

Knowledge-Based Systems

Summary (Ontology Part)

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Lecture Outline

- Knowledge Based Systems
 - What and Why
 - Applications and Further Challenges
 - Lifecycle of KBS
- **The TrOWL Award Announcement**
- Exam



Knowledge-Based Systems

- A knowledge-based system (KBS) is:
 - a program;
 - capable of making use of knowledge about certain domain(s) to make inference;
 - with a view to solving problems and giving advice.
- Sometimes knowledge bases also known as Semantic databases

RDB → RDF

- An RDF statement is a data unit with global and linkable ids for data and schema

| Student ID | Name | take-course |
|------------|------|-------------|
| p001 | John | cs3019 |
| p002 | Tom | cs3023 |

- [csd:p001 rdf:type csd:Student.]
- [csd:p002 rdf:type csd:Student.]
- [csd:p001 csd:name "John".]
- [csd:p002 csd:name "Tom".]
- [csd:p001 csd:take-course csd:cs3019.]
- [csd:p002 csd:take-course csd:cs3023.]

Schema in a Database System

- A database system includes some schema constraints, such as the foreign key constraint

| Student ID | Name | take-course |
|------------|------|-------------|
| p001 | John | cs3015 |
| p002 | Tom | cs3025 |

| Course ID | Title | coordinator |
|-----------|-------|-------------|
| cs3017 | AIS | AS |
| cs3025 | KBS | JP |

Schema in a Knowledge Based System

- 1) Allow schema constraints, such as **DisjointClasses**
(UndgStudent MastStudent)

| UndgStudent ID | Name | take-course |
|----------------|------|-------------|
| csd:p001 | John | csd:cs3014 |
| csd:p002 | Tom | csd:cs3025 |

| MastStudent ID | Name | take-course |
|----------------|------|-------------|
| csd:p008 | Yuan | csd:cs5010 |
| csd:p002 | Tom | csd:cs5017 |

Schema in a Knowledge Based System

2) Allow some reasoning based on axioms (open world assumption), such as **SubClassOf (MastStudent Student)**

| Student ID | Name | take-course |
|------------|------|-------------|
| csd:p001 | John | csd:cs3015 |
| csd:p002 | Tom | csd:cs3025 |

| MastStudent ID | Name | take-course |
|----------------|------|-------------|
| csd:p008 | Yuan | csd:cs5010 |
| csd:p002 | Tom | csd:cs5017 |

thus all the students include csd:p001, csd:p002, and csd:p008

rdf:range and Foreign Key: Revisit

- They are quite similar but not exactly the same,
 - due to the difference between open and closed world assumptions

| Student ID | Name | take-course |
|------------|------|-------------|
| p001 | John | cs3015 |
| p002 | Tom | cs3025 |

| Course ID | Title | coordinator |
|-----------|-------|-------------|
| cs3017 | AIS | AS |
| cs3025 | KBS | JP |

- Semantics of rdfs:range ([rdfs3])
 - $[p \text{ rdfs:range } D .] [a \text{ } p \text{ } b .] \Rightarrow [b \text{ rdf:type } D .]$

How about Primary Key

- RDF is NOT expressive enough to represent primary key
- We need OWL (Web Ontology Language) for that
- Example with Friend Of a Friend (Foaf) ontology
 - foaf:OnlineAccount **owl:hasKey**
(foaf:accountName
foaf:accountServiceHomepage)

Why Knowledge Bases



- Using an open world assumption
- There is a semantic gap between data and queries
- Knowledge bases used to store knowledge and experience
 - Many well-known ontology
 - E.g. SNOMED CT
 - Semantic applications populate terminologies with data
 - E.g. Chintan Patel et al (SWJ2007) populated SMOMED CT with 59 million ABox assertions.

Scalable Solution: Olympic 2012 web site

SPORT OLYMPICS

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Olympics ▶ London 2012 | Beijing 2008

19 October 2012 Last updated at 21:04



GB can 'sustain success' in Rio

UK Sport's new performance director Simon Timson says Team GB can repeat their London 2012 success at the 2016 Rio Games.



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ATHLETICS
[Bolt aims to defend sprint titles in Rio](#)

ATHLETICS
[Pole vaulter Dennison ends career](#)

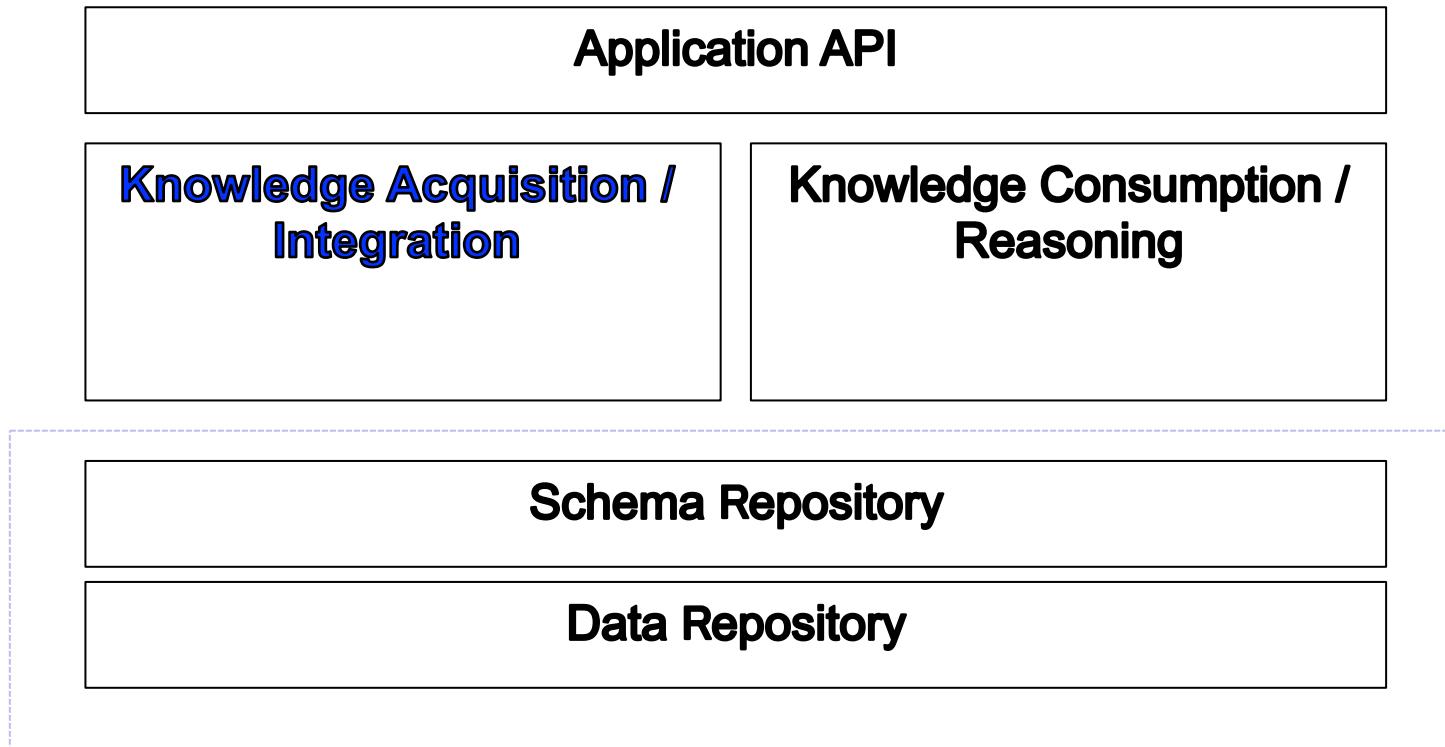
TAEKWONDO
[Cook considers nationality switch](#)

