OWL 1.1: Proposed extensions to OWL

Incremental extensions to OWL-DL, tractable logic fragments, future work

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Overview

- OWL (Web Ontology Language): Background
  - What is OWL
  - Description Logic
- OWL 1.1
  - OWL: Experiences and Directions workshop (2005)
  - *Modelling – New features*
  - *Tractability – Tractable logic fragments*
  - *Current progress*
  - *Beyond OWL 1.1*

What is OWL?

- Web Ontology Language
  - Ontology vocabulary for the Semantic Web designed to be human and machine processable
  - Ontology is a formal specification of a domain to be shared between large groups of stakeholders
  - Supersets RDF/S providing more expressive power
  - Divided into three ‘species’: OWL-Lite, OWL-DL, OWL-Full (layered according to expressiveness)
  - Reasoning tasks in OWL-Lite, OWL-DL are decidable
- OWL-Lite/DL based on Description Logics (DL)
  - Well founded, researched and supported
  - Automated reasoners exist for various DLs

    (*Racer, Pellet, FaCT++, Cerebra, KAON2, CEL, etc…*)
  - OWL-DL: Description logic $\mathcal{SHOIN}(D^+)$
  - OWL-Lite: Description logic $\mathcal{SHIF}(D^+)$

Some Description Logic

- Class (Concept)

  Human, MaleHuman, FemaleHuman

- Instance

  MaleHuman(John), FemaleHuman(Sarah)

- Property (Role)

  hasFriend(John, Sarah)

- Axioms
  - Subsumption

    $Human \sqsupseteq MaleHuman \qquad Human \sqsupseteq FemaleHuman$

  - Disjointness

    $MaleHuman \sqcap FemaleHuman \sqsubseteq \bot$

  - Property cardinality

    $Car \sqsubseteq hasWheels \geqslant 4 \sqcap hasWheels \leqslant 4$

  - Property quantification

    $Car \sqsubseteq \exists hasPart.Engine \sqcap \forall hasDriver.Human$

OWL 1.1: Extensions to OWL-DL

OWL 1.1

Modelling

- **Syntactic sugar** – Disjointness axioms, value restrictions
- **Meta-modelling** – Punning, semantic-free comments
- **Property constructs** – Role composition, etc
- **Datatype expressiveness** – Extended support

Tractability

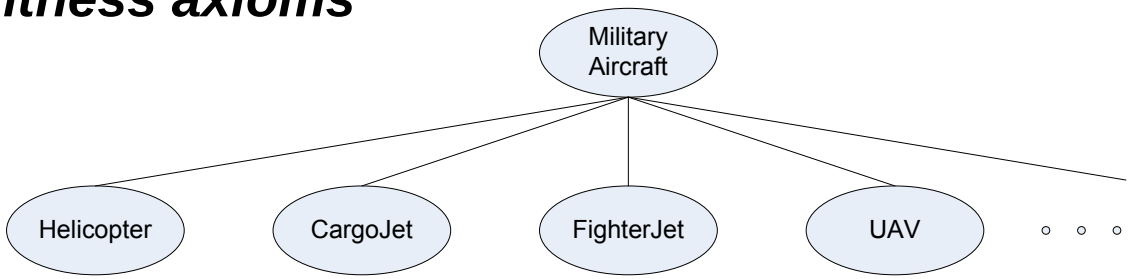
- **Tractable logic fragments** – Eg. *EL++, DL-Lite*

Current state

Future

OWL 1.1: Syntactic sugar

- ***Disjointness axioms***



OWL: Pairwise axioms between all disjoint classes ($\binom{n}{2}$ statements)

OWL 1.1: Disjointness between all classes of a set (1 statement)

- ***Value restrictions***

OWL-DL: Value restriction *hasValue* on a property to contain a specific individual:

$$\textit{Helicopter} \sqsubseteq \exists\, \textit{hasPropulsionSystem}.\{\textit{Turboshaft}\}$$

OWL 1.1: *valueNot* states that an instance is not associated with a property:

$$\textit{FighterJet} \sqsubseteq \neg\exists\, \textit{hasPropulsionSystem}.\{\textit{Turboshaft}\}$$

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OWL 1.1: Meta-modelling

- ***Meta-modelling***

OWL 1.1: (Weak) meta-modelling support via *punning*:

- Classes, properties and individuals may have the same name
- Interpretation is dependent on context
- Not compatible with RDF (and therefore, OWL-Full)

Engine(*Turboshaft*)

Engine $\sqsupseteq$ Turboshaft

- ***Semantic-free comments***

OWL: *AnnotationProperty*:

- Compiled as an RDF triple, thus has *semantic import*

OWL 1.1: *Comment:*

- Not compiled as an RDF triple (no semantic import)
- Survives transmission or processing

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OWL 1.1: New property (role) constructs

OWL-DL based on a description logic called $\mathcal{SHOIN}(D^+)$

Description logic $\mathcal{SROIQ}(D^+)$ allows for more expressivity while retaining decidability (basis for the logical extensions of OWL-DL as OWL 1.1)

- ***Disjoint roles***

  sisterOf(X,Y) disjoint from brotherOf(X,Y)

- ***Reflexive and irreflexive roles***

  Reflexive: *knows(X, X)*

  Irreflexive: *motherOf(X,Y)*

- ***Negated role assertions***

  $\neg$ *likes(John, Mary)*

- ***Universal role***

  $U \sqsupseteq R$ $\quad\quad$ $owl{:}Thing \sqsupseteq C$

- ***Local role reflexivity:*** *Self*

  $\exists likes.Self \sqsupseteq Narcist$

OWL 1.1: New property (role) constructs

- ***Qualified cardinality restrictions***

OWL: Cardinality restrictions on properties with no qualification of class

OWL 1.1: Class of cardinality restricted property can be qualified

Eg.

