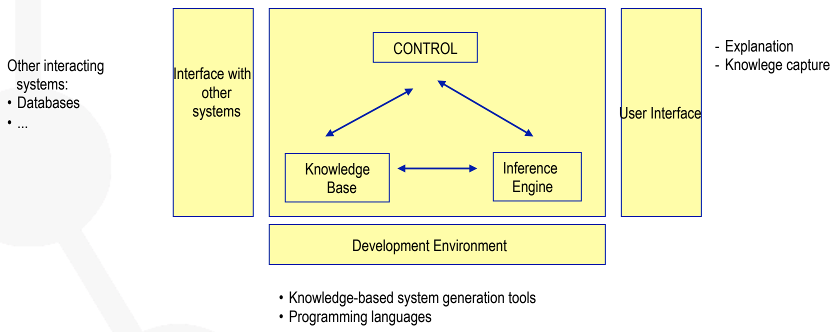
Knowledge Representation Formalisms

Oscar Corcho
ocorcho@fi.upm.es
Universidad Politécnica de Madrid

Architecture of a Knowledge-based System



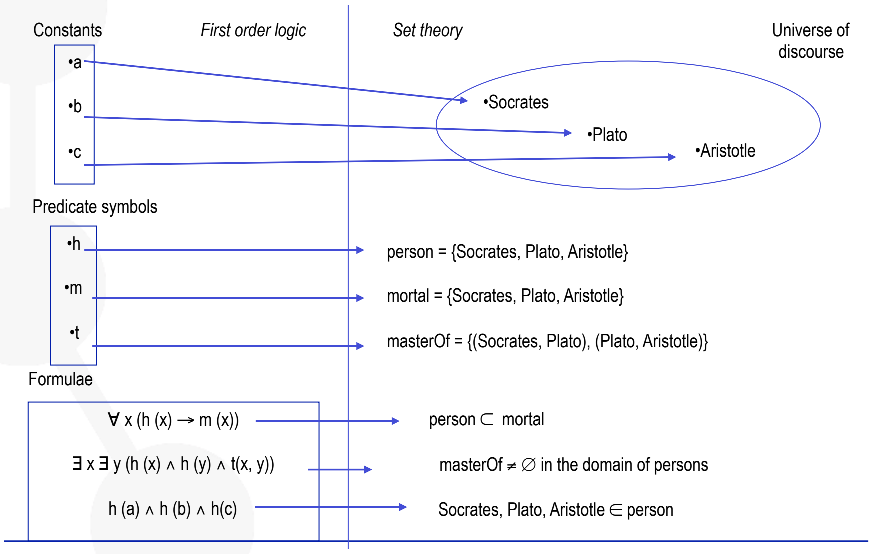
Knowledge Representation Formalisms. A Summary

- Knowledge representation
  - To store knowledge so that programs can process it and achieve the verisimilitude of human intelligence
- Knowledge representation formalisms/techniques
  - Originated from theories of human information processing.
  - Since knowledge is used to achieve intelligent behavior, the fundamental goal of knowledge representation is to represent knowledge in a manner as to facilitate inferencing i.e. drawing conclusions from knowledge.
  - Some examples are:
    - First order logic
    - Semantic networks and conceptual maps
    - Frames
    - Description logic
    - Production rules
    - Fuzzy logic
    - Bayesian networks
    - Etc.

These are the ones that we will analyse

First order logic. Basic elements

We can establish mappings between logical symbols and domain objects (universe of discourse)



First order logic. Formalisation

- We have a robot that delivers boxes to offices. We know:
  - Boxes in room 27 are smaller than those in room 28.
  - All boxes in the same room are of the same size.
  - In a given moment in time, we know:
    - i) Box A is inside room 27 or 28 (we do not know which one).
    - ii) Box B is inside room 27.
    - iii) Box B is not smaller than box A.
  - We want to test whether box A is in room 27.

First order logic. Formalisation. Solution

- We have a robot that delivers boxes to offices. We know:
  - Boxes in room 27 are smaller than those in room 28.

    ∀x ∀y (box(x) ∧ inside (x,h27) ∧ box(y) ∧ inside (y,h28) → smallerThan(x,y))
  - All boxes in the same room are of the same size.