[Woodward decides to quit BOA role](#)

Relive every GB Olympics medal



Architecture of Knowledge Based Systems



Course Roadmap

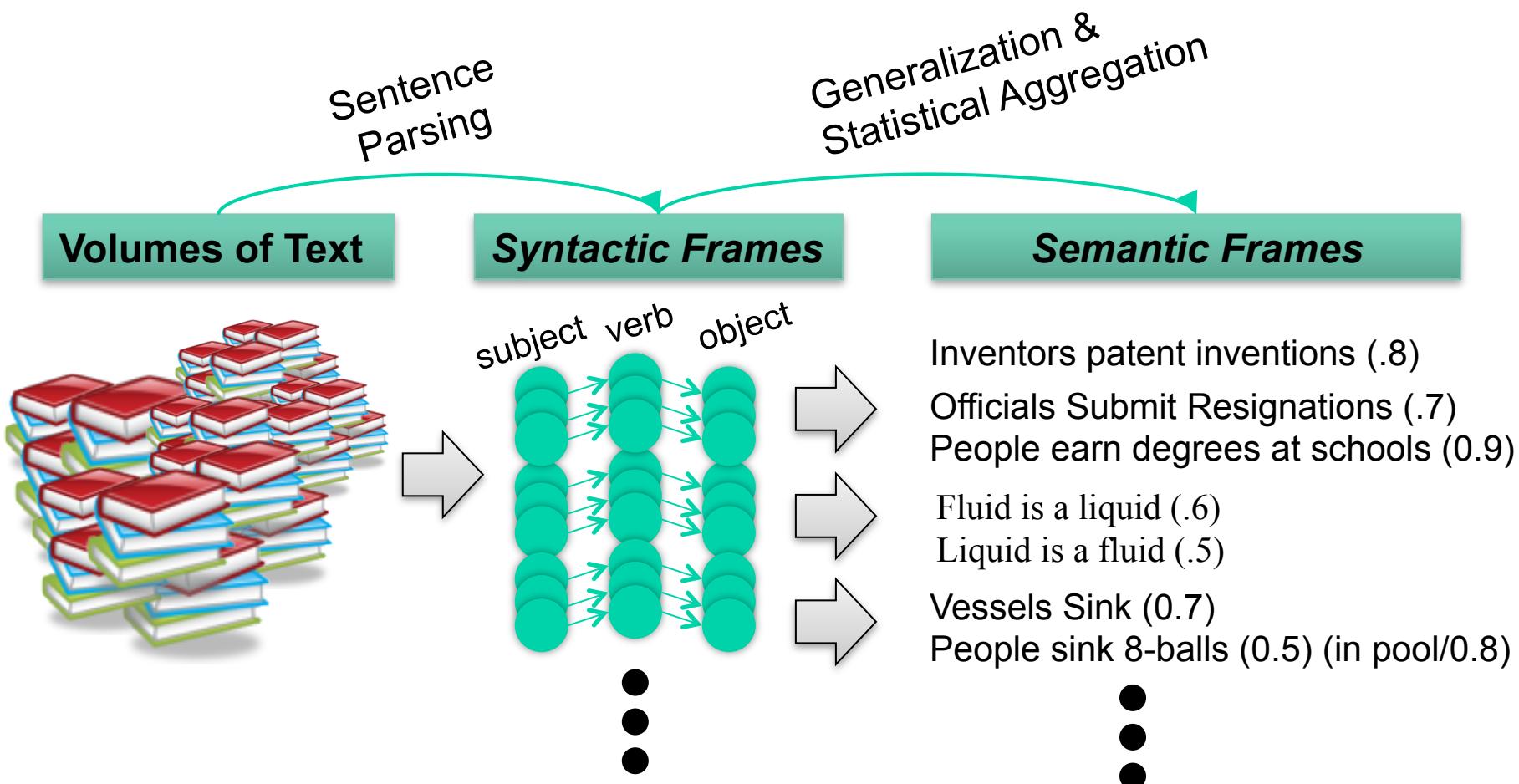


- Foundation
 - KR, ontology and rule; set theory
- Knowledge capture
- Knowledge representation
 - Ontology: Semantic Web standards RDF and OWL, Description Logics
 - Rule: Jess
- Knowledge reasoning
 - Ontology: formal semantics, tableaux algorithm
 - Rule: forward chaining, backward chaining
- Knowledge reuse and evaluation
- Meeting the real world
 - Jess and Java, Jess Efficiency, Invited talk

Interview: Knowledge Capture

- Unstructured interview
 - No detailed agenda
 - Few constraints
 - Delivers diverse, incomplete data
- Structured interview
 - Knowledge engineer plans and directs the session
 - Takes form of provider-elicitor dialogue
 - Delivers more focused expertise data

Automatic Learning for Watson



[Slide Credit: Joel Farrell]

Microsoft®
Research

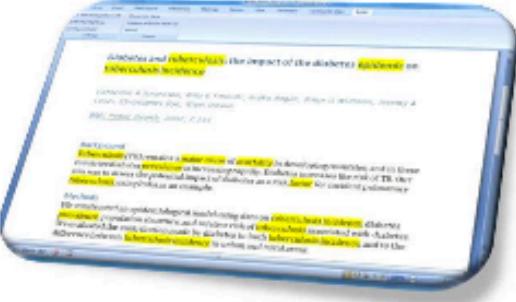
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Ontology Add-in for Word



Microsoft Research Connections' goal with this project is to enable communities who maintain ontologies to more easily experiment and to enhance the experience of authors who use Microsoft Word for content creation, incorporating semantic knowledge into the content.

This add-in should simplify the development and validation of ontologies, by making ontologies more accessible to a wide audience of authors and by enabling semantic content to be integrated in the authoring experience, capturing the author's intent and knowledge at the source, and facilitating downstream discoverability.

