Knowledge Representation & Modeling

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Knowledge Representation

Knowledge representation is a description of knowledge, or a set of conventions for knowledge, a data structure acceptable to computers for describing knowledge.

- The importance of knowledge representation
  - computer gets & uses knowledge
  - require the knowledge model that computer can handle
    - List、Table、Tree、Map、Set、etc.

Knowledge Representation

- Knowledge Carrier
  - language、character、picture
  - video、voice、model
- Early knowledge representation
  - First-Order Logic、Production Rule
  - Framework、Semantic Network、etc.

First-Order Logic

- Horn Logic
  - Atom

    $$p(t_1, t_2, ..., t_n)$$

    - has_child(A, B) => A has_child B

  - Rules

    $$H :- B_1, B_2, ..., B_n$$

    - H, Bi are all atoms
    - H: head atom、A: body atom
    - H can be obtained by $B_1, B_2, ..., B_n$
    - for example: has_child(A, B) :- has_son(A,B)

First-Order Logic

- Description Logic
  - concept
    - describe a field
    - student、teacher、professor、human、flower、etc.

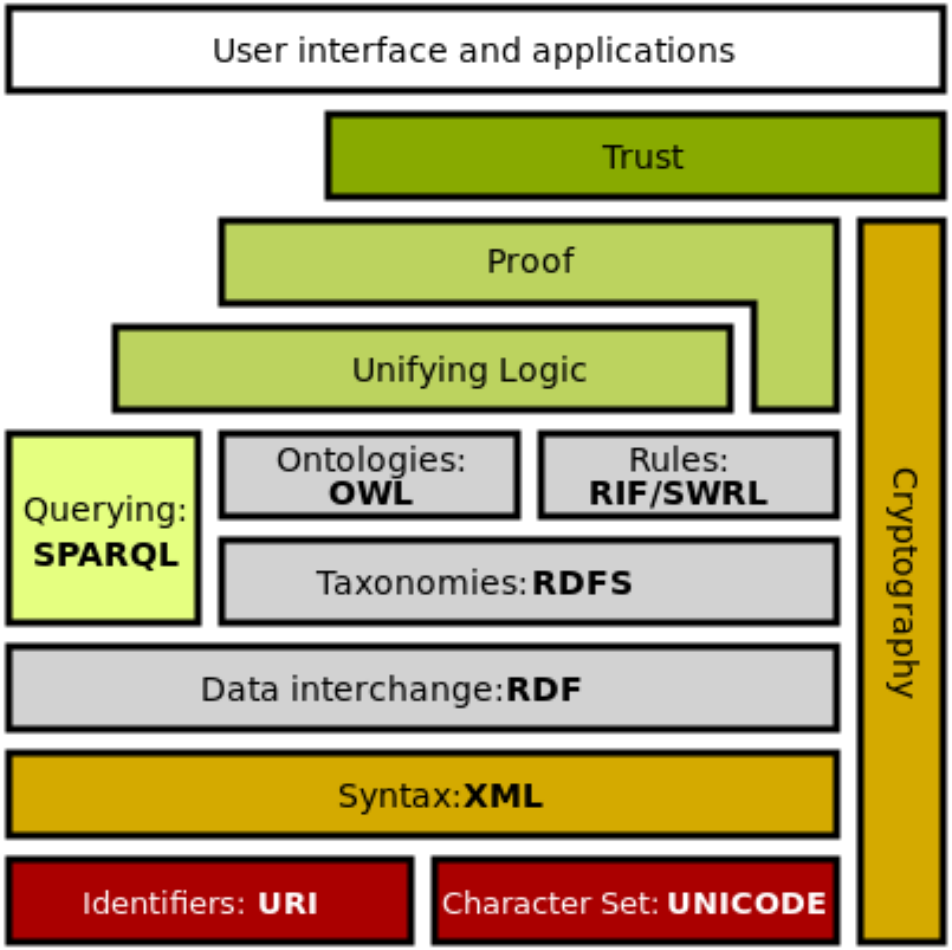
      $\{x \mid Student(x)\}$
  - relationship
    - binary relation in the field
    - x and y are friends

