

# Pellet: OWL-DL Reasoner

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# Who are we?

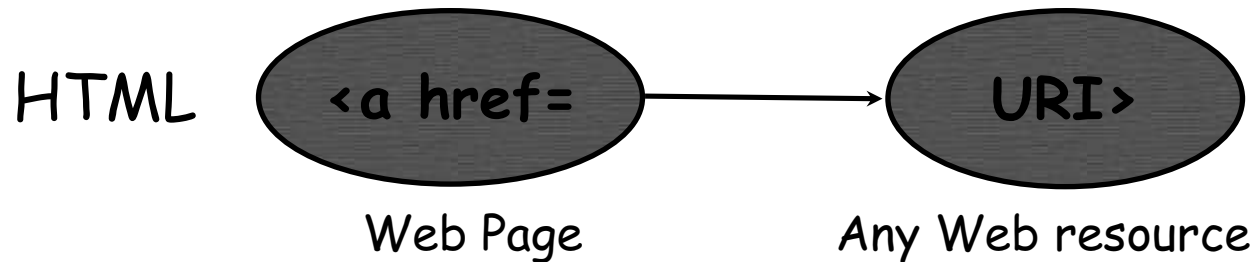
- Clark & Parsia, small consulting and R&D firm
  - Semantic Web technologies
  - Located in Washington, DC
- Background from University of Maryland
  - MINDSWAP research group
- Government and commercial clients
  - NASA, NCI, SAIC, NATO, ..
- <http://www.clarkparsia.com>

# What do we do?

- R&D on Semantic Web technologies
  - Focus on RDF and OWL
  - Scalable Description Logic reasoning
    - Pellet OWL-DL reasoner
- Problems we are working on
  - Support for ontology engineering
  - Information integration across disparate sources
  - Policy management and analysis
  - Semantic Web Services

# Semantic Web

- On the Web, there are links



- On Semantic Web, there are named links



# RDF Graphs

- An RDF graph is a collection of triples
  - [Evren, presentedAt, ASGWorkshop]
  - [ASGWorkshop, location, RutgersUniv]
- RDF Inferences
  - Not much to infer (rdf:type special)
- RDF-S: RDF Schema
  - Notion of a (rdfs:)Class
  - Class hierarchy, property hierarchy, domain-range axioms
  - Can build (inexpressive) taxonomies
  - Semantics based on a model theory

# OWL: Web Ontology Language

- Three varieties: OWL-Lite, OWL-DL, OWL-Full
  - Increasing expressivity and complexity
- Focus on OWL-DL
  - Based on Description Logics SHOIN(D)
  - Decidable subset of FOL
  - "Practical", highly optimized algorithms
  - Several implementations and lots of experience
- OWL-Lite: Not an interesting subset (there are others)
- OWL-Full: Undecidable, non-traditional semantics, no implementation

# OWL Entities

- Individuals: Provide information about objects
  - Evren, ASGWorkshop, ...
- Properties: Relations between objects
  - presentedAt, location, ... (abstract)
  - name, startDate, ... (concrete)
- Classes: Sets of objects
  - Named: Person, Event, Workshop, ...
  - Complex: Long *and* Boring, Genius *or* Liar, *not* Fun, presentedAt *some* Conference, attendee *all* IntelligentPeople, ...

# (Some) OWL Axioms

- Class axioms (TBox)
  - *Person subClassOf Animal, Person equivalentClass HumanBeing, Person disjointWith Workshop*
- Property axioms (RBox)
  - *presentedAt subPropertyOf attendedTo, attendedTo domain Person, attendedTo range Event, Functional startDate, Transitive location*
- Individual axioms/assertions (ABox)
  - *Evren rdf:type Person, Evren presentedAt ASGWorkshop*

# OWL 1.1

- More expressivity - corresponds to SROIQ(Dn)
  - qualified cardinality restrictions
  - local and global reflexivity, antisymmetry
  - disjoint properties
  - property chain inclusion axioms
- Improved datatype support
  - User-defined datatypes
  - n-ary datatypes
- Meta-modelling and annotations
  - Relax vocabulary separation using punning

# Why use RDF/OWL?

- W3C Recommendations
  - Well-defined syntax & semantics
  - Common medium for integration
  - Growing number of mature & robust tools
- Wide range of possibilities
  - RDF: Low expressivity, scalable reasoning
  - OWL: High expressivity, complex reasoning

# Pellet: OWL-DL Reasoner

- DL reasoner based on tableaux algorithms
  - Specifically designed for OWL
  - Primarily for OWL-DL ontologies
    - Heuristics to repair OWL Full ontologies
- Covers full expressivity of OWL-DL
  - Now supports OWL 1.1
- Available as open source software
  - <http://pellet.owldl.com>

