IN3060/4060 – Semantic Technologies – Spring 2021
Lecture 1: Introduction

Jieying Chen

15th January 2021

DEPARTMENT OF
INFORMATICS

UNIVERSITY OF
OSLO

Today's Plan

1. Introduction to Semantic Technologies

2. Practicalities

3. Software

Outline

1. Introduction to Semantic Technologies

2. Practicalities

3. Software

The Vision of a Semantic Web

A vision

I have a dream for the Web [in which computers] become capable of analyzing all the data on the Web—the content, links, and transactions between people and computers. A 'Semantic Web', which should make this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy and our daily lives will be handled by machines talking to machines. The 'intelligent agents' people have touted for ages will finally materialize.

Tim Berners-Lee

Quoted from: *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web.* Tim Berners-Lee with Mark Fischetti. Harper San Francisco, 1999.

Let's go to the cinema!

- Kringsjå studentby, 20:00. . .
- "Let's go to see *Fast & Furious 9* now!"
- Need to find out which cinema plays the movie tonight, e.g. on `http://www.google.no/movies`
- Need to find out where those cinemas are
- Need to find out which of those cinemas we can reach on time using public transport, e.g. on `http://www.ruter.no/`
- Web user needs to combine information from different sites
- Essentially a database join!
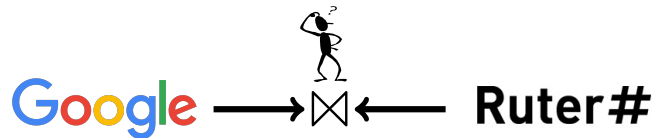
Google $\longrightarrow \bowtie \longleftarrow$ **Ruter#**

The Solution?

- Wait for Google to produce a Cinema+Public Transport mashup?

Ruter#

- But what about
  - Real estate + public transport?
  - Plane schedules and pricing + weather information?
  - Car rental + tourism?
  - Public information + private information (preferences, calendar, location, etc.)
- Can hardly wait for a separate mashup for each useful combination!

A Web of Data!

Imagine. . .

- All those websites publish their information in a machine-readable format.
- The data published by different sources is *linked*.
- Enough domain knowledge is available to machines to make use of the information.
- User-agents can find and combine published information in appropriate ways to answer the user's information needs.

But How?

- This sounds like a nice idea, but how can it work?
- There has been a lot of hype around the Semantic Web!
- Visions instantly transformed to promises (and $$$)
- Most of this simply does not work (yet?)
- But then, a lot does!
- Current *partial* solutions build on traditions of
  - Modelling
  - Calculating with Knowledge
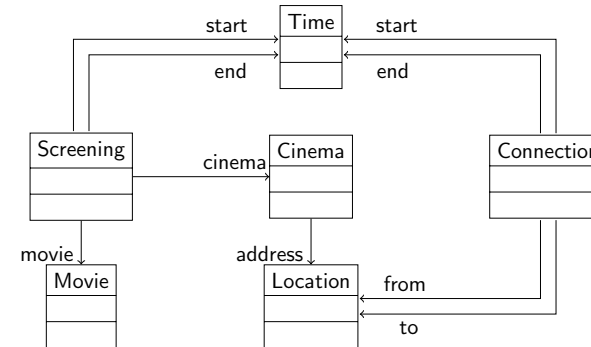 - Information Exchange

Building Models

- A *model* is a simplified representation of certain aspects of the real world.
- Made for
  - understanding
  - structuring
  - predicting
  - communicating
- Can be
  - Taxonomies (e.g. species, genus, family, etc. in biology)
  - Domain models, e.g. in UML
  - Numerical Models (Newtonian mechanics, Quantum mechanics)

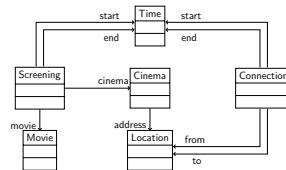## A Cinema Transport Model

An example of a UML domain model:

- What is the vocabulary?
- How is it connected?

A Query

What is it we want?
- Screening(s), movie(s, FF9)
- cinema(s, k), address(k, l)
- Connection(c), from(c, KRINGSJÅ), to(c, l)
- start(c, cStart), *before*(20:00, cStart)
- end(c, cEnd), start(s, sStart), *before*(cEnd, sStart)

Find s, k, l, c, cStart, cEnd, sStart satisfying this and we have the answer!