The goal of the add-in is to assist scientists in writing a manuscript that is easily integrated with existing and pending electronic resources. The major aims of this project are to add semantic information as XML mark-up to the manuscript using

CURIOS: OWL Adaptor for CMS

Domain ontology



LDCMS configuration (in php)

Knowledge-Base
Jeff Z. Pan

Screenshot of the CMS configuration interface showing the 'Person' display settings:

- DISPLAYS:** Master, Listing (selected), Details, Images, +Add.
- TITLE:** Title: People
- FORMAT:** Format: Table | Settings
- FIELDS:**
 - Person: URI (URI)
 - Person: dc:title (Title)
 - Person: dc:description (Description)
 - Person: HasFile (Files)
- FILTER CRITERIA:** Person: dc:title (~=(string))
- SORT CRITERIA:**

PAGE SETTINGS:

- Path: /people
- Menu: Normal: People
- Access: None
- HEADER:** Global: Text area
- FOOTER:**
- PAGER:** Use pager: Full | Paged, 20 items

EXPOSED FORM:

- Exposed form in block: No
- Exposed form style: Basic | Settings

OTHER:

- Machine Name: listing
- Comment: No comment

People

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed tempor, nisi id ultrices feugiat, enim eros auctor massa, et dictum lectus lorem mollis neque.

Search People Items per page: 20 Search

| Title | Description | Files |
|--------------------|--|-------|
| Catherine Gillies | Catherine, born in 1857, was a daughter of John and Ann nee Macaulay who moved from Boston to settle at Kirkhost. She was unmarried | |
| Margaret Mackay | MArgaret born c1761 was married to Donald Mackay and lived in Callanish; with issue. In 1841 she is enumerated (presumably a widow) with her daughter at 14 Kneep. | |
| Lewis Macleod | John was born at Jubilee, Cape Breton to Donald and Jessie nee MacIntchie. After his marriage to Christine nee Mackay from Whycocomagh they may have settled at Baddeck as their... | |
| John Macdonald | John Macdonald (1908-1981), son of Colin Macdonald and Mary Ferguson, 12 Keose was residing at 4 Marchmont Terrace, Glasgow when he married Annabella Macleod who had connections... | true |
| Alex Dan Mackinnon | Alex Dan was the son of Alexander Mackinnon and Mary Ann Macleod, 1 Garryard. He was unmarried. Alex served with the Royal Naval Patrol Service during the Second World War. | true |
| Joan Morrison | Joan Morrison was born to 9 Calbot and Laxdale; she married Norman Mackay (son of Donald, Upper Barvas) and both were school teachers in Stornoway. Their children were Margaret... | |
| Murdo Macleod | Murdo Macleod was born 1890 to 3 Calbot; he died an infant. | |
| Mary Maclean | Mary, born c1821, was a daughter of Angus and Isabella nee Macaulay, Uigean. She was married to Neil Mackay from Vallos; they settled in North Shawbost; with issue. | |
| Catherine Smith | Catherine (1883-1956) daughter of Malcolm Smith and Marion Macleod, 2 Balallan married Donald Mackinnon, 8 Ranish. | |
| Mary | Mary, born in 1873, was a daughter of John and Catherine nee Ferguson, No 1 Harkdale. She | |

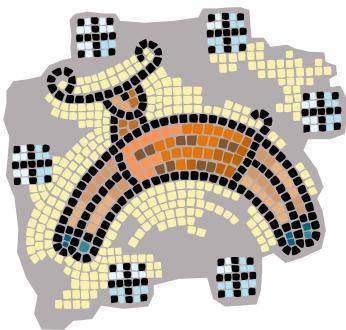
Competency Question

- A typical CQ: Which pizza has some cheese topping?
- When building an ontology, it is less important what the answer is
 - The ontology can be extended and modified so the answer is not final
- More importantly is whether the CQ can be answered meaningfully
 - The ability to ***answer CQs meaningfully*** can be regarded as a functional requirement of the ontology

Knowledge Representation: RDF and OWL

- RDF (Resource Description Framework)
 - Modern version of semantic network
 - Basic building block: Subject-property-value triple
 - Modern version of Semantic Network
 - Syntax (**exam only requires the use of N3 syntax**)
 - XML
 - Notation 3 (N3) syntax: [Jeff teach CS3025 .]
- OWL (Web Ontology Language)
 - More expressive power, such as
 - Disjointness of classes
 - **DisjointClasses** (csd:Male csd:Female)
 - Equivalent individuals
 - **SameIndividual** (csd:jpan w3:jpan)
 - Boolean combination of classes
 - **Class** (Person complete unionOf (csd:Male csd:Female))
 - Well known techniques for transforming semantic networks to ontologies
 - Based on Description Logics (**DL tables will be provided in the exam**)

DL Exercise



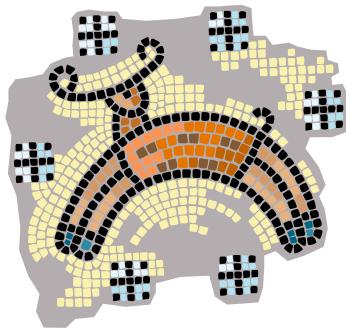
Q: Write down the following OWL axioms
in DL syntax

1. ObjectProperty (eats domain (Animal)
range (LivingThing))

2. ObjectProperty (owns domain (Person)
range (intersectionOf (LivingThing
complementOf (Person))))

Interpretations of Axioms

DL Exercise



Q: Write down the following OWL axioms
in DL syntax

ObjectProperty(R super(R_1) ... super(R_n)
domain(C_1) ... domain(C_k)
range(C_1) ... range(C_h)

$R \sqsubseteq R_i$
 $\geq 1R \sqsubseteq C_i$
 $T \sqsubseteq \forall R.C_i$

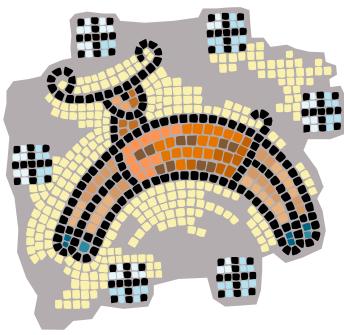
1. ObjectProperty (eats domain (Animal)
range (LivingThing))

$\geq 1 \text{ eat} \sqsubseteq \text{Animal}$
 $T \sqsubseteq \forall \text{eat}.\text{LivingThing}$