# Standard Reasoning Services

- KB Consistency
  - Does my data have conflicting information?
- Concept satisfiability
  - Is it possible for this class to have instances?
- Classification
  - Compute class hierarchy
- Realization
  - Find most specific classes for each instance

# Special Features

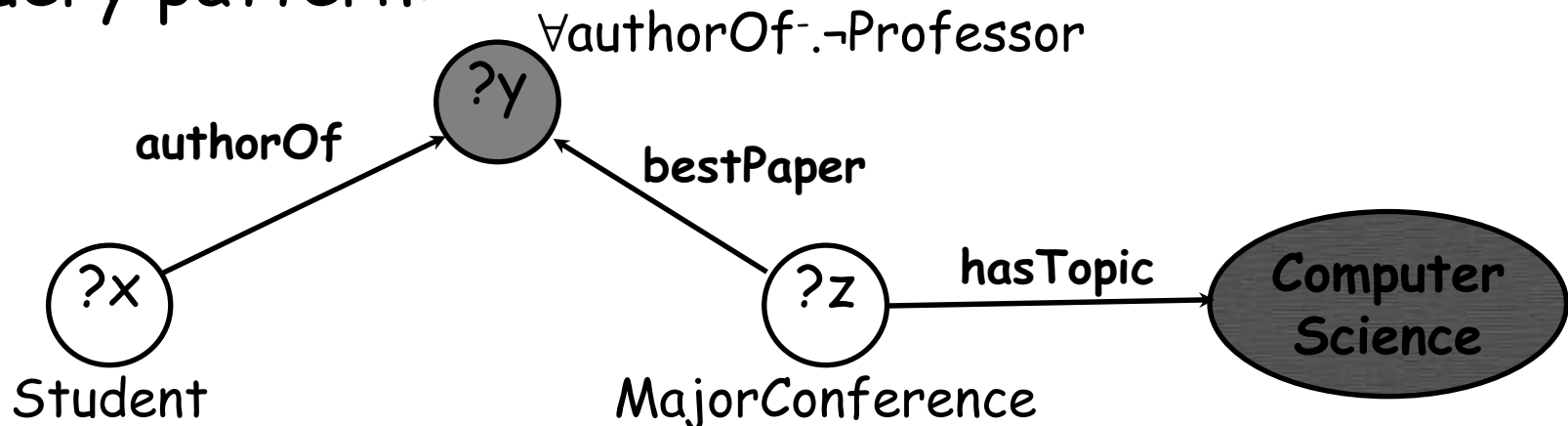
- Conjunctive Query Answering
- Justifications for entailments
- Extended datatype support
  - Reasoning with numeric or date/time intervals
- Extending DLs with rules
- Incremental reasoning
- Non-monotonic reasoning with K-operator
- Multi-ontology reasoning with E-connections

# Conjunctive Query Answering

- Find the students who won a best paper award in a major conference about computer science (and no professor is a co-author)

$q(?x, ?z)$ : Student(?x), authorOf(?x,?y),  
bestPaper(?z,?y), MajorConference(?z)  
hasTopic(?z, ComputerScience),  
( $\forall$ authorOf.¬Professor)(y)

- Query pattern:



# Query Answering

- Answers computed based on entailment relation
- Several different algorithms depending on
  - Existence of non-distinguished variables
  - Cycles in the query pattern
- Query optimizations (sometimes)
  - Query simplification
  - Cost-based analysis and query reordering
- Related to query subsumption (containment)

# SPARQL-DL

- SPARQL: Upcoming W3C recommendation
  - Geared towards querying RDF
  - Free-form graph matching
  - Harder to give semantics w.r.t.
- SPARQL-DL: SPARQL for OWL-DL
  - Extend conjunctive query language
  - Mixed ABox/TBox queries
  - Semantics based on OWL-DL entailment

# Uses of Pellet

- Ontology editing and management:
  - Bundled within Swoop, Protégé, TopBraid Composer
- Task Computing Environment (Fujitsu Labs)
- Explanation and impact analysis (NCI)
- Web Service discovery & composition (UMD, Univ. of Zurich, DFKI, DERI-WSML)
- Policy management & reasoning (C&P, Univ. of Stirling)
- Scalable query answering - ABox summarization (IBM)
- DRAGO distributed reasoner (ITC-IRST)
- KIIDS: The Knowledge-Intensive Interactive Digital Storytelling system (Univ. of Madrid)

# Links

- Download and give it a try:
  - <http://pellet.owldl.com>
- Give us feedback:
  - [pellet-users@owldl.com](mailto:pellet-users@owldl.com)
- Ask for commercial support:
  - [inquiries@clarkparsia.com](mailto:inquiries@clarkparsia.com)
- Other interesting stuff:
  - <http://www.clarkparsia.com>