      $\{< x, y > \mid Friend(x, y)\}$
  - individual
    - a entity in a field

First-Order Logic

- Description Logic
  - TBOX & ABOX
  - TBOX
    - the name of concepts and relationships
      - Student、Teacher、has_student、has_teacher
    - declaration axioms inclusive relations
      - has_student(A, B) => has_teacher(B, A)
  - ABOX
    - concept assertion
      - Student(Tom)
      - Teacher(Jack)
    - relationship assertion
      - has_student(Jack, Tom)

Knowledge Representation Framework based on Semantic Network

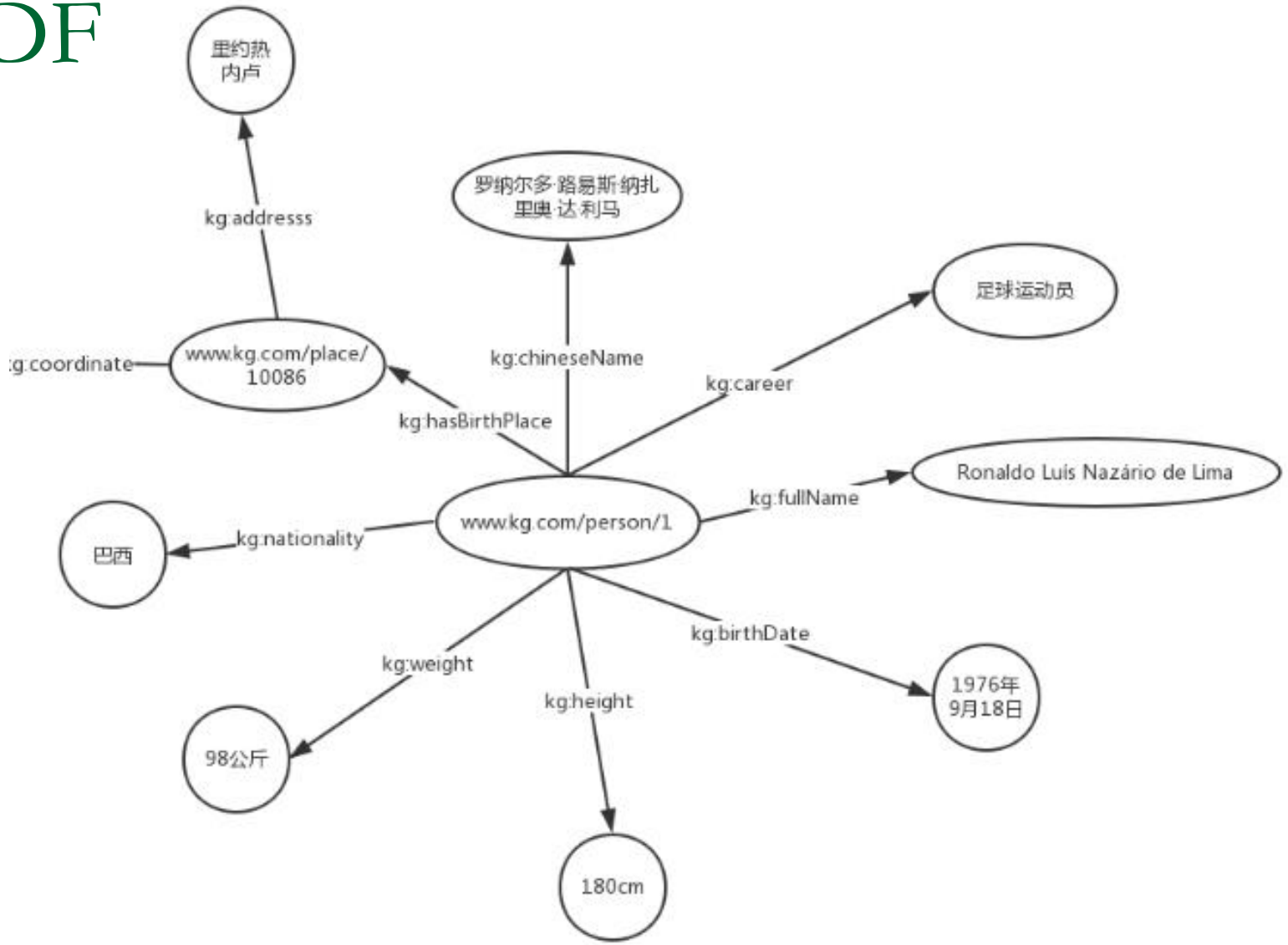


RDF: Resource Description Framework

- A triple model
  - (subject, predicate, object)

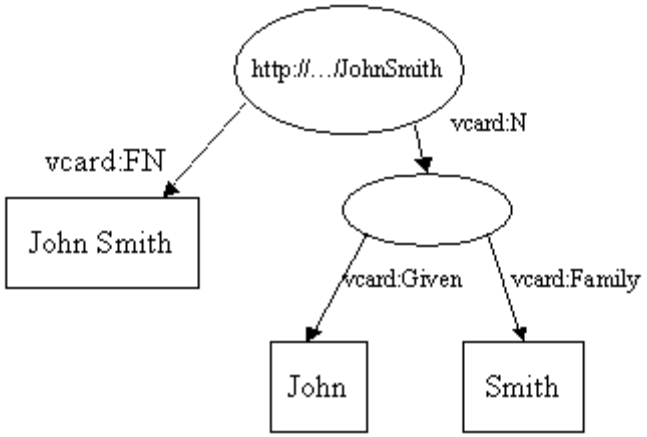
- A graph model
- Resources and properties are identified by URIs
  - http://www.demo.com/people#3214
- Value of properties can be URI resources or literals
  - literal value can be typed with XML datatype
    - ^^xsd:string
    - ^^xsd:integer

RDF


里约热内卢
kg:addresss
罗纳尔多·路易斯·纳扎里奥·达·利马
足球运动员
:g:coordinate
www.kg.com/place/10086
kg:chineseName
kg:career
kg:hasBirthPlace
Ronaldo Luís Nazário de Lima
kg:fullName
巴西
kg:nationality
www.kg.com/person/1
kg:birthDate
kg:weight
kg:height
1976年9月18日
98公斤
180cm

