

CMSC 671

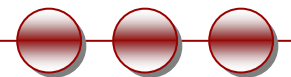
Fall 2010

Thu 10/28/10

Description Logics
Ontologies in OWL
Semantic Web

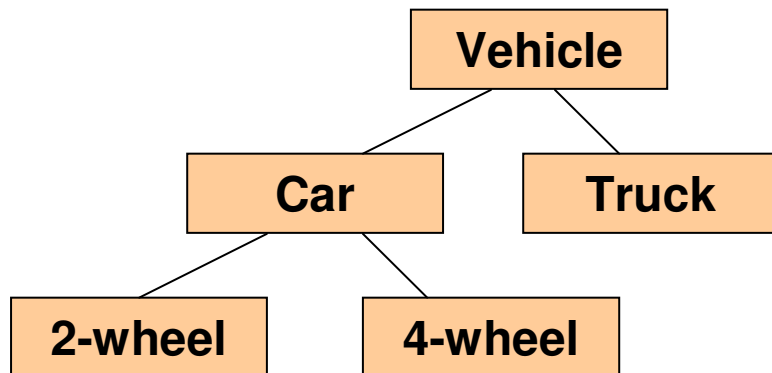
Prof. Laura Zavala, laura.zavala@umbc.edu, ITE 373, 410-455-8775

Some content on the slides has been taken from the tutorials at
<http://owl.cs.manchester.ac.uk/tutorials/protegeowl/tutorial/>



Ontologies

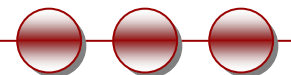
- Specification of a conceptualization
- Representations of concepts
- Explicit formal specifications of the terms in the domain and relations among them
- Usually represented as a type hierarchy



Why do we need an ontology

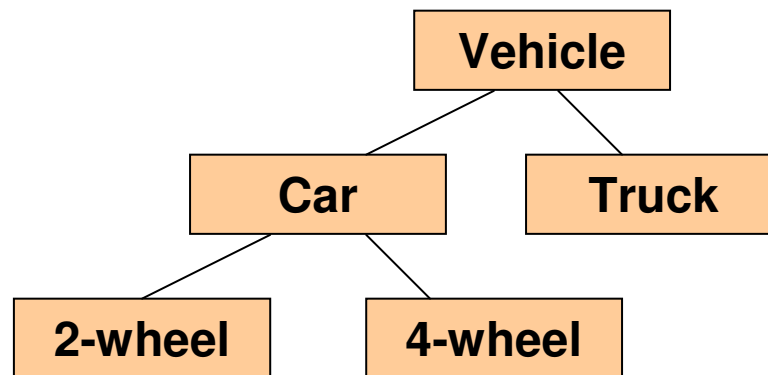


- To share common understanding of the structure of information among people or software agents
- To enable reuse of domain knowledge
- To make domain assumptions explicit
- To separate domain knowledge from the operational knowledge
 - We can merge, extend, and change
- To analyze domain knowledge



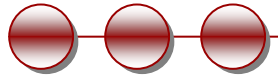
Description Logics

- Describe definitions and properties of categories
- Current systems take care to keep the languages simple, so that all inference can be done in polynomial time (in the number of objects)
 - ensuring tractability of inference

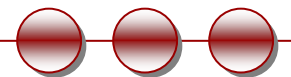


Description Logics (2)

- More expressive than propositional logic
- More efficient decision problems than first order predicate logic
- DL are of particular importance in providing a logical formalism for Ontologies and the Semantic Web



The Semantic Web: Means Many Things to Many People

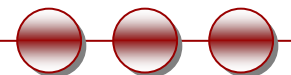




What is the Semantic Web?

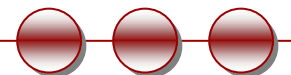
The **Semantic Web** is an evolving extension of the World Wide Web in which web content can be expressed not only in natural language, but also in a form that can be understood, interpreted and used by software agents, thus permitting them to find, share and integrate information more easily.

It derives from W3C director Tim Berners-Lee's vision of the Web as a universal medium for data, information, and knowledge exchange.