- Maybe not the easiest way to ask, but it's a start.
- Models are an important part of a Web of Data!
- Need to connect models from different domains.

Nothing But Questions?

- Tim Berners-Lee talks about "intelligent agents"
- More than just question answering.
- "Agents" can act!
- Make a doctor's appointment:
  - Find and commit to a time that fits agenda and public transport
  - Notify the employer
  - Possibly reschedule conflicting meetings
  - . . .
- Queries over distributed information are at the centre of all this.

Calculating

- What is calculation?

$$A \text{ owns } x \text{ } Bs$$
$$A \text{ gets another } y \text{ } Bs$$
$$\overline{A \text{ now owns } (x+y) \text{ } Bs}$$

e.g.

$$\text{Peter owns } 1 \text{ apple}$$
$$\text{Peter gets another } 4 \text{ apples}$$
$$\overline{\text{Peter now owns } 5 \text{ apples}}$$

- Calculation is algorithmic manipulation of numbers. . .
- . . . where the *meaning* of the numbers is not needed
- Can calculate $1 + 4 = 5$ without knowing what is counted
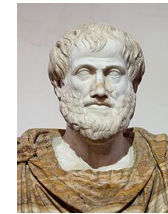- Abstraction!

Calculating with Knowledge

- Can be traced back to Aristotle (384–322 BC)
- Modus Barbara:

$$\text{All } A \text{ are } B$$
$$\text{All } B \text{ are } C$$
$$\overline{\text{All } A \text{ are } C}$$

e.g.

$$\text{All Greeks are men}$$
$$\text{All men are mortal}$$
$$\overline{\text{All Greeks are mortal}}$$

- Algorithmic manipulation of *knowledge*. . .
- . . . where the *meaning* of the words is not needed!
- Also an abstraction!
- The topic of *formal logic*

Computing with Knowledge About Movies

- Query: find a *fun event* we can reach by public transport
- Knowledge base:
  1. A movie screening is an event
  2. A movie screening is fun if the movie being shown is not a documentary
  3. Justin Lin does not direct documentaries
  4. Justin Lin directed *Fast & Furious 9*
  5. There is a screening of *Fast & Furious 9* at 19:00.
     . . .
- Let us calculate. . .
  6. From 3 and 4: *Fast & Furious 9* is not a documentary
  7. From 6 and 2: A screening of *Fast & Furious 9* is fun
  8. From 1, 5, 7: there is a fun event at 19:00
     . . .
- Computing with Knowledge is an important part of a Web of Data!

Exchanging Information
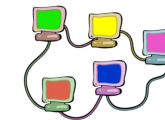
- 1974: The Internet: Global network. Unified network addresses. TCP/IP protocol.
- 1990: The WWW: HTTP protocol. HTML markup. URLs.
- 1996: XML: more data-oriented markup.

- All these (and more) are obviously ingredients for a Web of Data!

- Semantic Web standards are being managed by W3C.

The "Home" of the Semantic Web

See the W3C pages for the Semantic Web effort:

`http://www.w3.org/2013/data/`

For standards (RDF, OWL, SPARQL, etc.), see:

`http://www.w3.org/2001/sw/wiki/Main_Page`

Bringing it together

- RDF as common knowledge format:
  - `movie:FF9 movie:director people:jLin.`
  - `people:jLin people:name "Justin Lin".`
- URIs to avoid naming conflicts:
  - `http://heim.ifi.uio.no/jieyingc/movies#FF9`
- existing protocols to move data:
  - Use HTTP for queries to a semantic web server
  - Use XML for answers, to encode RDF, etc.
- OWL to express ontologies
  - Somewhat like UML class diagrams but better for Sem. Web
- Reasoners to infer new knowledge
  - Hidden from other tools by standardized interfaces

The AAA slogan

Anyone can say Anything about Anything.

