org/1999/02/22-rdf-syntax-ns#type http://data.eksempel.no/Kraftverk .
```

Prefixes

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix : <http://data.eksempel.no/> .

:Tynna rdf:type :Kraftverk .
```

Literals and URIs

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix : <http://data.eksempel.no/> .

:Tynna a :Kraftverk ;
  rdfs:label "Tynna"@nb, "Tynna"@en ;
  :kommune :Rennebu ;
  :erIDrift true ;
  :iDriftDato "1913-01-01"^^xsd:date ;
  :maksYtelse "0.07"^^xsd:double .
```



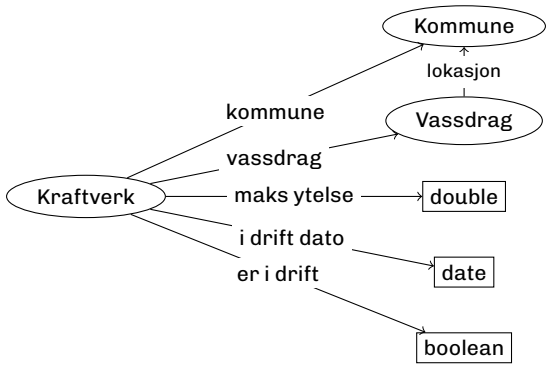
Property semantics

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix : <http://data.eksempel.no/> .

:kommune a rdf:Property ;
  rdfs:label "kommune"@nb, "municipality"@en ;
  rdfs:domain :Kraftverk ;
  rdfs:range :Kommune .
```

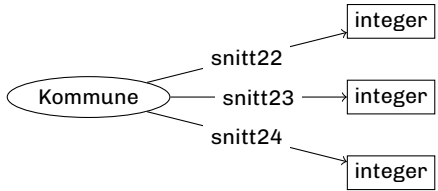
Classification

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .
@prefix : <http://data.eksempel.no/> .

:Kraftverk a rdfs:Class ;
  skos:prefLabel "Kraftverk"@nb, "Power station"@en ;
  skos:altLabel "Power plant"@en .

:Vannkraftverk rdfs:subClassOf :Kraftverk ;
  skos:prefLabel "Vannkraftverk"@nb, "Vasskraftverk"@nn, "Hydroelectric power station"@en .

:Mikrovannkraftverk rdfs:subClassOf :Vannkraftverk .

:Vindkraftverk rdfs:subClassOf :Kraftverk .
```

DATA

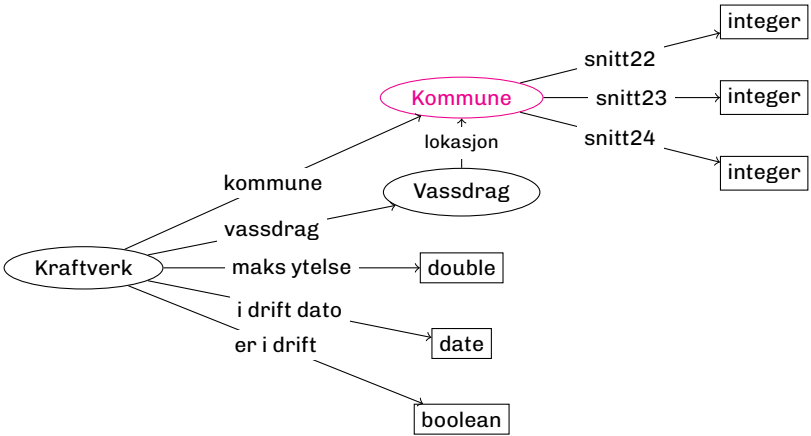


NVE Vannkraftverk `https://www.nve.no/energi/energisystem/vannkraft/vannkraftdatabase/`



SSB Lønn `https://www.ssb.no/statbank/table/12852/`

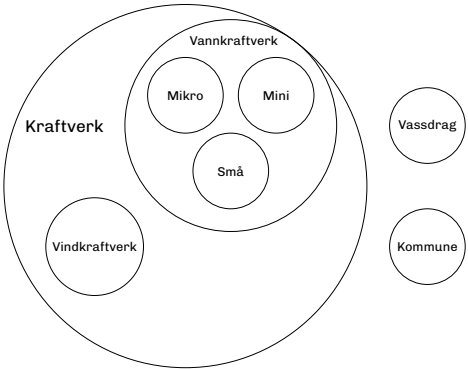
Global, unique identifiers ❤



ONTOLOGIES

Ontology

Vocabulary	A collection of words, concepts, terms (and/or RDF resources).
Taxonomy	A classification of the vocabulary.
Ontology	A description of concepts and categories (classes) and their properties, including the relation between them.



Properties	**Datatype**
kommune	Kommune (URI)
vassdrag	Vassdrag (URI)
maks ytelse	double
i drift dato	date
er i drift	boolean
snitt22	integer
snitt23	integer
snitt24	integer

Software: Protégé — `https://protege.stanford.edu/`

MAPPING

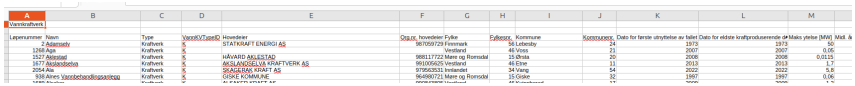
Resonable Ontology Templates (OTTR)

- Mapping language for RDF
- Open source
- Developed by academia in Norway, used in industry

`https://ottr.xyz/`

`https://github.com/veleda/ottr-masterclass`

tpl



↓

tpl.ttl