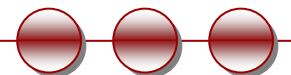
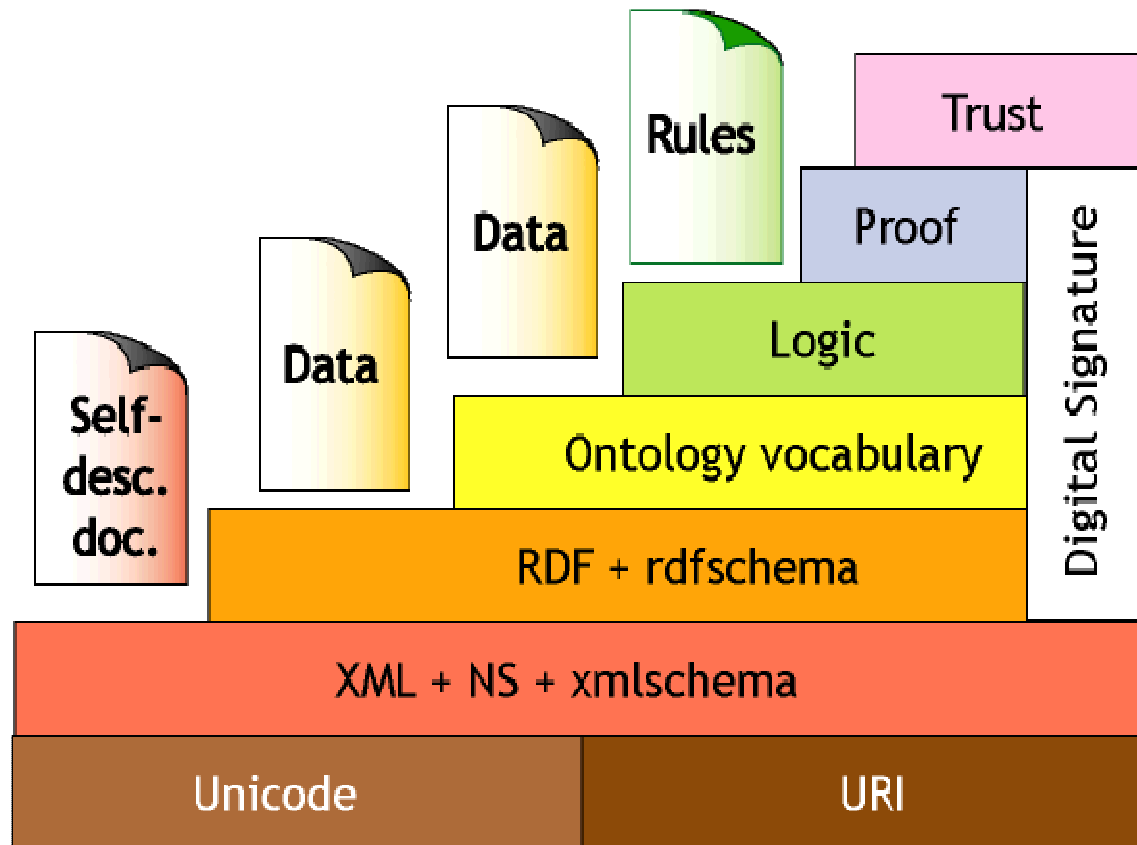


Semantic Web

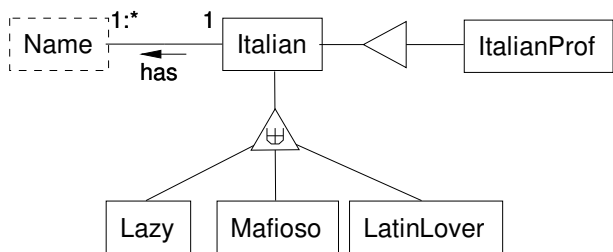
- A group of methods and technologies to allow machines to understand the meaning - or "semantics" - of information on the World Wide Web
 - Resource Description Framework (RDF)
 - ABox
 - Triple Stores
 - Allegro, OntoBroker, Sesame, Virtuoso, RDFBroker, Jena, ...
 - SPARQL is a protocol and query language for semantic web data sources (in RDF)
 - **Ontologies**
 - Web Ontology Language (OWL), RDFs, ...
 - TBox
 - Rule Engines or Systems (Forward Chaining and Backward Chaining)
 - Pellet, Jena, Fact, Fact++, SwetRules, Jess, RuleML, ...



