

Integrative Approach for Semantic Image Annotation and Retrieval



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2ND Workshop of Challenges and Promise of Semantic Web, Nottingham Trent University



Outline

- A note on Semantic Web
 - Image retrieval techniques
 - Case study for Semantic Web based Image Retrieval (SWIR)
 - Project cycle for SWIR project
 - Semantic-based Query Expansion
 - Conclusions
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THE SEMANTIC WEB

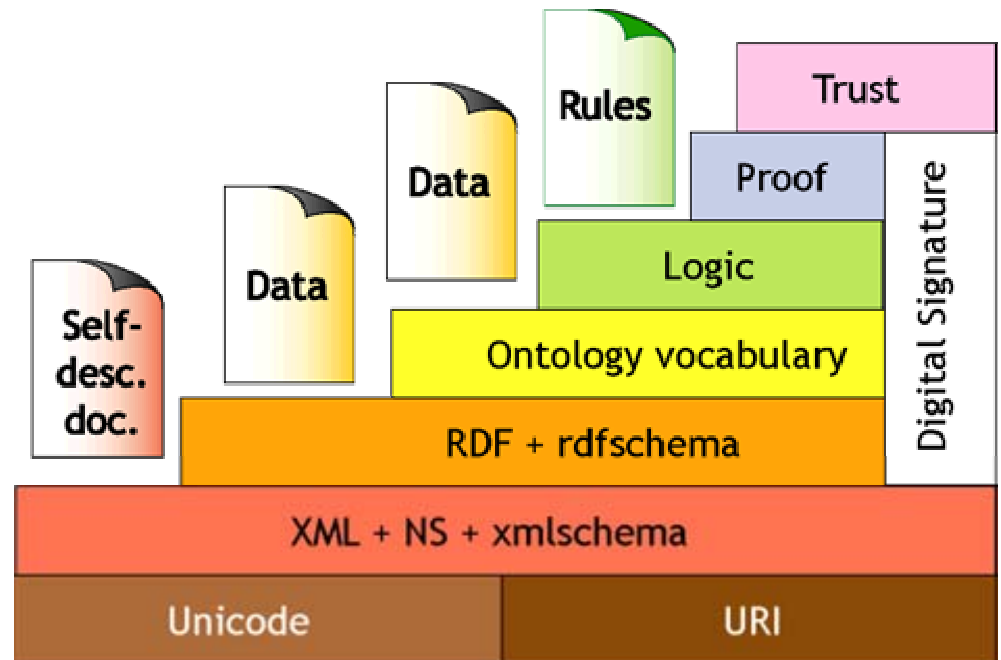
A new form of Web content
that is meaningful to computers
will unleash a revolution of new abilities

by
TIM BERNERS-LEE,
JAMES HENDLER and
ORA LASSILA

PHOTO CREDIT HERE

Semantic Web

- Extension to current WWW



Semantic Web Layer Cake (Berners-Lee, 99; Swartz-Hendler, 2001)

Search : Free-Text vs. Semantic Web

Free-Text

- Lack of accuracy
- Have to rely on the annotator to provide all possible keywords
- Repetitive annotation effort
- Lack of structure, concepts and relationships

Semantic

- Adds structure, Concepts-Relationship
- Provide for Inference (Implicit reasoning)
- Accurate results

Image Retrieval Techniques

- **Caption-based annotation and retrieval**
 - Without semantics?
 - To improve computer's understanding of the image objects and their interactions
 - Practicality of use
 - **Content-based annotation and retrieval**
 - Image recognition
 - Automatic annotation
 - Is a complex problem
 - Legacy image classification
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Case study for Semantic Web based image retrieval (SWIR)

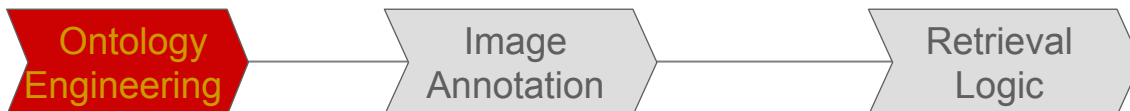
- Goal of case study:
 - To build a classification and indexing system
 - To improve the end-user experience
 - Dynamics of Retrieval process
 - Not web-based
 - Real-time relay of images to customers
 - Colossal amount of images
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Project cycle for SWIR project