OWL-DL:

NormalHand

hasFinger = 5

OWL 1.1:

NormalHand

hasFinger.Finger = 4

hasFinger.Thumb = 1

- ***Role composition***

Given: $owns \circ hasPart \sqsubseteq owns$

CarOwner

$\exists owns.Car$

Car

$\exists hasPart.Engine$

Derive: *CarOwner*

$\exists owns.Engine$

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OWL 1.1: Extended datatype support

- OWL: Limited datatype support
  - Unary XML Schema Datatypes (XSD) in datatype properties as *data ranges*

    hasWidth.(xsd:integer)
  - Enumerated datatypes

    hasTennisScore.(oneOf(0, 15, 30, 40))

- OWL 1.1: Extends support (restrictions)
  - Arbitrary number of conjunctive finite datatype restrictions
    - Length of a list
    - Pattern (regular expression) for a string
    - Ranges for numbers
  - Constraints relating individual values

    A > B

OWL 1.1: Tractability

- OWL: Lite, DL, Full
  - Increasing expressivity and complexity of reasoning
  - High worst-case computational complexity in all cases; at least ExpTime (*deterministic exponential time*)
- OWL 1.1
  - Describes several families of sub-languages, geared toward different applications
  - Many sub-languages have known polynomial time algorithms for important reasoning tasks
    - Scalable subsumption hierarchy computation (large TBoxes)
    - Scalable instance checking and query answering (large ABoxes)

OWL 1.1: Tractable fragment *EL++*

EL++

- Geared towards ontologies with large numbers of *concepts*
- Primary focus on large *life science ontologies*:
  - Gene Ontolgy (*Genomics*)
  - SNOMED (*Systematized Nomenclature of Medicine*)
  - GALEN (*Clinical terminology for medical concepts*)
- Supports polynomial time reasoning for:
  - Ontology consistency, concept satisfiablility, subsumption and instance checking
- Limited expressivity, cannot describe:
  - Union, negation, universal property quantification
  - Cardinality restrictions; inverse, functional properties, etc.
- Reasoner implementation
  - CEL (*F. Baader, et al*.), Technische Universität Dresden
  - Currently only supports *EL+*; extension to *EL++* planned

OWL 1.1: Tractable fragment ***DL-Lite***

DL-Lite

- Geared towards ontologies with large numbers of *instances*
  - Allows separation of terminological component (concepts) from assertional component (instances)
  - Allows instances to be maintained in *secondary storage* (DBMS)
- Formulated to take advantage of a database engine (eg. SQL) for high performance query answering
- Characteristics similar to EL++

  Polynomial time reasoning for:
  - Consistency, satisfiablility, subsumption and instance checking
- Different terminological modeling constructs:
  - Allows inverse roles, negated concepts
  - Restricted concept and role inclusion axioms (no role composition)
- Reasoner implementation
  - QuOnto (*D. Calvanese, et al*.), DIS, University of Rome
  - Terminological component reasoning and DBMS wrapper

OWL 1.1: Current progress

- Still not yet finalized
- Developing outside any standardization process
  - Influenced by needs of OWL community
  - Current goal is to develop the state of the art before proposal to standards body (W3C)
- Proposed extensions already supported (or will be soon) by many existing tools
  - Racer, KAON2, FaCT++ already support QCR
  - Developers DL reasoning tools pledging support for extensions to support reasoning over $\mathcal{SROIQ}(D^+)$ and the other proposed extensions
- Syntax: *DIG 2.0*
  - DIG 1.1 used as interface to many DL reasoners
  - To include role composition

Beyond OWL 1.1

- OWL 1.1: One small step in an incremental improvement to OWL
- Intended to start a movement towards a larger extension of OWL (“OWL 2.0”)
  - More syntactic sugar (XPath and XSLT macros)
  - Conjunctive query answering – extensions to SPARQL (which supports queries over RDF graphs) to OWL
  - Integration with rules (possibly extensions to RIF specifically for OWL based on SWRL or variants)
  - Non-monotonic constructs
  - Extensions to meta-modeling constructs (eg. domain modeling)

OWL 1.1: Proposed extensions to OWL

References

Next Steps for OWL (under submission), *Bernardo Cuenca Grau, Ian Horrocks, Bijan Parsia, Peter Patel-Schneider and Ulrike Sattler*
http://www.cs.man.ac.uk/%7Ebcg/OWL1-1.pdf

The OWL 1.1 Extension to the W3C OWL Web Ontology Language
http://owl1_1.cs.manchester.ac.uk/

OWL: Experiences and Directions Workshop (Galway, November 2005)
http://www.mindswap.org/OWLWorkshop

The Description Logic Handbook: Theory, Implementation and Applications.
http://www.cambridge.org/catalogue/catalogue.asp?isbn=0521781760

CEL
http://lat.inf.tu-dresden.de/systems/cel/

QuOnto
http://www.dis.uniroma1.it/~quonto/

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Semantic Sensor Networks Workshop

A workshop of the 5th International Semantic Web Conference ISWC 2006

www.ict.csiro.au

http://ict.csiro.au/ssn06

The goal of the Semantic Sensor Net workshop is to develop an understanding of the ways semantic web technologies, including ontologies, agent architectures and semantic web services can contribute to the growth, application and deployment of large-scale sensor networks.

Now seeking paper submissions!

Paper Submission Deadline*: ***10th July, 2006***

Notification of Acceptance: *4th September, 2006*

Final Manuscript due: *18th September, 2006*

Workshop Date: *6th November, 2006*

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