The Layer Cake of the Semantic Web



Ontology Language ~ OSM/OWL



Lazy(x) => not ItalianProf(x)
ItalianProf(x) => not Lazy(x)
Mafioso(x) => not ItalianProf(x)
ItalianProf(x) => not Mafioso(x)

```
<owl:Ontology>
```

```
...
```

```
<owl:Class rdf:ID="Italian">
```

```
<owl:unionOf rdf:parseType="owl:collection">
```

```
<owl:Class ref:resource="#Lazy"/>
```

```
<owl:Class ref:resource="#Mafioso"/>
```

```
<owl:Class ref:resource="#LatinLover"/>
```

```
...
```

```
<owl:Restriction>
```

```
<owl:onProperty rdf:resource="#hasName"/>
```

```
<owl:minCardinality>
```

```
<rdf:datatype="&xsd:#nonNegativeInteger">1</...>
```

```
</owl:minCardinality>
```

```
<owl:maxCardinality>
```

```
...
```

```
<owl:Class rdf:ID="LatinLover">
```

```
<rdfs:subClassOf rdf:resource="#Italian"/>
```

```
<owl:disjointWith rdf:resource="#Lazy"/>
```

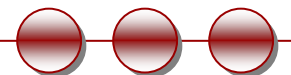
```
<owl:disjointWith rdf:resource="#Mafioso"/>
```

```
...
```

```
<owl:ObjectProperty rdf:ID="hasName">
```

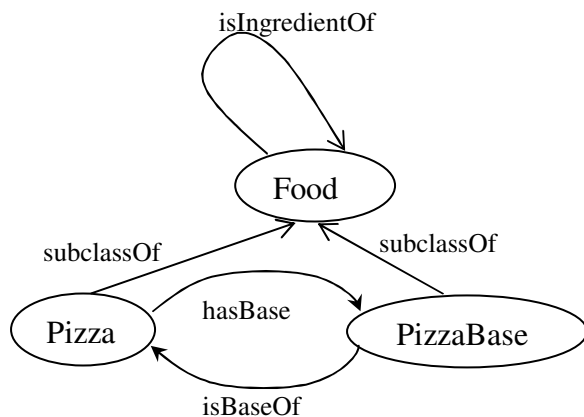
```
<rdfs:domain rdf:resource="#Italian"/>
```

```
<rdfs:range rdf:resource="#Name"/>
```



OWL Example: Pizza Ontology

- Ontologies in OWL are not trees, they are graphs.
 - They are not only a hierarchy of classes
 - They represent objects and relations about those objects (which includes subsumption relations, i.e. subclasses)

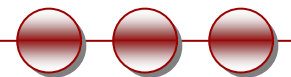


```
<owl:Class rdf:about="#Food"/>
```

```
<owl:Class rdf:about="#Pizza">  
  <rdfs:subClassOf rdf:resource="#Food"/>  
</owl:Class>
```

```
<owl:ObjectProperty rdf:about="#hasBase">  
  <rdf:type rdf:resource="#owl:FunctionalProperty"/>  
  <rdf:type rdf:resource="#owl:InverseFunctionalProperty"/>  
  <rdfs:domain rdf:resource="#Pizza"/>  
  <rdfs:range rdf:resource="#PizzaBase"/>  
  <rdfs:subPropertyOf rdf:resource="#hasIngredient"/>  
  <owl:inverseOf rdf:resource="#isBaseOf"/>  
</owl:ObjectProperty>
```

...