Interpretations of Descriptions

| Abstract Syntax | DL Syntax | Semantics |
|---|--------------------------|--|
| Class(A) | A | $A^{\mathcal{I}} \subseteq \Delta^{\mathcal{I}}$ |
| Class(owl:Thing) | T | $T^{\mathcal{I}} = \Delta^{\mathcal{I}}$ |
| Class(owl:Nothing) | \perp | $\perp^{\mathcal{I}} = \emptyset$ |
| intersectionOf(C_1, C_2, \dots) | $C_1 \sqcap C_2$ | $(C_1 \sqcap C_2)^{\mathcal{I}} = C_1^{\mathcal{I}} \cap C_2^{\mathcal{I}}$ |
| unionOf(C_1, C_2, \dots) | $C_1 \sqcup C_2$ | $(C_1 \sqcup C_2)^{\mathcal{I}} = C_1^{\mathcal{I}} \cup C_2^{\mathcal{I}}$ |
| complementOf(C) | $\neg C$ | $(\neg C)^{\mathcal{I}} = \Delta^{\mathcal{I}} \setminus C^{\mathcal{I}}$ |
| oneOf(o_1, o_2, \dots) | $\{o_1\} \sqcup \{o_2\}$ | $(\{o_1\} \sqcup \{o_2\})^{\mathcal{I}} = \{o_1^{\mathcal{I}}, o_2^{\mathcal{I}}\}$ |
| restriction(R someValuesFrom(C)) | $\exists R.C$ | $(\exists R.C)^{\mathcal{I}} = \{x \mid \exists y. \langle x, y \rangle \in R^{\mathcal{I}} \wedge y \in C^{\mathcal{I}}\}$ |
| restriction(R allValuesFrom(C)) | $\forall R.C$ | $(\forall R.C)^{\mathcal{I}} = \{x \mid \forall y. \langle x, y \rangle \in R^{\mathcal{I}} \rightarrow y \in C^{\mathcal{I}}\}$ |
| restriction(R hasValue(o)) | $\exists R.\{o\}$ | $(\exists R.\{o\})^{\mathcal{I}} = \{x \mid \langle x, o^{\mathcal{I}} \rangle \in R^{\mathcal{I}}\}$ |
| restriction(R minCardinality(m)) | $\geq mR$ | $(\geq mR)^{\mathcal{I}} = \{x \mid \#\{y. \langle x, y \rangle \in R^{\mathcal{I}}\} \geq m\}$ |
| restriction(R maxCardinality(m)) | $\leq mR$ | $(\leq mR)^{\mathcal{I}} = \{x \mid \#\{y. \langle x, y \rangle \in R^{\mathcal{I}}\} \leq m\}$ |
| restriction(T someValuesFrom(u)) | $\exists T.u$ | $(\exists T.u)^{\mathcal{I}} = \{x \mid \exists t. \langle x, t \rangle \in T^{\mathcal{I}} \wedge t \in u^{\mathbf{D}}\}$ |
| restriction(T allValuesFrom(u)) | $\forall T.u$ | $(\forall T.u)^{\mathcal{I}} = \{x \mid \exists t. \langle x, t \rangle \in T^{\mathcal{I}} \rightarrow t \in u^{\mathbf{D}}\}$ |
| restriction(T hasValue(w)) | $\exists T.\{w\}$ | $(\exists T.\{w\})^{\mathcal{I}} = \{x \mid \langle x, w^{\mathbf{D}} \rangle \in T^{\mathcal{I}}\}$ |
| restriction(T minCardinality(m)) | $\geq mT$ | $(\geq mT)^{\mathcal{I}} = \{x \mid \#\{t \mid \langle x, t \rangle \in T^{\mathcal{I}}\} \geq m\}$ |
| restriction(T maxCardinality(m)) | $\leq mT$ | $(\leq mT)^{\mathcal{I}} = \{x \mid \#\{t \mid \langle x, t \rangle \in T^{\mathcal{I}}\} \leq m\}$ |
| ObjectProperty(S) | S | $S^{\mathcal{I}} \subseteq \Delta^{\mathcal{I}} \times \Delta^{\mathcal{I}}$ |
| ObjectProperty(S' inverseOf(S)) | S^- | $(S^-)^{\mathcal{I}} \subseteq \Delta^{\mathcal{I}} \times \Delta^{\mathcal{I}}$ |
| DatatypeProperty(T) | T | $T^{\mathcal{I}} \subseteq \Delta^{\mathcal{I}} \times \Delta_D$ |

DL Exercise



Q: Write down the following OWL axioms in DL syntax

| | |
|---|-------------------------------|
| $\text{ObjectProperty}(R \text{ super}(R_1) \dots \text{super}(R_n))$ | $R \sqsubseteq R_i$ |
| $\text{domain}(C_1) \dots \text{domain}(C_k)$ | $\geq 1 R \sqsubseteq C_i$ |
| $\text{range}(C_1) \dots \text{range}(C_h)$ | $T \sqsubseteq \forall R.C_i$ |
| | |
| $\text{intersectionOf}(C_1, C_2, \dots)$ | $C_1 \sqcap C_2$ |
| $\text{unionOf}(C_1, C_2, \dots)$ | $C_1 \sqcup C_2$ |
| $\text{complementOf}(C)$ | $\neg C$ |

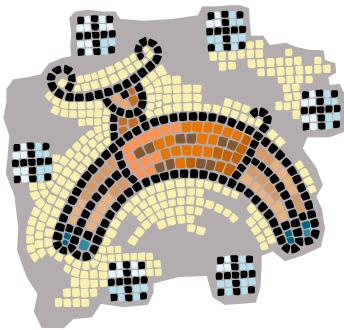
2. $\text{ObjectProperty} (\text{owns domain (Person)} \\ \text{range (intersectionOf (LivingThing} \\ \text{complementOf (Person))))}$

$\geq 1 \text{own} \sqsubseteq \text{Person}$

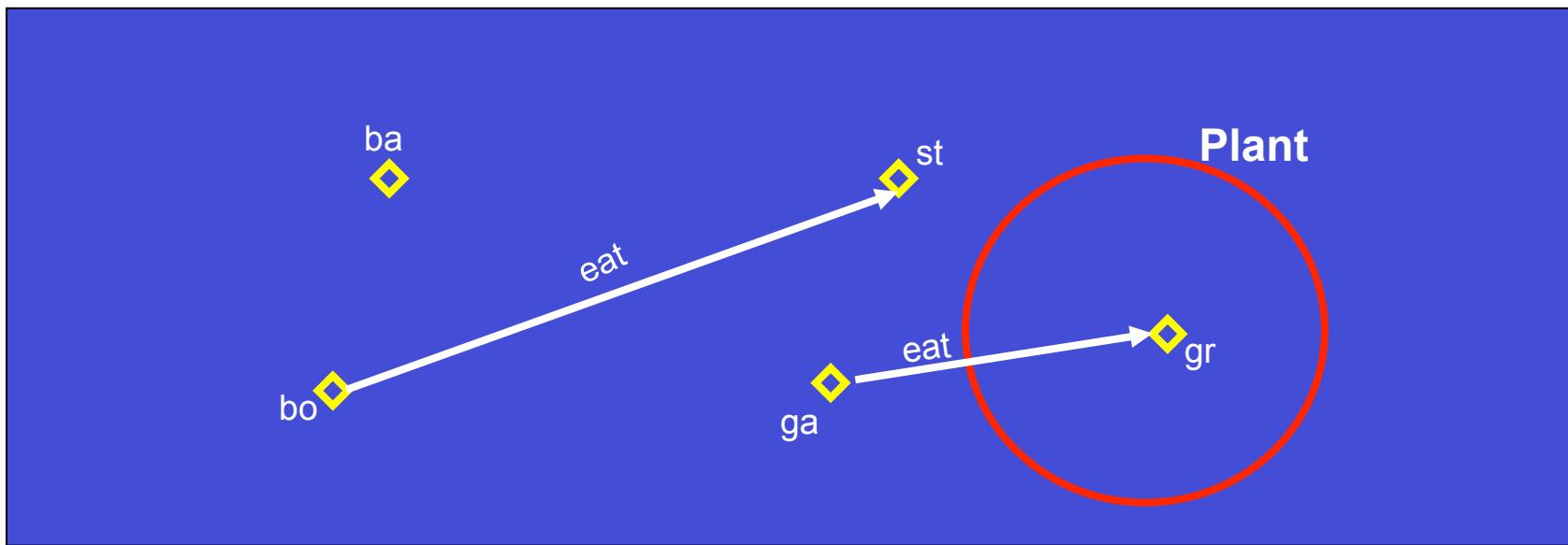
$T \sqsubseteq \forall \text{eat.}(\text{LivingThing} \sqcap \neg \text{Person})$