RDF

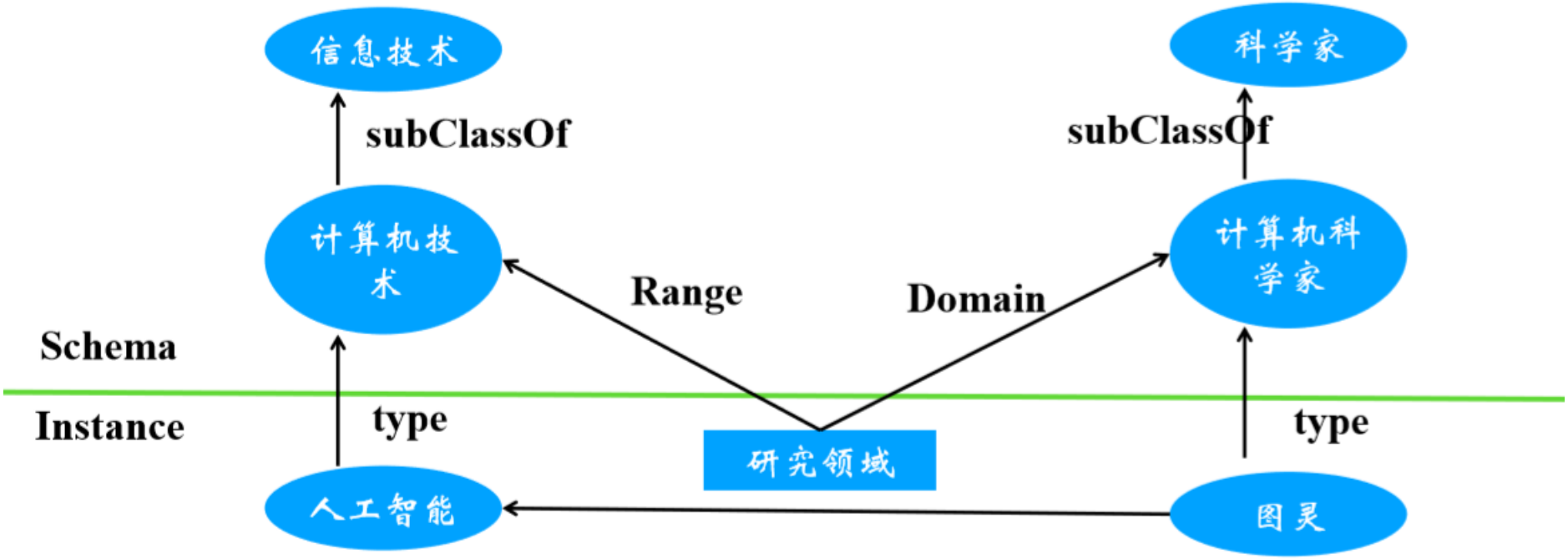
- Blank Nodes
  - a resource without URI to identificate
  - use _:x、_:a to identificate



- Serialization methods