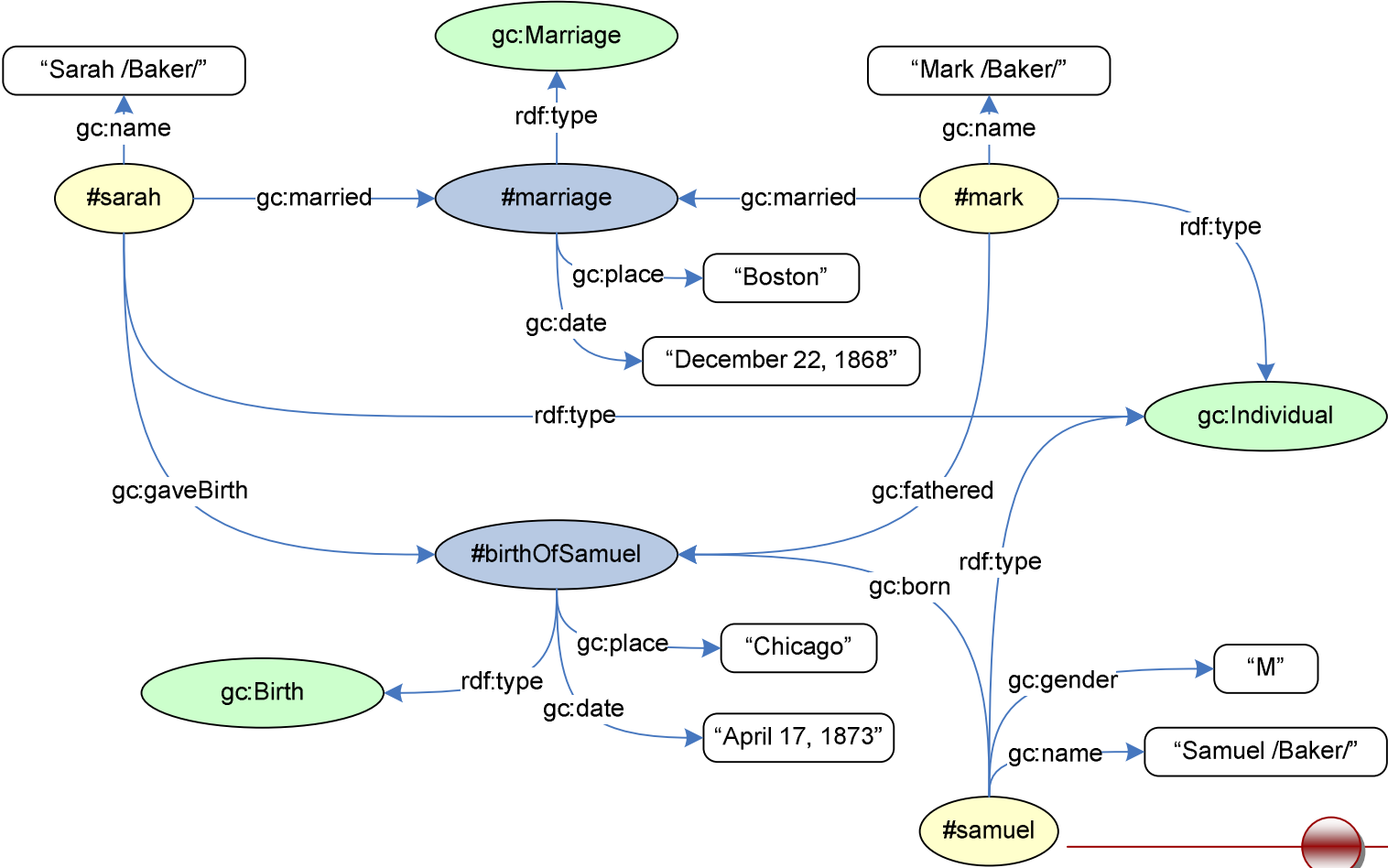
RDF & RDFS

- RDF (Resource Description Framework)
 - A triple model where every assertion is decomposed in three parts: (subject, predicate, object) for instance (tutorial.php, author, "Fabien").
 - The subject is a URI identifying a resource. The predicate is a binary relation identified by a URI. The object is either a URI identifying a resource or a literal value.
 - Each triple can be seen as a labeled arc and joining these arcs one obtains a graph that describes URI-identified resources and their relations.

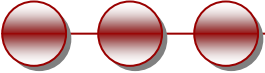
- RDFS (RDF Schema)
 - RDFS is a set of primitives to describe **lightweight ontologies**
 - RDFS allows us to:
 - name and declare a vocabulary (name resource types and binary relation types called properties);
 - specify the signature of properties (type of the domain i.e. type of the subject and type of the range i.e. type of the object);
 - specify the (multiple)-inheritance links between the types of classes (subClassOf);
 - specify the (multiple)-inheritance links between the types of properties (subPropertyOf);

RDF Graph

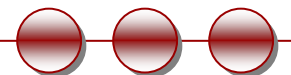
(How to think about RDF)



SPARQL

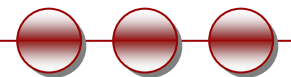
- 
- (An RDF Query Language)
 - Specifies queries over an RDF triple store
 - Schema for the triple store ([e.g. the Genealogy Core, gc](#))
 - Example: get names and, if available, gender and birthdate of people born in the 1880's.

```
SELECT ?Name ?Gender ?BirthDate
WHERE { ?IndividualURI gc:name ?Name .
        OPTIONAL { ?IndividualURI gc:gender ?Gender ;
                  gc:born ?Birth .
                  ?Birth gc:date ?BirthDate } .
        FILTER REGEX(?BirthDate, "188\\d") }
```

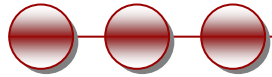


The dbpedia knowledge base

- **DBpedia** is a community effort to extract structured information from Wikipedia and to make this information available on the Web. DBpedia allows you to ask sophisticated queries against Wikipedia, and to link other data sets on the Web to Wikipedia data.