Understanding DL Semantics

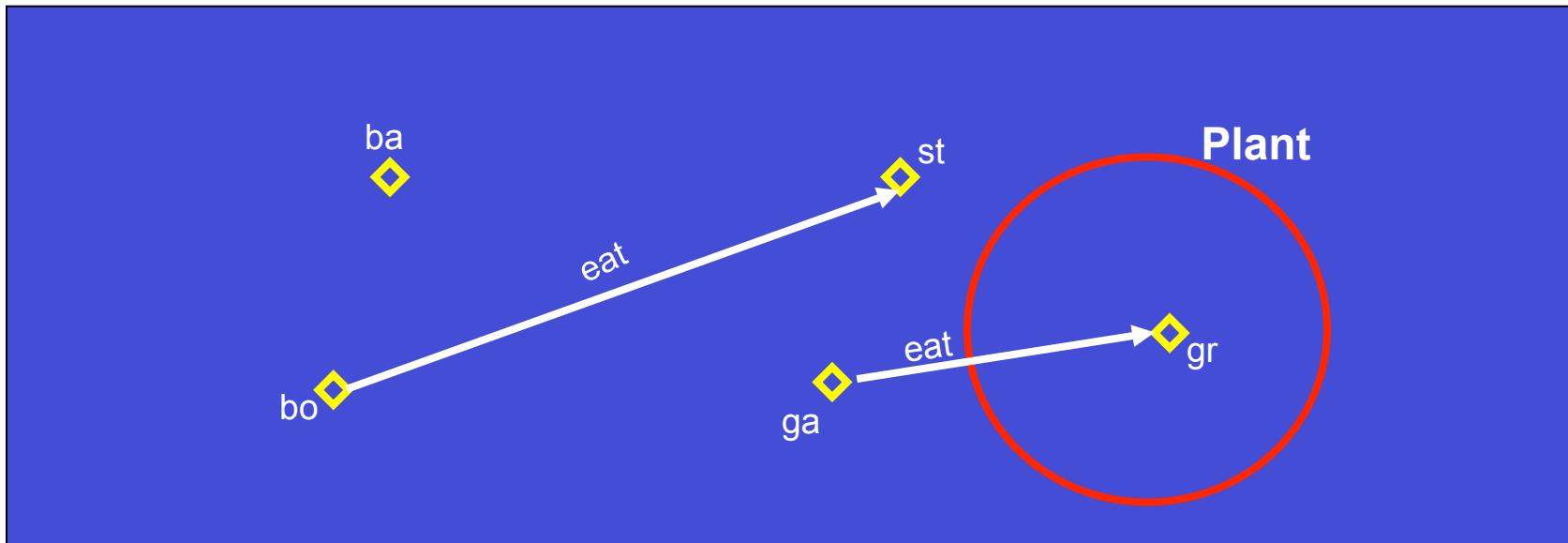
Q: Given the following interpretation



1. $\Delta^I = \{ga, bo, ba, gr, st\}$
2. $Plant^I = \{gr\}$
3. $eat^I = \{<ga, gr>, <bo, st>\}$
4. $partOf^I = ;$



DL Semantics Exercise



5. $(\exists \text{partOf}.\text{Plant})^!$

$= \{x | \exists y. \langle x, y \rangle \in \text{partOf}^! \wedge y \in \text{Plant}^! \}$ (Semantics of $\exists R.C$)

$= \{x | \exists y. \langle x, y \rangle \in \emptyset; \wedge y \in \{\text{gr}\} \}$ (from 2,4)

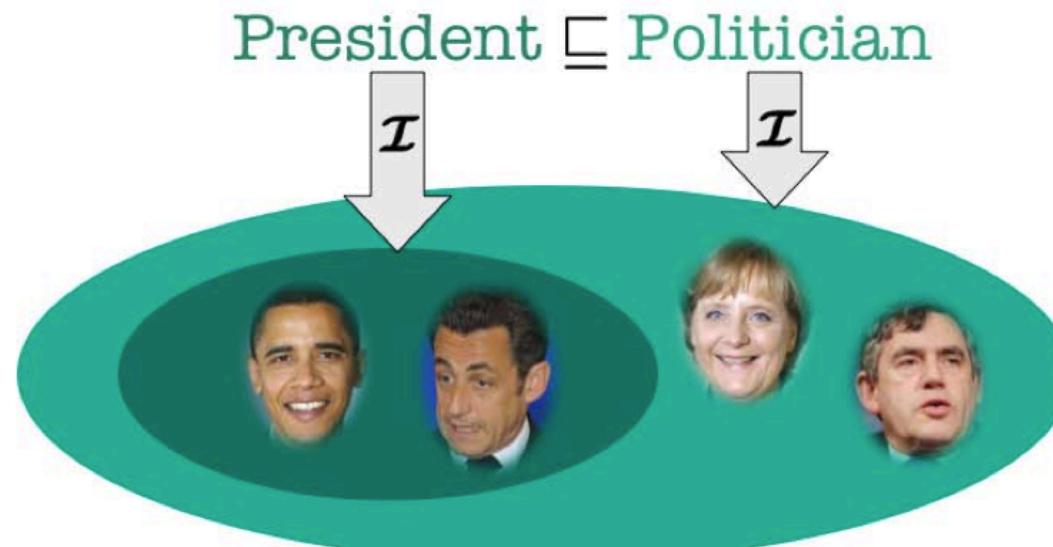
$= \emptyset$

“Every individual of the class restriction must have at least one partOf relation with an instance of the class **Plant**”

Axioms



- Axioms are used to “filter out” invalid interpretations from valid ones
 - An interpretation \mathcal{I} is a model for an ontology O if it satisfies all its axioms
 - An ontology O is consistent if it has some model (valid interpretation).