- **Ontology Engineering**
 - Domain Analysis
 - Consistency checking
 - Coverage
 - Normalisation: reducing the redundancy
 - **Semantic Image Annotation**
 - **Retrieval application logic**
 - Reasoners
 - Image Retrieval
-

Domain Analysis

- Understanding the characteristics of entities in a specific domain is key to using semantic-based techniques
- Design decisions
 - Limiting to the sports domain
 - Bottom-up approach - Examining free-text and non-semantic caption accompanying images (65k image captions)
 - Use of external, public ontologies
 - Cache system for effectiveness



Domain Analysis : OWL

- Web Ontology Language
 - Official W3C Standard since Feb 2004
 - Based on predecessors (DAML+OIL)
 - A Web Language: Based on RDF(S)
 - An Ontology Language: Based on logic
 - OWL DL is the subset of OWL (Full) that is optimized for reasoning and knowledge modeling
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Domain Analysis: Protégé Ontology Editor

ImageDescription Protégé 3.2 beta (file:\C:\Program%20Files\Protege_3.2_beta\ImageDescription.pprj, OWL / RDF Files)

File Edit Project OWL Code Tools Window Help

Subclass Explorer: For Project: [red dot]

Asserted Hierarchy

- Colour:Range
- Colour:Unit
- Countries:Country
- Countries:ISO3166DefinedCountry
- portal:Composite-Publication
- aktors:Thing
- country-ont:Country
- sports:MainSports
- colour:Colour
- colour:Unit
- Image
 - SportImage**
- Intangible-Thing
 - Area
 - Characteristic
 - Action
 - Feeling
 - ImageProperties
 - Membership
 - SportFederation
- Tangible-Thing
 - Location
 - Object
 - Accessory
 - Person
 - Temporal-Thing
 - ObjectCharacteristic
 - SpecialAttribute

Class Editor: For Class: SportImage (instance of owl:Class) Inferred View

| Property | Value | Lang |
|-----------------|--|------|
| owl:versionInfo | v 1.1.1 | |
| rdfs:comment | SportImage Class. Contains Information about sportsimage | |

Properties and Restrictions

- hasLocation (multiple Location)
- hasObjectCharacteristic (multiple ObjectCharacteristic)
- hasSportEvent (multiple SportEvent)
- hasAreaInFocus (multiple Area)
- hasCreationDate (multiple aktors:Calendar-Date)
- hasDescription (multiple string)
- hasFrameView (multiple FrameView)
- hasObject (multiple Tangible-Thing)
- hasPhotographer (multiple Photographer)
- hasPhotoRefNumber (multiple int)
- hasPhysicalFileLocation (multiple string)