The dbpedia knowledge base



en.wikipedia.org/wiki/Obama

Barack Obama

From Wikipedia, the free encyclopedia
(Redirected from Obama)

"Barack" and "Obama" redirect here. For other uses, see Barack (disambiguation) and Obama (disambiguation).

Barack Hussein Obama II (/ɡˈbɑːrk huːseɪn oʊbɑːma/) is the 44th and current President of the United States. He is the first African American to hold the office. Obama previously served as a United States Senator from Illinois, from January 2005 until he resigned after his election to the presidency in November 2008.

A native of Honolulu, Hawaii, Obama is a graduate of Columbia University and Harvard Law School, where he was the president of the Harvard Law Review. He was a community organizer in Chicago before earning his law degree. He worked as a civil rights attorney in Chicago and taught constitutional law at the University of Chicago Law School from 1992 to 2004.

Obama served three terms in the Illinois Senate from 1997 to 2004. Following an unsuccessful bid against a Democratic incumbent for a seat in the U.S. House of Representatives in 2002, he ran for United States Senate in 2004.^[4] Several events brought him to national attention during the campaign, including his victory in the March 2004 Democratic primary and his keynote address at the Democratic National Convention in July 2004. He won election to the U.S. Senate in November 2004. His presidential campaign began in February 2007, and after a close campaign in the 2008 Democratic Party presidential primaries against Hillary Rodham Clinton, he won his party's nomination. In the 2008 general election, he defeated Republican nominee John McCain and was inaugurated as president on January 20, 2009.

As president, Obama signed economic stimulus legislation in the form of the American Recovery and Reinvestment Act in February 2009. Other domestic policy initiatives include the Patient Protection and Affordable Care Act, a major piece of health care reform legislation which he signed into law in March 2010, and the Dodd-Frank Wall Street Reform and Consumer Protection Act, which forms part of his financial regulatory reform efforts, which he signed in July 2010. In foreign policy, Obama gradually withdrew combat troops from Iraq, increased troop levels in Afghanistan, and signed an arms control treaty with Russia. On October 6, 2009, Obama was named the 2009 Nobel Peace Prize laureate.

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 - 1.1 Chicago community organizer and Harvard Law School
 - 1.2 University of Chicago Law School and civil rights attorney
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 - 2.1 State Senator: 1997–2004
 - 2.2 U.S. Senate campaign
 - 2.3 U.S. Senator: 2005–2008
 - 2.3.1 Legislation
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- 3 Presidential campaign: 2008
- 4 Presidency
 - 4.1 First days
 - 4.2 Domestic policy
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 - 4.2.2 Health care reform
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 - 4.3 Foreign policy
 - 4.3.1 Iraq War
 - 4.3.2 War in Afghanistan
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Early life and career

Main article: *Early life and career of Barack Obama*

Obama was born August 4, 1961, at Kapiolani Memorial & Gynecological Hospital in Honolulu, Hawaii.^{[5][6]} His mother, Stanley Ann Dunham, was born in Wichita, Kansas, of mostly English, some German,^{[7][8][9]} and Irish descent. His great-great-grandfather hailed from County Down.^[10] His father, Barack Obama, Sr., was a Luo from Nyangoma Kogelo, Nyanza Province, Kenya. Obama is the first President to have been born in Hawaii.^{[11][12]} Obama's parents met in 1960 in a Russian language class at the University of Hawaii.^{[13][14]} The couple married on February 2, 1961,^[15] but separated when Obama Sr. went to Harvard University on scholarship, and divorced in 1964.^[14] Obama Sr. remained and returned to Kenya, calling Barack in Hawaii only once, in 1971. He died in an automobile accident in 1982.^[16]