- IMDB: `movie:FF9 movie:director people:jLin.`
- Saga Kino: `movie:FF9 movie:shownAt oslokino:Saga.`
- VG: `movie:FF9 vg:terningkast 3.`
- Three statements from three sources about the same subject `movie:FF9`!
- My homepage: `movie:FF9 movie:director mg:myself.`

Problems with the Semantic Web

- Relies on ontologies
  - Have to agree on and communicate ontologies
  - Have to agree on the precise meaning of ontologies
- Anyone can say Anything about Anything
  - Good, simple, necessary
  - Difficult to locate relevant information
  - Difficult to trust data sources
  - Have to deal with unreliable, inconsistent data
  - Have to deal with enormous amounts of data
- . . .
- Extent of these problems is in stark contrast to the visions that have been stated and the promises that have been made.
- Hype has brought some amount of discredit to the Semantic Web effort.

Semantic technologies

- If Tim Berners-Lee's vision of a Semantic Web is still far away, then what is this course about?
- Let's have a look at what we do have:
  - W3C standards: RDF, SPARQL, OWL, some more
  - Technology like reasoners, ontology editors
  - Public datasets like Wikidata (1.1B facts), DBpedia (3B facts), Freebase (2B facts)...
  - Existing ontologies for applications in medicine, industry, some of them with over 1M concepts
  - Interfacing to relational databases, etc.
- Possible, and a lot easier, to use Semantic Web technologies for more closed, controlled applications
- We talk about "semantic technologies" since they make sense independent of the Web
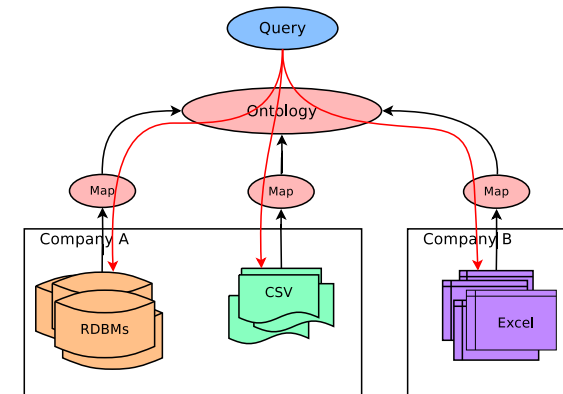
Data integration

- One of the foremost problems in industry today
  - within one organization
  - between organizations
- Enormous amounts of data gathered over the last decades
  - different formats, different data models
  - specialists needed to find, access, convert data when it is needed
  - large need for automated, unified data access
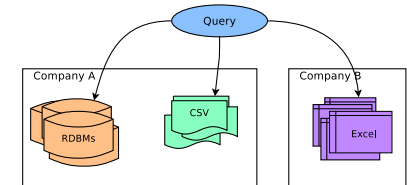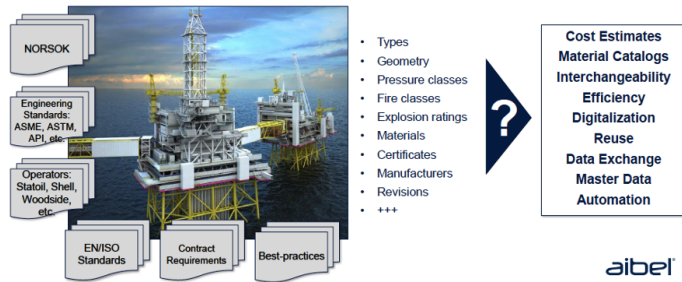
Ontology-based data access

- Use ontology to define common vocabulary
- Possibly by connecting ontologies for different sources using mediating ontologies
- Create mappings between the common vocabulary and what is in the data sources.
- Access data using queries expressed using the common vocabulary
- Background machinery gives answers as if data had always been stored according to a common data model

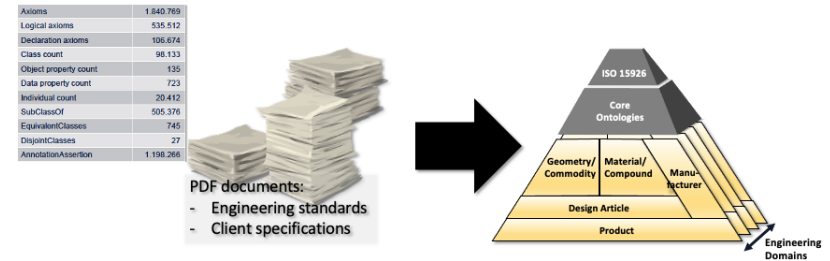## Ontology-based data access (cont.)