DL Reasoning Services

- Basic OWL DL Reasoning services
 - Class subsumption checking
 - subsume matching, plugin matching
 - Class equivalence checking
 - exact matching
 - Class satisfiability checking
 - intersection matching
 - Ontology consistency checking
 - Class instance checking
 - Property instance checking

Prove it!

Prove if the following equivalences hold



$$C \sqcap D \equiv D \sqcap C$$

$$(C \sqcap D)^I = C^I \cap D^I$$

$$(D \sqcap C)^I = D^I \cap C^I = C^I \cap D^I$$

$$(C \sqcap D) \sqcap E \equiv C \sqcap (D \sqcap E)$$

$$C \sqcap (D \sqcup E) \equiv (C \sqcap D) \sqcup E$$

Class Equivalence



Two class descriptions are called “**equivalent**” (written as $C \equiv D$) if for every single interpretation I we have $C^I = D^I$.

$$C \sqcap D \equiv D \sqcap C$$

$$C \sqcup D \equiv D \sqcup C$$

$$(C \sqcap D) \sqcap E \equiv C \sqcap (D \sqcap E)$$

$$(C \sqcup D) \sqcup E \equiv C \sqcup (D \sqcup E)$$

$$C \sqcap C \equiv C$$

$$C \sqcup C \equiv C$$

$$(C \sqcup D) \sqcap E \equiv (C \sqcap E) \sqcup (D \sqcap E)$$

$$(C \sqcup D) \sqcap C \equiv C$$

$$(C \sqcap D) \sqcup E \equiv (C \sqcup E) \sqcap (D \sqcup E)$$

$$(C \sqcap D) \sqcup C \equiv C$$

$$\neg\neg C \equiv C$$

$$\neg\exists r.C \equiv \forall r.\neg C$$

$$\geqslant 0r.C \equiv \top$$

$$\neg(C \sqcap D) \equiv \neg D \sqcup \neg C$$

$$\neg\forall r.C \equiv \exists r.\neg C$$

$$\geqslant 1r.C \equiv \exists r.C$$

$$\neg(C \sqcup D) \equiv \neg D \sqcap \neg C$$

$$\neg\leqslant nr.C \equiv \geqslant (n+1)r.C$$

$$\leqslant 0r.C \equiv \forall r.\neg C$$

Class Subsumption Checking



- | | |
|---|---|
| Class(A partial $C_1 \dots C_n$) | $A \sqsubseteq C_1 \sqcap \dots \sqcap C_n$ $A \equiv C_1 \sqcap \dots \sqcap C_n$ |
| • Class(A complete $C_1 \dots C_n$) | $A \sqsubseteq C_1 \sqcap \dots \sqcap C_n$ $A \equiv C_1 \sqcap \dots \sqcap C_n$ |

- **Question:** Given the following ontology O ,

- Class (C complete complementOf (

restriction (eats someValuesFrom (Plant))))
 - Class (D complete restriction (eats

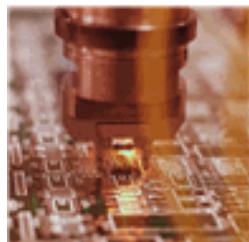
allValuesFrom (complementOf (Plant))))

Does O entail Class(C partial D)?

$$\begin{aligned}\neg \exists r.C &\equiv \forall r.\neg C \\ \neg \forall r.C &\equiv \exists r.\neg C\end{aligned}$$

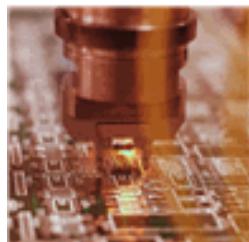
Does O entails $\neg \exists \text{eats. Plant} \sqsubseteq \forall \text{eats.}(\neg \text{Plant})$? **true**

Tableaux Algorithm



- The first sound and complete algorithm for expressive DLs
 - Ontology Consistency Checking
 - Class Satisfiability Checking
 - Instance Checking
 - Subsumption Checking
- Basic idea: Build an interpretation
 - A **tableau** is a representative of an interpretation
 - We can construct an interpretation based on a tableau

Key Steps



1. Initialise the tableau
 - depending on the reasoning tasks
2. Repair the initial tableau by applying expansion rules
 - so as to add new information into the tableau
 - this might require backtracking
3. If the tableau satisfy all the axioms, returns **Consistent**
4. If every possible attempt repair results in some contradiction, returns **Inconsistent**
 - **Contradiction:** $\{A, \neg A\} \subseteq L(x)$ or $\{\perp\} \subseteq L(x)$ (\perp is bottom, interpreted as **empty set**)

Class Instance Checking



- Given an ontology O , a class C and an individual x , check if for every interpretation I of O , x^I is in C^I
- Question:** given the following ontology O ,
 - Class (OldLady partial)
restriction (hasPet allValuesFrom (Cat))
 - Individual (Minnie type (OldLady)
value (hasPet Tom))
- Does O entail Individual (Tom type (Cat)) ?

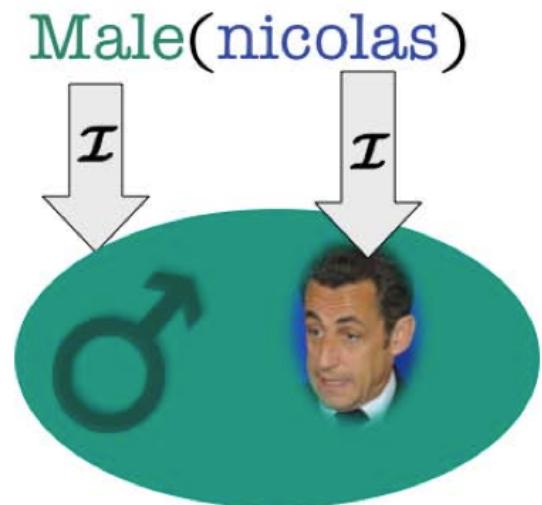
Class Instance Checking



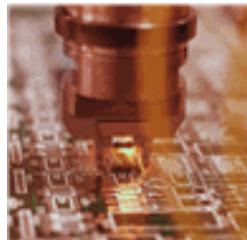
- Can we reduce class instance checking to another reasoning task?
- How about Ontology Consistency Checking
 - If O entails $C(x)$, then in every interpretation I of O , we have x^I is in C^I
 - It means $O \cup O\{\neg C(x)\}$ is inconsistent

Example

- If an ontology O entails $\text{Male}(\text{nicolas})$
 - then in every interpretation I of O
 - we have $\text{nicolas}^I \in \text{Male}^I$
- Now if we extend O to O' with a new axiom
 - $\neg\text{Male}(\text{nicolas})$ (*)
- How to construct an interpretation I' for O' ?
 - as all interpretations of O' should satisfy O
 - we could start from interpretations of O
- It is easy to see that I' does not exist
 - If I' does not satisfy O , then it does not satisfy O' either
 - If I' satisfies O , then it does not satisfy $\neg\text{Male}(\text{nicolas})$