After her divorce, Dunham married Indonesian student Lolo Soetoro, who was attending college in Hawaii. When Suharto, a military leader in Soetoro's home country, came to power in 1967, all Indonesian students studying abroad were recalled, and the family moved to the Menteng neighborhood of Jakarta.^{[17][18]} From ages six to ten, Obama attended local schools in Jakarta, including Basuki Public School and St. Francis of Assisi School.^{[19][20]}

In 1971, Obama returned to Honolulu to live with his maternal grandparents, Madelyn and Stanley Annou Dunham, and attended Punahoa School, a private college preparatory school, from the fifth grade until his graduation from high school in 1978.^[21] Obama's mother returned to Hawaii in 1972, remaining there until 1977 when she went back to Indonesia to work as an anthropological field worker. She finally returned to Hawaii in 1994 and lived there for one year, before dying of ovarian cancer.^[22]

Of his early childhood, Obama recalled, "That my father looked nothing like the people around me—that he was black as pitch, my mother white as milk—barely registered in my mind."^[23] He described his struggles as a young adult to reconcile social perceptions of his multiracial heritage.^[24] Reflecting later on his formative years in Honolulu, Obama wrote: "The opportunity that Hawaii offered—to experience a variety of cultures in a climate of mutual respect—became an integral part of my world view, and a basis for the values that I hold most dear."^[25] Obama has also written and talked about using alcohol, marijuana and cocaine during his teenage years to "push questions of who I was out of my mind."^[26] At the 2008 Civil Forum on the Presidency, Obama identified his high-school drug use as his "greatest moral failure."^[27]

Following high school, Obama moved to Los Angeles in 1979 to attend Occidental College.^[28] In February 1981, he made his first public speech, calling for Cooden's divestment from South Africa.^[29] In mid-1981, Obama traveled to Indonesia to visit his mother and sister Maya, and visited the families of college friends in India and Pakistan for three weeks.^[30]

Barack Obama



44th President of the United States

Incumbent

Assumed office
January 20, 2009
1 year, 261 days

Vice President: Joe Biden

Preceded by: George W. Bush

United States Senator from Illinois

In office
January 3, 2005 – November 16, 2008

Preceded by: Peter Fitzgerald
Succeeded by: Roland Burris

Member of the Illinois Senate from the 13th district

In office
January 5, 1997 – November 4, 2004

Preceded by: Alice Palmer
Succeeded by: Kwame Raouf

Born
August 4, 1961 (age 49)^[1]
Honolulu, Hawaii^[2]

Political party: Democratic

Spouse(s): Michelle Robinson Obama

Children: Malia, Sasha

Residence: White House (Official)
Chicago, Illinois (Private)

Alma mater: Occidental College
Columbia University (B.A.)
Harvard Law School (J.D.)

Occupation: Community organizer
Lawyer
Constitutional law professor
Author

Dbpedia: knowledge extracted from Wikipedia Infoboxes

Barack Obama



44th President of the United States
Incumbent
Assumed office
January 20, 2009
1 year, 281 days
Vice President Joe Biden
Preceded by George W. Bush

United States Senator from Illinois
In office
January 3, 2005 – November 16, 2008
Preceded by Peter Fitzgerald
Succeeded by Roland Burris

Member of the Illinois Senate from the 13th district
In office
January 8, 1997 – November 4, 2004
Preceded by Alice Palmer

Jon Bon Jovi



Jon Bon Jovi, 2007

Background information

Birth name John Francis Bongiovi, Jr.
Also known as Jon Bon Jovi
Born March 2, 1962 (age 48)
Perth Amboy, New Jersey,
Genres Hard rock, glam metal, country rock, Rock
Occupations Musician, songwriter, actor, philanthropist, producer
Instruments Vocals, guitar, piano, harmonica, drums, percussion instruments, harp, bass guitar, banjo, french horn, trumpet, trombone, clarinet, cello
Years active 1978–present
Labels Island, Mercury
Associated acts Bon Jovi, Southside Johnny & The Asbury Jukes, Skid Row
Website <http://www.bonjovi.com>

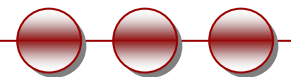


Theatrical poster

Directed by David Fincher
Produced by David Fincher
Scott Rudin
Kevin Spacey
Dana Brunetti
Michael De Luca
Ceán Chaffin
Screenplay by Aaron Sorkin
Based on *The Accidental Billionaires* by Ben Mezrich
Starring Jesse Eisenberg
Andrew Garfield
Justin Timberlake
Brenda Song
Rooney Mara
Armie Hammer
Max Minghella
Music by Trent Reznor
Atticus Ross
Cinematography Jeff Cronenweth

The dbpedia knowledge base

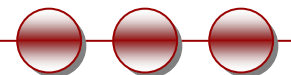
- The DBpedia data set uses a large multi-domain ontology which has been derived from Wikipedia.
- The DBpedia data set currently describes 3.4 million “things” with over 1 billion “facts” (March 2010).