  - RDF/XML、N-Triples、Turtle、RDFa、JSON-LD、etc.

RDFS： RDF Schema

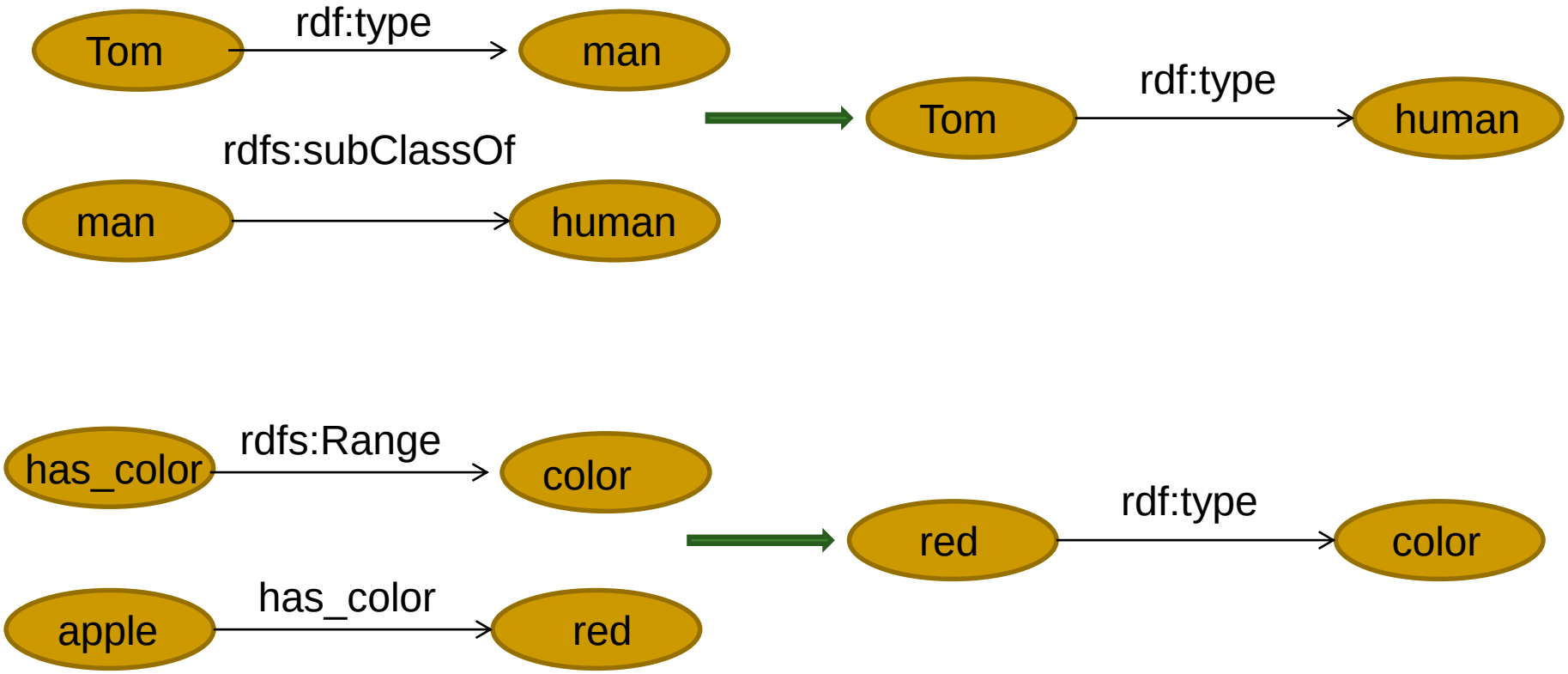
similar to the design of table and field in database