Applications in Norway

Managing Complex Requirements

- Types
- Geometry
- Pressure classes
- Fire classes
- Explosion ratings
- Materials
- Certificates
- Manufacturers
- Revisions
- +++

Cost Estimates
Material Catalogs
Interchangeability
Efficiency
Digitalization
Reuse
Data Exchange
Master Data
Automation

aibel

Source: Christian M. Hansen (Aibel)

Material Master Data (MMD) for Piping Systems

Axioms	1.840.769
Logical axioms	535.512
Declaration axioms	106.674
Class count	98.133
Object property count	135
Data property count	723
Individual count	20.412
SubClassOf	505.376
EquivalentClasses	745
DisjointClasses	27
AnnotationAssertion	1.198.266

PDF documents:
- Engineering standards
- Client specifications

- **Represent the contents of documents as an *ontology***
  - PDF documents: Engineering standards, client specifications
- **Hierarchy of types and requirements for type membership**
- **Make explicit the *meaning* of document contents**
  - Available to both humans and computers

aibel

Source: Christian M. Hansen (Aibel), David Cameron (SIRIUS)

This course

The aim of this course is to teach you. . .

- . . . enough of the semantics in semantic technologies (logic, reasoning) for you to get an idea of what this is all about, what can and cannot be done.
- . . . enough of the technology in semantic technologies (standards, languages, programming interfaces) for you to be able to use them in practice.
- . . . enough overview for you to know where to look and what to read when you need a deeper understanding of either side.

If you want to learn more:

- Contact us for possible MSc degree topics

The ASR group – Analytical Solutions and Reasoning

- Resarch in semantic technologies, mostly around Ontology-based Data Access.
- Optique http://www.optique-project.eu/
  - 4 year EU project (2012–2016), led by ASR
  - Ontology Based Data-Access
  - Industry: Siemens, Equinor, DNV, fluid Ops
  - Universities: Oxford, Hamburg, Bolzano, Rome, Athens
- Sirius http://www.sirius-labs.no/
  - Center for Scalable Data Access in the Oil&Gas Domain
  - 8 years funding, 3 left
  - UiO, U Oxford, NTNU, Equinor, IBM, Computas, Numascale . . .

Optique

SIRIUS

The ASR group – Analytical Solutions and Reasoning

- Resarch in semantic technologies, mostly around Ontology-based Data Access.
- Optique http://www.optique-project.eu/
  - 4 year EU project (2012–2016), led by ASR
  - Ontology Based Data-Access
  - Industry: Siemens, Equinor, DNV, fluid Ops
  - Universities: Oxford, Hamburg, Bolzano, Rome, Athens
- Sirius http://www.sirius-labs.no/
  - Center for Scalable Data Access in the Oil&Gas Domain
  - 8 years funding, 3 left
  - UiO, U Oxford, NTNU, Equinor, IBM, Computas, Numascale ...
- BigMed: personalised medicine
- Project with NIVA: aquatic life and toxines
- Great opportunities for both practically and theoretically oriented MSc theses, PhD work,... with strong connections to industry and public sector!
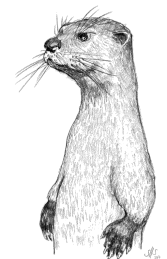

MSc project in Brazil?

Open part-time Java programmer position

- On the **OTTR project** (topic of 2 lectures)
- No sem. web tech. experience required, (but beneficial; put your newly acquired knowledge to use)
- Application deadline: January 31 2021
- Full position description:
  https://www.mn.uio.no/ifi/om/jobb/
  part-time-programmer-for-the-reasonable-ontology-templates.html

Outline

1. Introduction to Semantic Technologies

2. **Practicalities**

3. Software

When, Where, and Who

When and Where
- Lectures Friday 10:15–12:00 on Zoom: `https://uio.zoom.us/j/64475436633`
- No lecture 2nd of April (Easter break)
- Homepage: `http://www.uio.no/studier/emner/matnat/ifi/IN3060/`
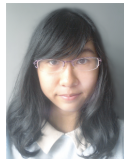
Lecturer

Jieying Chen
(`jieyingc@ifi.uio.no`)