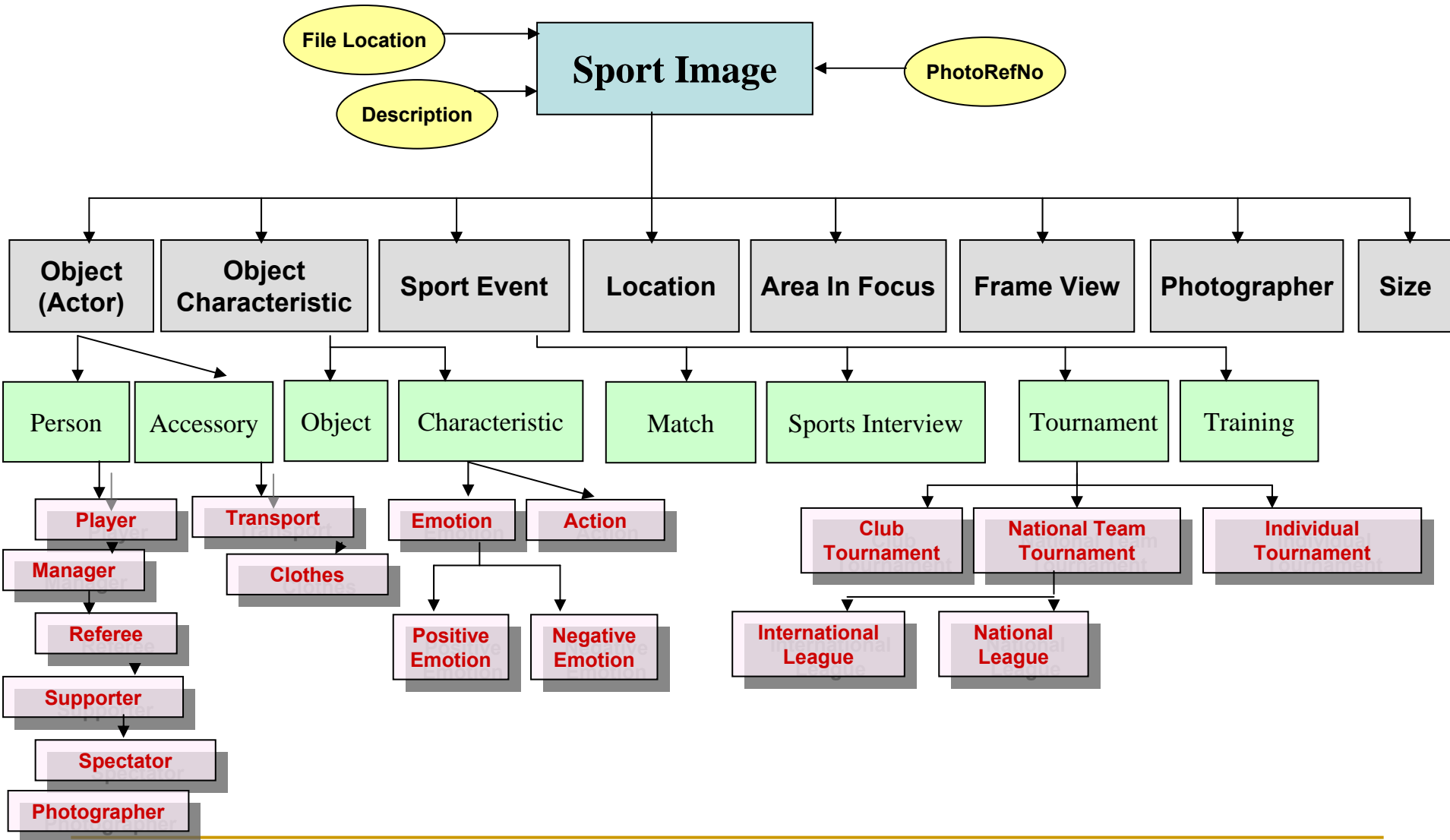
Superclasses: Image

Disjoints

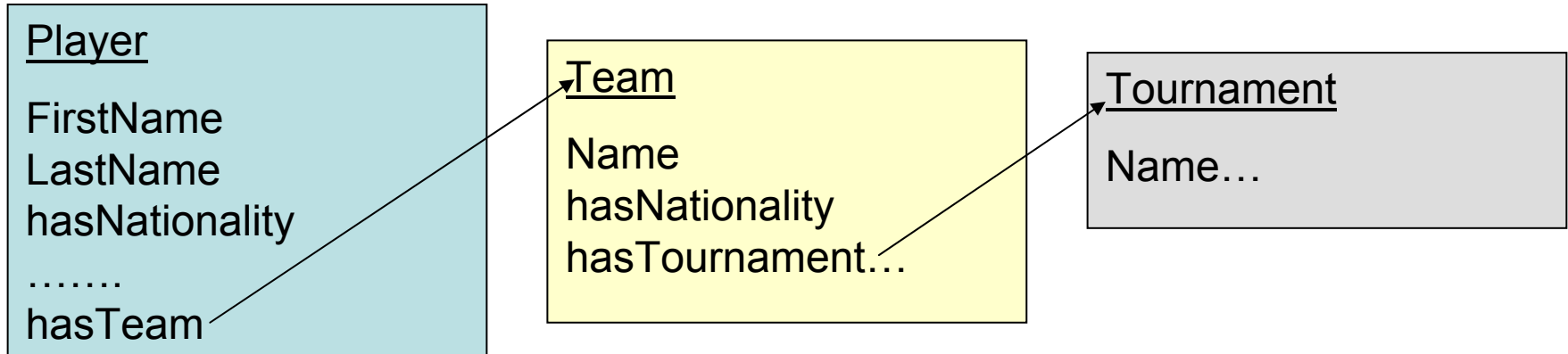
Logic View Properties View



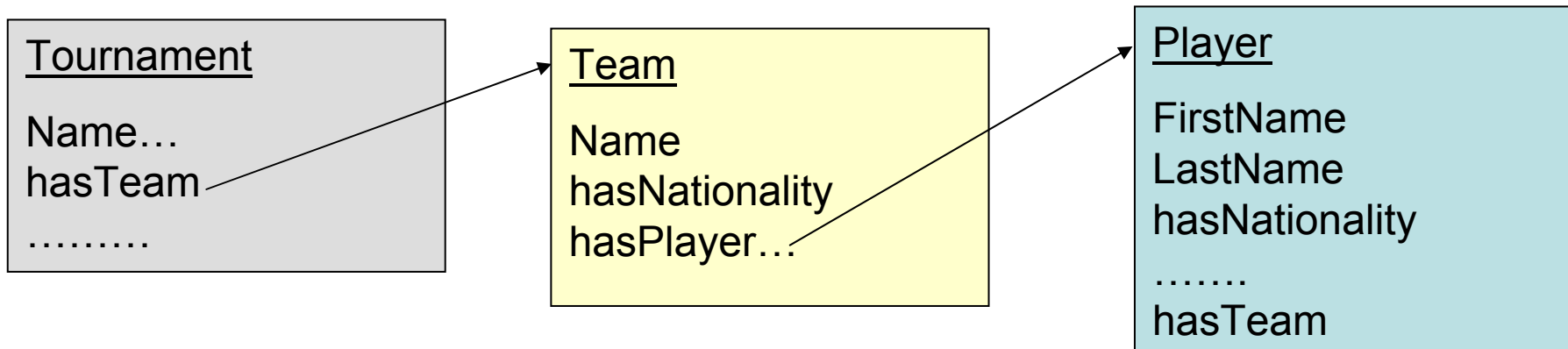
Domain Analysis



Good practice: Consistency Checking



a. Inconsistent



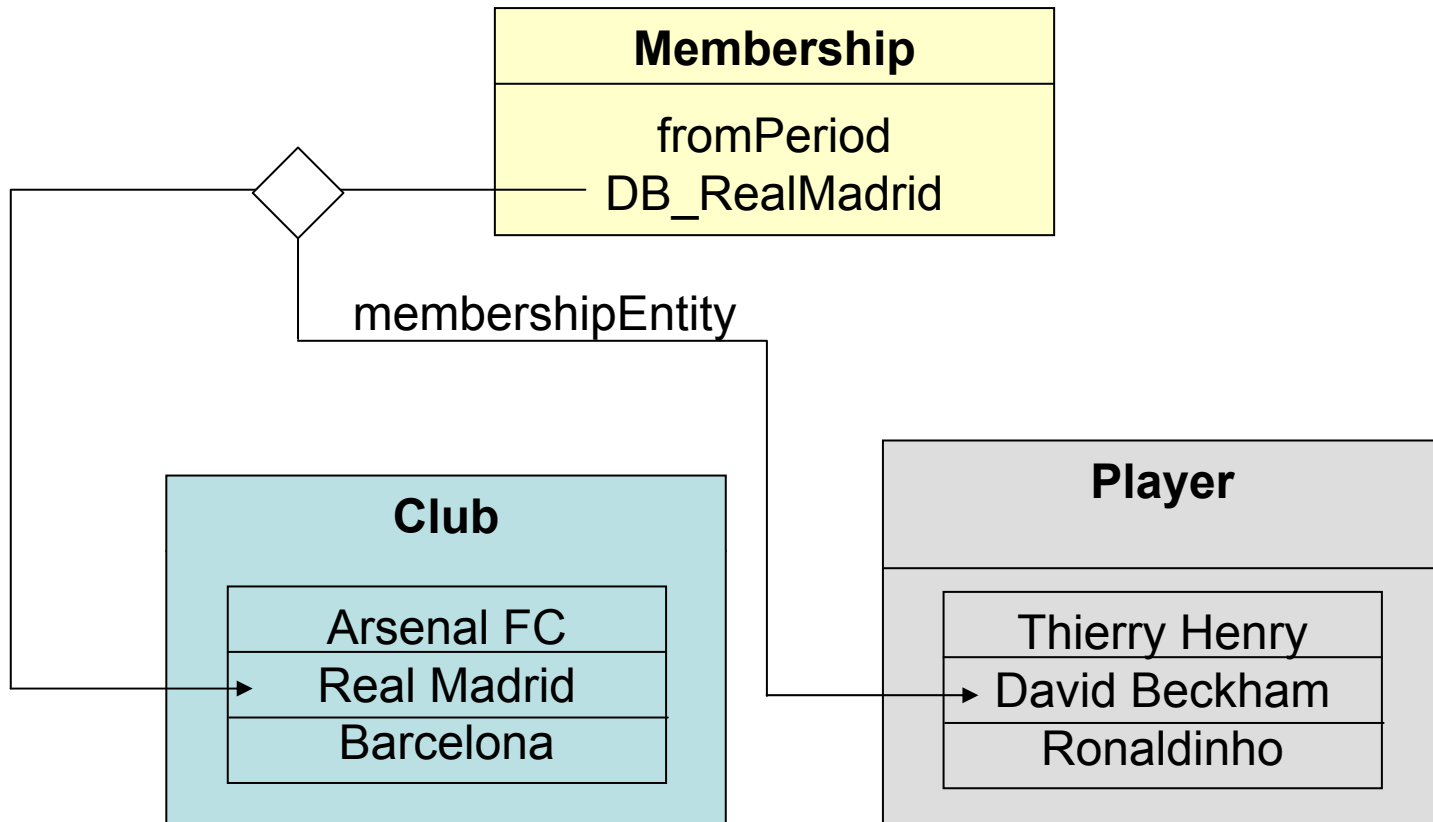
b. Consistent

Ontology
Engineering

Image
Annotation

Retrieval
Logic

Good practice: Normalisation

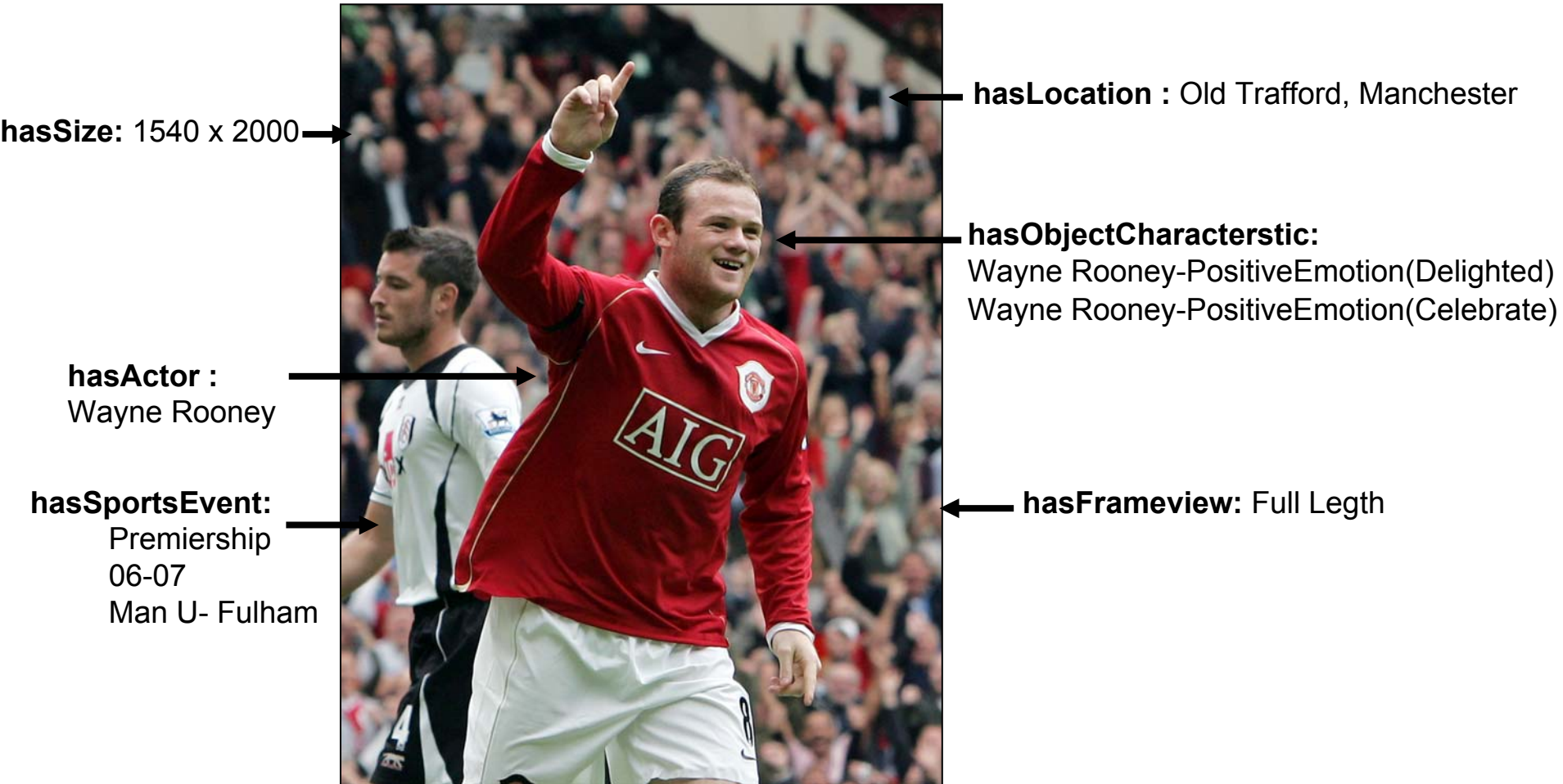


Ontology
Engineering

Image
Annotation

Retrieval
Logic

Annotation

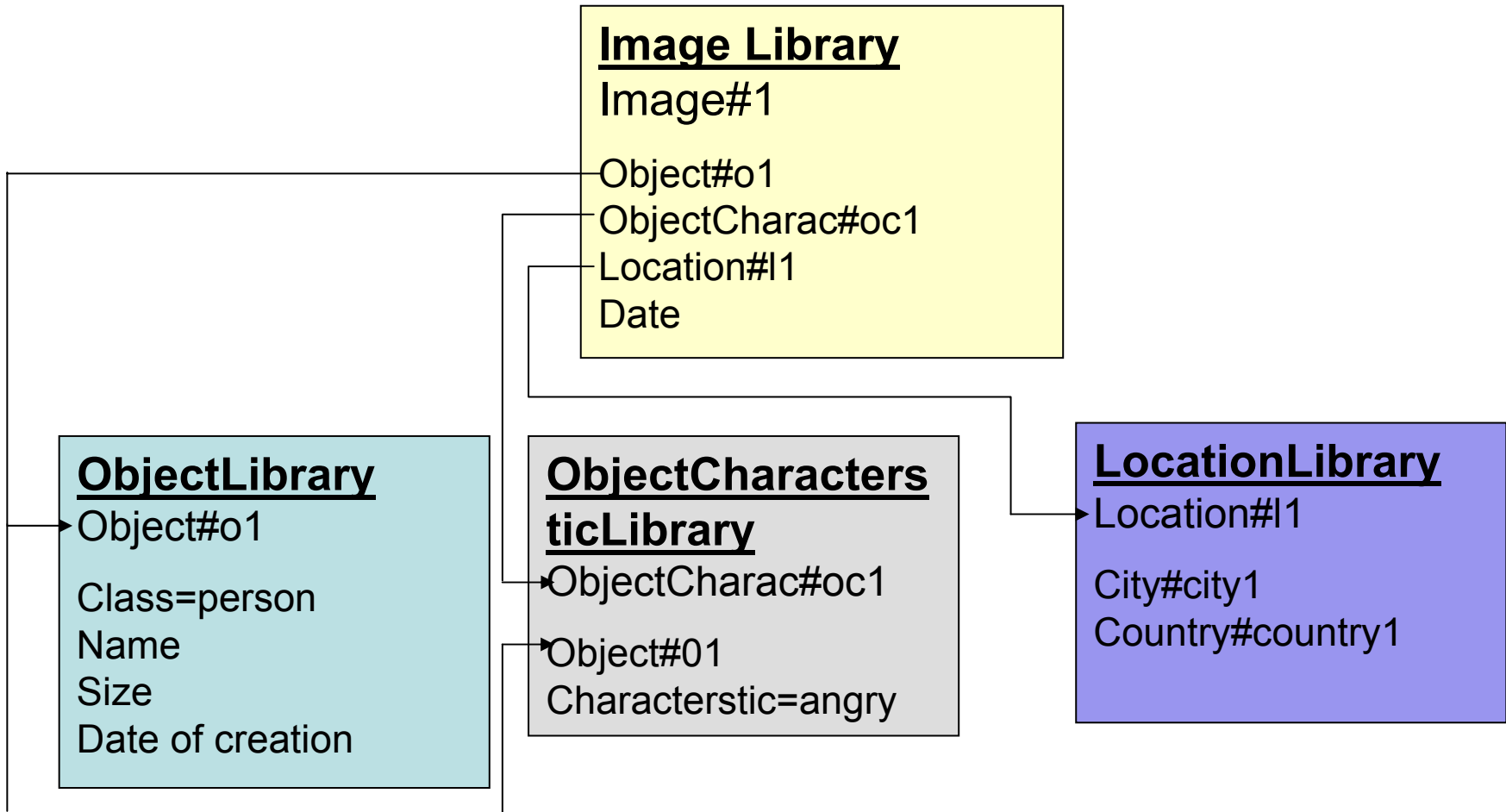


Ontology
Engineering

Image