Class, subClassOf, type, Property, subPropertyOf, Domain, Range, etc.

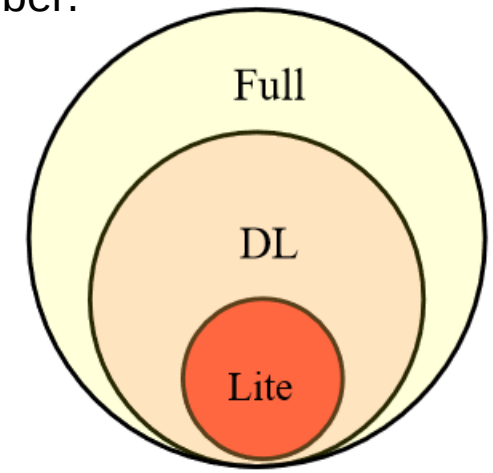
RDFS: RDF Schema

- In RDFS, we can do some reasoning



OWL: Web Ontology Language

- Defect of RDF(S)
  - rdfs:range is global, cannot define special range for some class
  - cannot define equivalence or inequivalence of classes、properties、individuals
  - cannot define disjoint of classes
  - cannot define the range constraint for property value
    - A person has and has only one ID number.
- OWL extends RDF(S)
  - OWL Lite
  - OWL DL
  - OWL Full



OWL

- Equivalence
  - exp:广州 owl:sameIndividualAs exp:羊城
  - ep:广州 owl:sameIndividualAs exp:羊城
- Transitive
  - exp:contain rdf:type owl:TransitiveProperty
    - if (A contain B) & (B contain C) => (A contain C)
- Inverse
  - exp:contain owl:inverseOf exp:belongTo
- Symmetric
  - exp:friend rdf:type owl:SymmetricProperty
- functional、allValuesFrom、someValuesFrom、cardinality、intersection、etc.card

OWL2 (new version)

- OWL2 subclass:
  - OWL2 RL
  - OWL2 QL
    - more for individual
    - design for ontology query
  - OWL2 EL
    - more for concept

SPARQL

The query language for RDF

```
SELECT ?student ?email  ?home
FROM <http://www2.warwick.ac.uk/rdf/student>
WHERE {
 ?student exp:studies exp:CS909 .
OPTIONAL { ?student foaf:mbox?email .
                ?student foaf:homepage ?home. }
}
```

we want to know the student's name、email、address, who studies CS909

Protege

Stanford 本体编辑工具

https://protege.stanford.edu/

参考资料：http://mowl-power.cs.man.ac.uk/protegeowltutorial/resources/ProtegeOWLTutorialP4_v1_3.pdf