Expansion Rules for Some Constructors



| | | |
|--|-------------------------|---|
| $x \bullet \{C_1 \sqcap C_2, \dots\}$ | \rightarrow_{\sqcap} | $x \bullet \{C_1 \sqcap C_2, C_1, C_2, \dots\}$ |
| $x \bullet \{C_1 \sqcup C_2, \dots\}$ | \rightarrow_{\sqcup} | $x \bullet \{C_1 \sqcup C_2, C, \dots\}$ for $C \in \{C_1, C_2\}$ |
| $x \bullet \{\exists R.C, \dots\}$ | \rightarrow_{\exists} | $x \bullet \{\exists R.C, \dots\}$ R $y \bullet \{C\}$ |
| $x \bullet \{\forall R.C, \dots\}$ R $y \bullet \{\dots\}$ | \rightarrow_{\forall} | $x \bullet \{\forall R.C, \dots\}$ R $y \bullet \{C, \dots\}$ |

Class Instance Checking

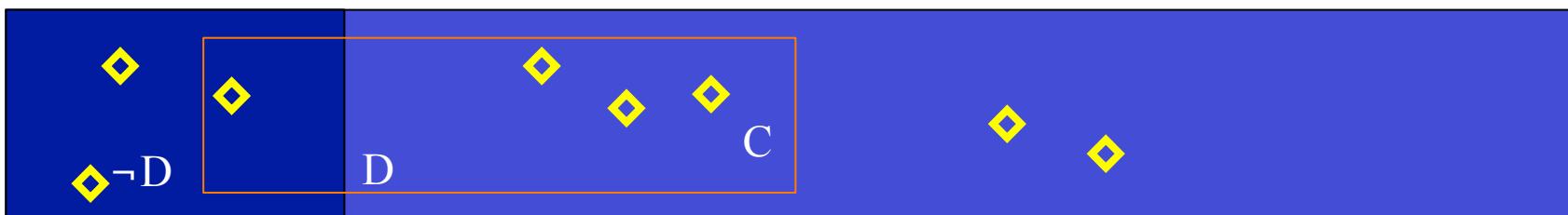


- **Question:** given the following ontology O,
 - $\text{OldLady} \sqsubseteq \forall \text{hasPet.Cat}$
 - $\text{OldLady}(\text{Minnie})$
 - $\text{hasPet}(\text{Minnie}, \text{Tom})$
 - **$\neg \text{Cat}(\text{Tom})$**
- Does O entail Individual (Tom type (Cat)) ?

From Subsumption Checking to Class Unsatisfiability Checking



- Some reasoning services can be reduced to each other
- E.g. class subsumption checking to class (un)satisfiability checking
 - $O \models C \sqsubseteq D$ iff $C \sqcap \neg D$ is unsatisfiable ?



Example: Class Subsumption Checking



- Question: Given the following ontology O ,
 - Class (Chinese partial Person)
 - Class (English partial Person)
 - Class (Confucian partial Chinese)
 - Class (Confucian partial English)
- To check $O \models \text{Confucian} \sqsubseteq \text{Person}$, we need to check if $(\text{Confucian} \sqcap \neg \text{Person})$ is unsatisfiable

Assessments



- 25% Continuous Assessment
 - Demonstrate practical skills related to ontology and rule, including building a **reasoner**
 - **Challenge: implementation of the inverse object property expansion rule.**
- **The TrOWL Award**
 - **for the best reasoner among the assessment submissions**

The TrOWL Reasoner



- http://www.slideshare.net/jeffpan_sw/the-rise-of-approximate-ontology-reasoning-is-it-mainstream-yet

Winner(s) of the TrOWL Award



- **Winners are ...**

Exam



- 75% of overall marking
- Apply CS3025 learning outcomes
 - 2 hours
 - 2 questions: one on ontology and the other on Jess

CS4046 Semantic Web Engineering

despicable me 2

Web Images Maps Shopping News More Search tools

About 163,000,000 results (0.29 seconds)

Despicable Me 2 showtimes for San Francisco, CA

See showtimes for 3D

Despicable Me 2

despicableme.com/

A short description of the movie, ratings, release date, directors, cast, etc.

1hr 38min - Rated PG - Animation

In summer 2013, get ready for more Minion madness in Despicable Me 2. Chris Meledandri and his acclaimed filmmaking team ...

AMC Van Ness 14 - 1000 Van Ness Avenue, San Francisco, CA - Map

11:25am - 2:05 - 4:55 - 7:40 - 10:30pm

Century San Francisco Centre 9 and XD - 835 Market St., San Francisco, CA - Map

7:00 - 9:25pm

+ Show more theaters

Despicable Me 2

despicableme.com/

Rating: 7.8/10 - 51,274 votes

Directed by Pierre Coffin, Chris Renaud. With Steve Carell, Kristen Wiig, Benjamin Bratt, Miranda Cosgrove. Gru is recruited by the Anti-Villain ...

Release Info - Full cast and crew - Videos - Version 3

Despicable Me 2 - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/Despicable_Me_2

Despicable Me 2 is a 2013 American 3D computer-animated comedy film and the sequel to the 2010 animated film Despicable Me. Produced by Illumination ...

Minions (film) - Despicable Me (franchise) - Anney International Animated ...

Despicable Me 2 - Official Trailer #3 (HD) Steve Carell - YouTube

www.youtube.com/watch?v=HwXbtZjbVE

Mar 19, 2013 - Uploaded by joblomovienetwork

http://www.joblo.com - "Despicable Me 2 - Official Trailer #3"

Universal Pictures and Illumination Entertainment ...