Exercises

Exercises
- Practical exercises every week
- Digital teaching Zoom & Assembler (3417), Monday 14:15–16:00, starting **next** week
- Exercises available on website well in advance. Come prepared!
- First session: help with setting up software. Bring your laptop!
- In general: part repetition of lectures, part exercises

Teacher

Han Yu (`hany@math.uio.no`)

Mandatory Assignments

Assignments
- Seven mandatory assignments
- Corrected by teacher. **Tell us if you don't get feedback!**
- Pass/Fail
- Must have passed all assignments in order to attend exam
- First four assignments, and nr 7
  - Small, about one per week (first one published on 22 January)
  - (semi-)automated correction
  - One attempt
- Fifth and Sixth assignment:
  - More substantial, timing will be announced
  - Manual correction
  - Two attempts
- For INF4060:
  - More substantial assignments five and six
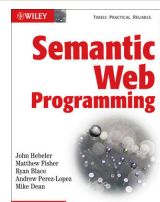
Mattermost

Exam

- Four hours written Exam
- Same exam for INF3060 and INF4060
- Grades A–F
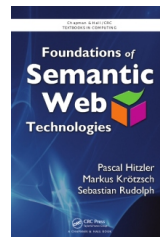- Probably 11 June – Check semester page!

Reading

- For practical aspects:

  Semantic Web Programming.
  Hebeler, Fisher, Blace, Perez-Lopez.
  Wiley 2009

- For theoretical aspects:

  Foundations of Semantic Web Technologies.
  Hitzler, Krötzsch, Rudolph.
  CRC Press 2009

- Can buy both in Akademika
- Slides available on course homepage

Outline

1. Introduction to Semantic Technologies

2. Practicalities

3. Software

Software

- Programming-oriented course.
- With non-trivial theoretical components.
- Various off-the-shelf software required to work on exercises.
- Installation help in weekly exercises and exercise sessions.
- Most software already installed on ifi machines.

Software: Java

In principle, any programming language can be used for semantic web programming, but. . .

- Will explain Sem. Web programming using Java libraries
- The textbook concentrates on Java
- Exercises are built around Java

  So: get latest JDK from

  `http://www.oracle.com/technetwork/java/javase/downloads/index.html`

Software: Eclipse

In principle, you can use any environment to develop Java programs, but. . .

- The Eclipse IDE is free, open source software
- It is particularly suited for Java development
- We will use the Eclipse IDE for demonstrations
- We will be able to help you with Eclipse problems

  So: get the latest Eclipse IDE from

  `http://www.eclipse.org/`

Software: Jena

There are various Java libraries for Sem. Web programming out there, but. . .

- The textbook uses Jena
- It is one of the most used and mature Java libraries for Sem. Web
- It is powerful enough for our purposes
        Download Jena 3.17.0 from:
          `http://jena.apache.org/`

Alternatives:

- Sesame, `http://www.openrdf.org/`
- OWL API, `http://owlapi.sourceforge.net/`
- Redland RDF Libraries (C), `http://librdf.org/`
- etc., Google for "RDF library". . .

Software: Pellet

There are several reasoning systems around, but. . .

- The textbook uses Pellet
- It is open source software
- It has a direct interface to Jena
- It is one of the more mature and comprehensive reasoners
- It is powerful enough for our purposes

Pellet sources are available from:

`https://github.com/complexible/pellet`

But wait a bit. . . maybe we can offer a precompiled package. Alternatives:

- FaCT++, `http://owl.man.ac.uk/factplusplus/`
- Hermit, `http://hermit-reasoner.com/`
- ELK, `https://www.cs.ox.ac.uk/isg/tools/ELK/`
- etc., `http://en.wikipedia.org/wiki/Semantic_reasoner`

Software: Protégé

There are several ontology editors available, but. . .

- The textbook uses Protégé
- It is open source software
- It is the most widely used ontology editor
- Probably the best non-commercial one

$\diamond$ protégé

So: get Protégé 5.5 from

`http://protege.stanford.edu/`

Alternatives:

- see `http://en.wikipedia.org/wiki/Ontology_editor`

Next weeks. . .

- RDF – knowledge representation
- Jena – Java API for RDF
- SPARQL – Query Language
- Maths & Logic
- . . . reasoning and semantics