Annotation

Retrieval
Logic

Annotation: Image Library



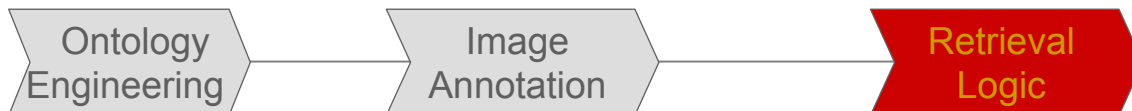
Ontology
Engineering

Image
Annotation

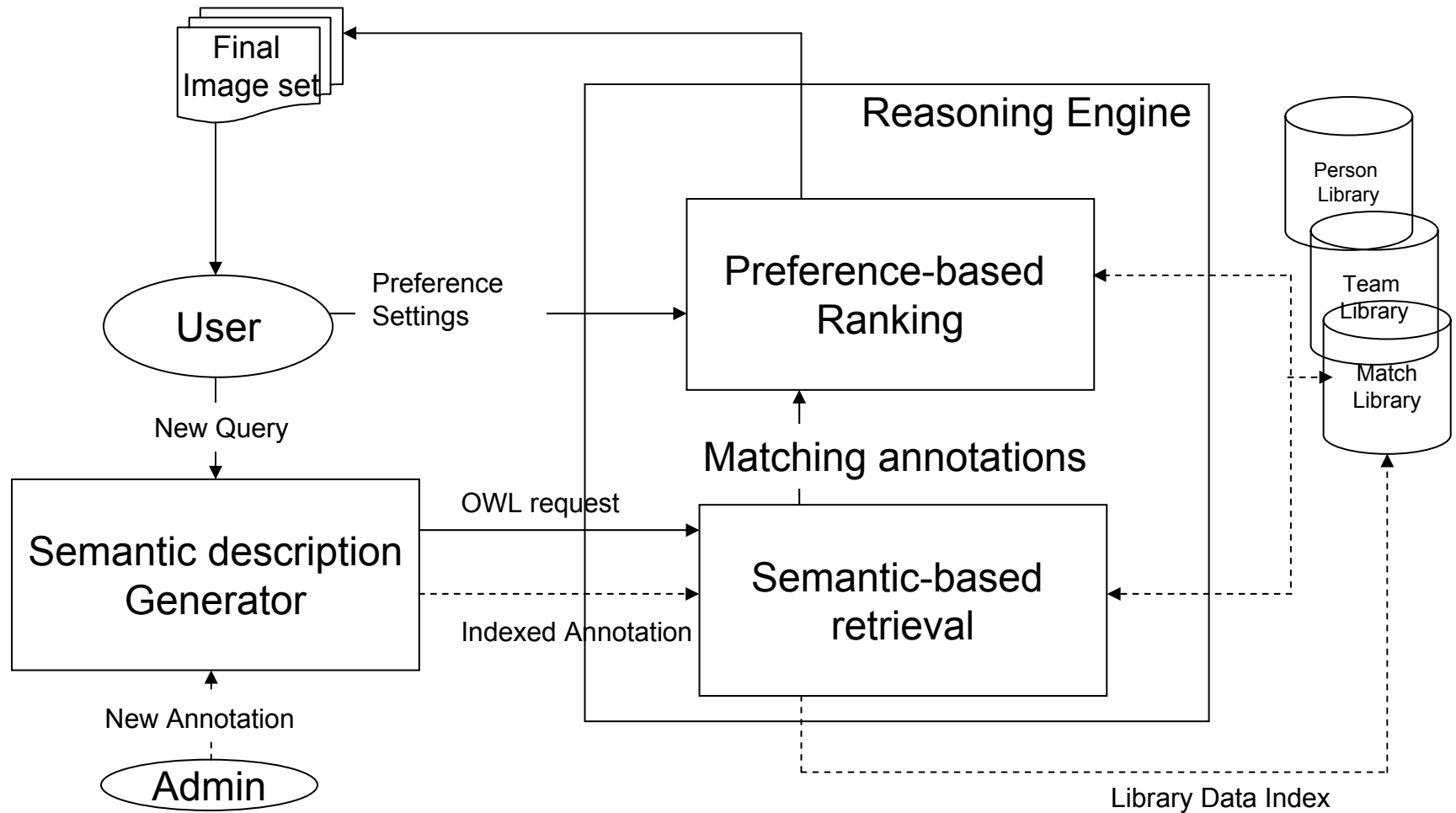
Retrieval
Logic

Application Logic Design: Reasoner

- Reasoner required for:
 - ❑ Consistency checking
 - ❑ Concept satisfiability
 - ❑ Classification
 - ❑ Realization
 - ❑ Query Answering
 - ❑ Other housekeeping work
- Pellet OWL reasoner
 - ❑ Extends Jena
 - ❑ Sound and complete OWL-DL reasoner



Application Logic Design: Retrieval Process



Ontology Engineering

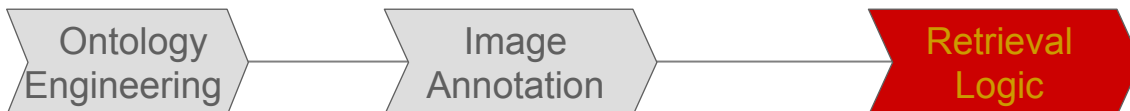