Despicable Me 2 - Rotten Tomatoes

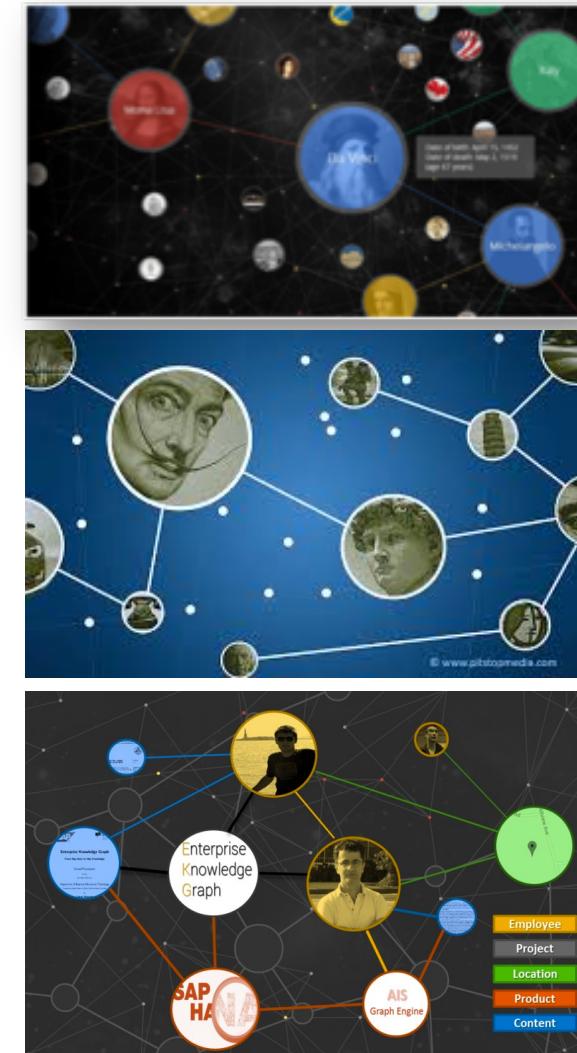
www.rottentomatoes.com/m/despicable_me_2/

Rating: 75% - 162 reviews

Review: It may not be as inspired as its predecessor, but Despicable Me 2 offers plenty of eye-popping visual inventiveness and a number of big...

News for despicable me 2

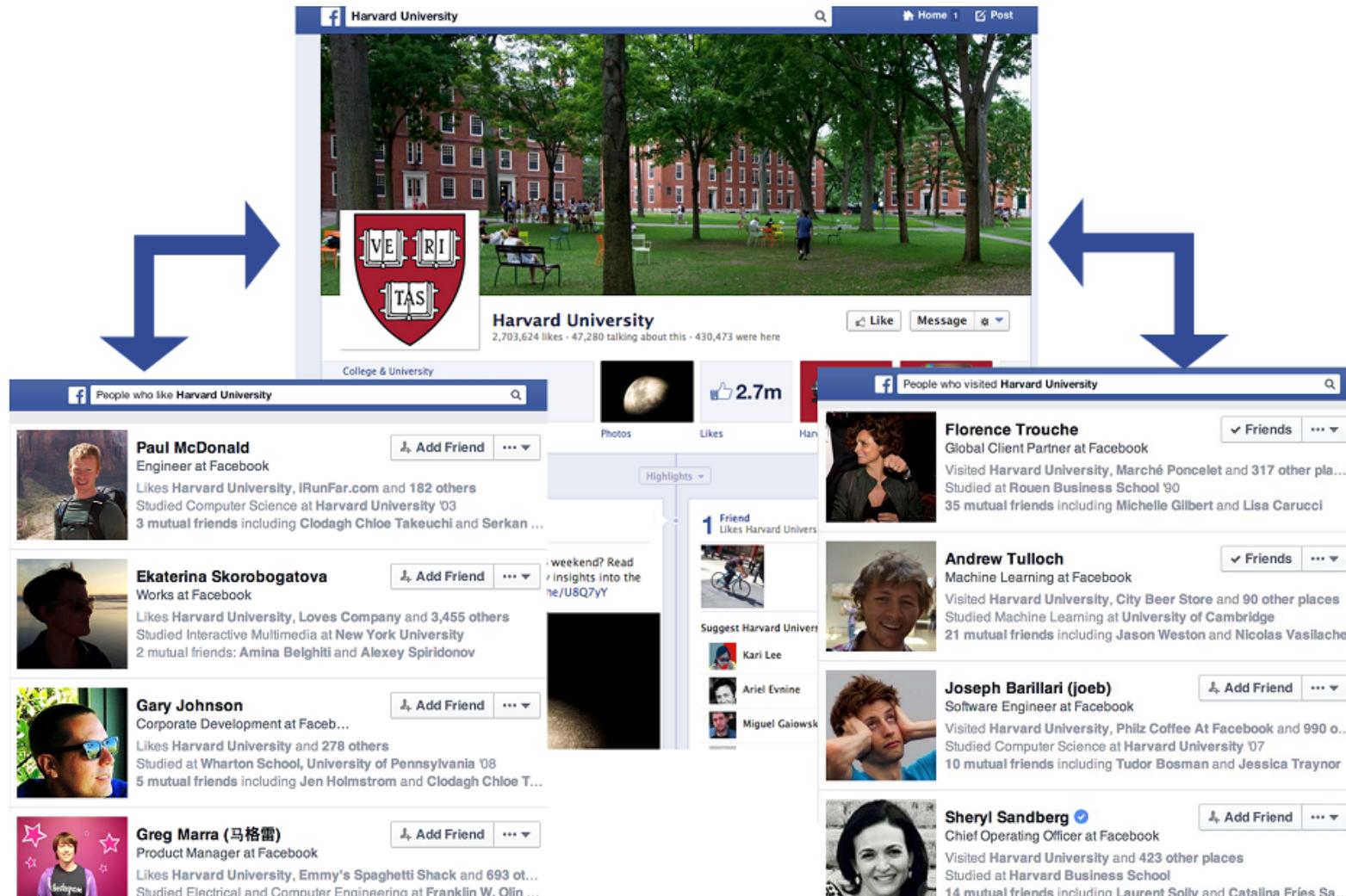
NBCUniversal CEO: 'Despicable Me 2' Will Be Most Profitable Film in Universal's History



[Credit: H Wang]

Knowledge-Based Systems
Jeff Z. Pan

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Structured search within the graph



The screenshot shows a Facebook search results page with a query bar at the top: "People who like Harvard University and Basketball and work at Facebook". Below the query, there are five search results, each showing a profile picture, name, title, and a brief bio. The profiles belong to Mike Vernal, Jared Morgenstern, Florin Ratiu, Ning Zhang, and Zhongyuan Xu. A blue callout box with the text "Structured search within the graph" points to the search bar.

Introducing Graph Search



The landing page has a dark blue header with the text "Introducing Graph Search". Below the header, there is a search bar with the query "People who like Cycling and are from my hometown". Below the search bar, there are several user profiles displayed in a grid format, each with a photo, name, title, and a brief bio. The profiles include Sharon Hwang, Morin Oluwole, Russ Maschmeyer, Peter Jordan, and Anish Bhasin.

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A. What is the computer system that played against human opponents on “Jeopardy”... and won.

Why Jeopardy?

The game of *Jeopardy!* makes great demands on its players – from the range of topical knowledge covered to the nuances in language employed in the clues. The question IBM had for itself was “is it possible to build a computer system that could process big data and come up with sensible answers in seconds—so well that it could compete with human opponents?”

[Slide Credit: Dalal et al.]

Knowledge-Based Systems
Jeff Z. Pan

Where to go from here

- Reading
 - slides
- Understanding
 - practicals
 - sample exam questions
- Q&A
 - email me your question
 - I will send my answer to the mailing list



Please feel free to contact if you would like to do
an Honours project related to KBS