```
1  @prefix : <http://data.eksempel.no/> .
2  @prefix tpl: <http://data.eksempel.no/tpl/> .
3  @prefix ottr: <http://ns.ottr.xyz/0.4/> .
4  @prefix o-rdf: <https://tpl.ottr.xyz/rdf/0.1/> .
5  @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
6  @prefix owl: <http://www.w3.org/2002/07/owl#> .
7
8  tpl:Vannkraftverk[
9      ?id,
10     ?navn,
11     ?maksYtelse,
12     ?ErIDrift,
13     ?IDriftDato,
14     ? ?Nedborsfeltnavn,
15     ? ?feltnavn,
16     ?Kommune
17 ] :: {
18     ottr:Triple(?id, rdf:type, :Kraftverk),
19     ottr:Triple(?id, rdf:type, owl:NamedIndividual),
20     ottr:Triple(?id, rdfs:label, ?navn),
21     ottr:Triple(?id, :maksYtelse, ?maksYtelse),
22     ottr:Triple(?id, :erIDrift, ?ErIDrift),
23     ottr:Triple(?id, :iDriftDato, ?IDriftDato),
24     ottr:Triple(?id, :vassdrag, ?Nedborsfeltnavn),
25     ottr:Triple(?id, :kommune, ?Kommune),
26     ottr:Triple(?Nedborsfeltnavn, rdf:type, owl:NamedIndividual),
27     ottr:Triple(?Nedborsfeltnavn, rdf:type, :Vassdrag),
28     ottr:Triple(?Nedborsfeltnavn, rdfs:label, ?feltnavn),
29     ottr:Triple(?Nedborsfeltnavn, :lokasjon, ?Kommune)
30
31 } .
```

Generate RDF from input through mapping

```
m = Mapping(tpl)
m.expand(tpl_uri, input_data)
m.write_triples(output, format="turtle")
```

Framework for Python: `https://datatreehouse.github.io/maplib`

SPARQL

Graph patterns

```
SELECT *
WHERE {
  ?s ?p ?o .
}
```

Federation

```
##### FEDERATED TO WIKIDATA
SELECT DISTINCT ?kommune ?population
WHERE {
  ?s :kommune ?kommune .

  SERVICE <https://query.wikidata.org/sparql> {
    ?a ?p ?kommune ;
       wdt:P1082 ?population .
  }
} LIMIT 10
```

SQL		SPARQL
SELECT * FROM A INNER JOIN B ON A.KEY = B.KEY	$A \cap B$ 	SELECT * WHERE A B
SELECT * FROM A LEFT JOIN B ON A.KEY = B.KEY	A 	SELECT * WHERE A OPTIONAL {B}
SELECT * FROM A LEFT JOIN B ON A.KEY = B.KEY WHERE B.KEY IS NULL	$A \setminus B$ 	SELECT * WHERE A FILTER NOT EXSISTS {B}
SELECT * FROM A OUTER JOIN B ON A.KEY = B.KEY	$A \cup B$ 	SELECT * WHERE {A} UNION {B}

Tools & Resources

Ontology modeling	Protégé	`https://protege.stanford.edu/`
Mapping	OTTR	`https://ottr.xyz/`
Data engineering framework	maplib	`https://datatreehouse.github.io/maplib`
Triple store & SPARQL endpoint	Apache Jena Fuseki	`https://jena.apache.org/`

Talk	`https://github.com/veleda/there-is-more-to-life-than-sql`
Free online training	`https://open.hpi.de/courses/knowledgegraphs2023`
Open data from public organisations	`https://data.norge.no/nb`

Play with SPARQL! `https://query.wikidata.org/`