Image Annotation

Retrieval Logic

Application Logic Design: Retrieval Process

- Preferences
 - User Preference
 - Configuration Preference – Business point of view
- First phase- Makes sure that the user preferred images are retrieved
- Second Phase-Configuration Preferences and Other parts of user query to rank the retrieved images
- Nearest Neighbour

$$ADoM = \frac{\sum_{i=1}^n W_i \times sim(f_i^N, f_i^R)}{\sum_{i=1}^n W_i}$$



Extending retrieval Process: Query Expansion (QE)

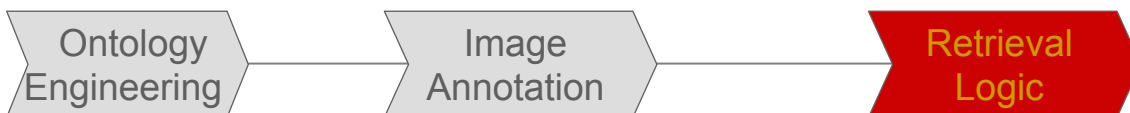
- Improving recall and Relevance
 - QE in literature
 - statistical and probabilistic methods
 - lexical databases based methods
 - Novel approaches using Semantic Web
 - Semantic Web : Best platform
 - language expressiveness
 - Reasoning capacity
-

Query Expansion: Definition

If query has concept C^p as the primary search concept and C^s as the secondary search concept provided by the searcher then we define query expansion on C^p as follows:

Let's say $C^{p'}$ is the alternative concept, δ is the distance between C^p and $C^{p'}$ concepts and Ψ is the expected distance between these two concepts implying them related. Hence the expansion function is:

$$\sum_{i=1}^n (C^p \xrightarrow{\delta_i, \Psi_i} C_i^{p'}) , \delta_i \geq \Psi_i$$

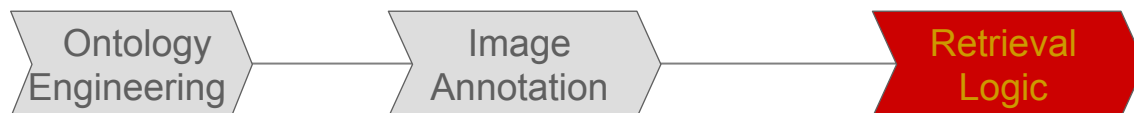


Query Expansion: Issues

- The definition of query expansion raises two further issues:
 - How to formalize the relatedness between two concepts and how to decide which relationships to choose from when there are multiple alternatives?
 - How to avoid query drift by achieving $\delta \geq \Psi$ in the above equation? Query drift is a by-product of query expansion where the resultant concept might be distant from the user's original intentions.

Query Expansion: Semantic Relationship

- How to formalize the relatedness between two concepts
 - *Taxonomy Relationships (TR)*
 - *Rules based relationships (RR)*
 - *Property Relationships (PR)*
- How to avoid Query Drift hence achieve $\delta \geq \psi$?
 - Two phase system
 - Expanding preferred terms



Conclusions

- SWIR- Annotation, Retrieval, Query Expansion
 - Test scenarios can easily be readapted to cater for other retrieval priorities
 - Commercial value
 - Future work - content recognition technology for semi-automatic annotation
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