Querying dbpedia

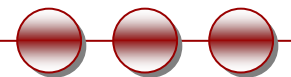
- SPARQL
- Example queries
 - All soccer players, who played as goalkeeper for a club that has a stadium with more than 40.000 seats and who are born in a country with more than 10 million inhabitants
 - People who were born in Berlin before 1900
 - German musicians with German and English descriptions
 - German musicians who were born in Berlin
 - French films
 - First-person shooter computer games
 - Luxury cars
- <http://wiki.dbpedia.org/OnlineAccess>





Querying dbpedia

- You write your queries and try them at some public endpoint
 - <http://DBpedia.org/sparql>
 - <http://DBpedia.org/snorql>
- You can use some SPARQL query builder, e.g. <http://querybuilder.dbpedia.org/>



Querying dbpedia

- French Films

```
SELECT ?film
```

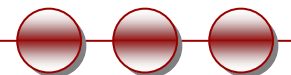
```
WHERE
```

```
{ ?film skos:subject  
  <http://dbpedia.org/resource/Category:French_films>  
}
```


Other semantic data initiatives

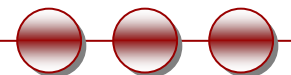


- Freebase
- GeoNames
- Data.gov
 - *An Official Web Site of the United States Government*
 - Is now hosting one of the largest open collections of RDF datasets in the world!



OWL: Web Ontology Language

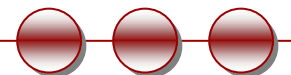
- Part of the  Semantic Web Framework
- Explicit semantics for reasoning about systems of categories.
- Open World
- Different Flavours
 - Lite, DL, Full
 - EL, QL, RL
- Several Common Representations (syntax)
 - XML, N3, Abstract Syntax





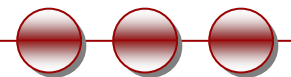
OWL and RDF

- Resource Description Framework (RDF)
 - Describes a graph of nodes and arcs, each normally identified by a URI
 - RDF statements are triples
 - subject → predicate → object
 - Myhouse → isLocatedIn → Maryland
 - Maryland → isA → State
 - Semantics are limited and use is unconstrained compared to OWL



OWL and RDFS

- RDF Schema (RDFS)
 - Adds the notion of classes to RDF
 - Allows hierarchies of classes and properties
 - OWL has the same interpretation of some RDFS statements (subsumption, domain, and range)



OWL RDF/XML Syntax

- Several Common Representations (syntax)
 - XML, N3, Abstract Syntax

```
<owl:Class rdf:ID="SpicyPizza">
  <rdfs:label xml:lang="pt">PizzaTemperada</rdfs:label>
  <rdfs:comment xml:lang="en">Any pizza that has a spicy topping is a SpicyPizza</rdfs:comment>
  <owl:equivalentClass>
    <owl:Class>
      <owl:intersectionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#Pizza"/>
        <owl:Restriction>
          <owl:onProperty>
            <owl:ObjectProperty rdf:about="#hasTopping"/>
          </owl:onProperty>
          <owl:someValuesFrom rdf:resource="#SpicyTopping"/>
        </owl:Restriction>
      </owl:intersectionOf>
    </owl:Class>
  </owl:equivalentClass>
</owl:Class>
```

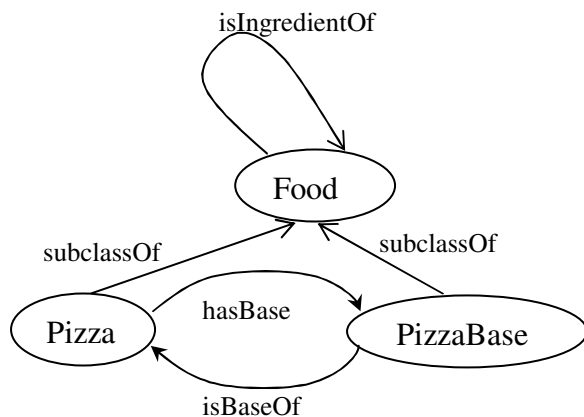
- class inclusion (**SubClassOf**)
- class equivalence (**EquivalentClasses**)
- class disjointness (**DisjointClasses**)
- object property inclusion (**SubObjectPropertyOf**) with or without property chains, and data property inclusion (**SubDataPropertyOf**)
- property equivalence (**EquivalentObjectProperties** and **EquivalentDataProperties**),
- transitive object properties (**TransitiveObjectProperty**)
- reflexive object properties (**ReflexiveObjectProperty**)
- domain restrictions (**ObjectPropertyDomain** and **DataPropertyDomain**)
- range restrictions (**ObjectPropertyRange** and **DataPropertyRange**)
- assertions (**SameIndividual**, **DifferentIndividuals**, **ClassAssertion**, **ObjectPropertyAssertion**, **DataPropertyAssertion**, **NegativeObjectPropertyAssertion**, and **NegativeDataPropertyAssertion**)
- functional data properties (**FunctionalDataProperty**)
- keys (**HasKey**)

OWL Reasoning

- Reasoners are used to infer information that is not explicitly contained in the ontology
 - Consistency checking
 - Subsumption checking
 - Equivalence checking
 - Instantiation Checking
- Protégé
 - Fact++, Pellet, Racer, Kaon2

OWL Example: Pizza Ontology

- Ontologies in OWL are not trees, they are graphs.
 - They are not only a hierarchy of classes
 - They represent objects and relations about those objects (which includes subsumption relations, i.e. subclasses)

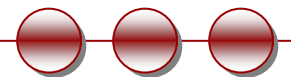


```
<owl:Class rdf:about="#Food"/>
```

```
<owl:Class rdf:about="#Pizza">
  <rdfs:subClassOf rdf:resource="#Food"/>
</owl:Class>
```

```
<owl:ObjectProperty rdf:about="#hasBase">
  <rdf:type rdf:resource="#owl:FunctionalProperty"/>
  <rdf:type rdf:resource="#owl:InverseFunctionalProperty"/>
  <rdfs:domain rdf:resource="#Pizza"/>
  <rdfs:range rdf:resource="#PizzaBase"/>
  <rdfs:subPropertyOf rdf:resource="#hasIngredient"/>
  <owl:inverseOf rdf:resource="#isBaseOf"/>
</owl:ObjectProperty>
```

...



Protégé + OWL

The screenshot displays the Protégé OWL editor interface for a pizza ontology. The window title is "pizza.owl (http://www.co-ode.org/ontologies/pizza/pizza.owl) - [C:\Users\Laura\Desktop\CMSC\pizzaCMSC671.owl]". The menu bar includes File, Edit, Ontologies, Reasoner, Tools, Refactor, Tabs, View, Window, and Help. The toolbar shows navigation and search icons. The main interface is divided into several panes:

- Active Ontology:** Shows the current ontology file.
- Classes:** Displays the "Asserted class hierarchy" for PizzaBase, showing a tree structure: Thing (parent) -> Food (child) -> Pizza (child) -> PizzaBase (child) -> DeepPanBase (child) -> ThinAndCrispyBase (child) -> PizzaTopping (child).
- Text Outline Tree:** Shows the "Text Outline Tree: (all properties) PizzaBase" with checkboxes for "Show min 0", "Show inherited", and "Show asserted (for all nodes)".
- Usage:** Shows the "Usage: PizzaBase" with checkboxes for "this", "disjoints", and "named sub/superclasses". It lists properties: PizzaTopping (disjointWith PizzaBase), ThinAndCrispyBase (subclassOf PizzaBase), hasBase (range PizzaBase), and isBaseOf (domain PizzaBase).
- Object Properties:** Shows the "Object properties: hasBase" with checkboxes for "hasIngredient", "hasBase", "hasTopping", "isIngredientOf", and "isBaseOf".
- Characteristics:** Shows the "Characteristics: has" with checkboxes for Functional, Inverse functional, Transitive, Symmetric, and Asymmetric.
- Description:** Shows the "Description: hasBase" with domains (Intersection) and ranges (Intersection) for Pizza and PizzaBase.