    ∀x ∀y ∀h (box(x) ∧ box(y) ∧ room(h) ∧ room(x,h) ∧ inside(y,h) → sameSizeAs(x,y))
  - In a given moment in time, we know :
    - i) Box A is inside room 27 or 28 (we do not know which one).

      box(a) ∧ room(h27) ∧ room(h28) ∧ (inside(a,h27) ∨ inside (a,h28))
    - ii) Box B is inside room 27.

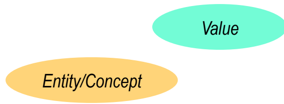
      box(b) ∧ inside(b,h27)
    - iii) Box B is not smaller than box A.

      ¬smallerThan(b,a)
  - We want to test whether box A is in room 27.

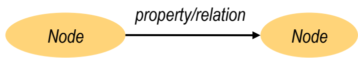
    inside(a,h27)?

Semantic Network. Basic elements

- Nodes
  - They represent entities or concepts, or values



- Edges
  - They represent properties or relations



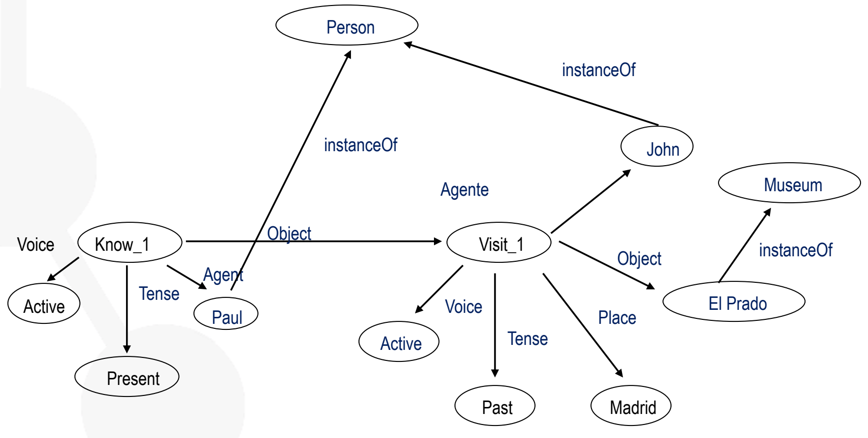
- The semantics (mapping to the real world) depends on the tags used for nodes and edges
- There is no predefined KR vocabulary
  - Although sometimes there are *structural* edges

Semantic networks. Example

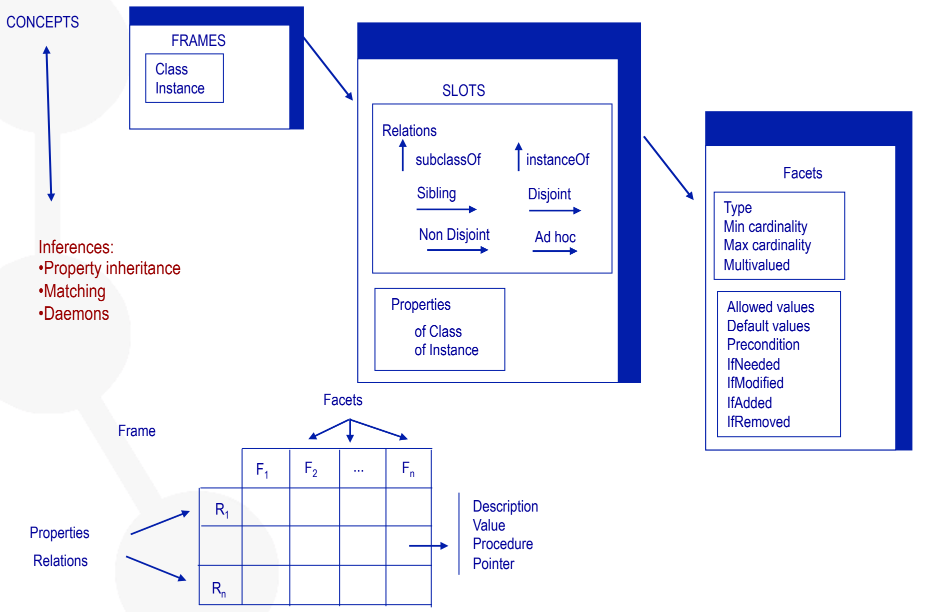
- Paul and John are persons
- El Prado is a museum
- Paul knows that John visited El Prado in Madrid

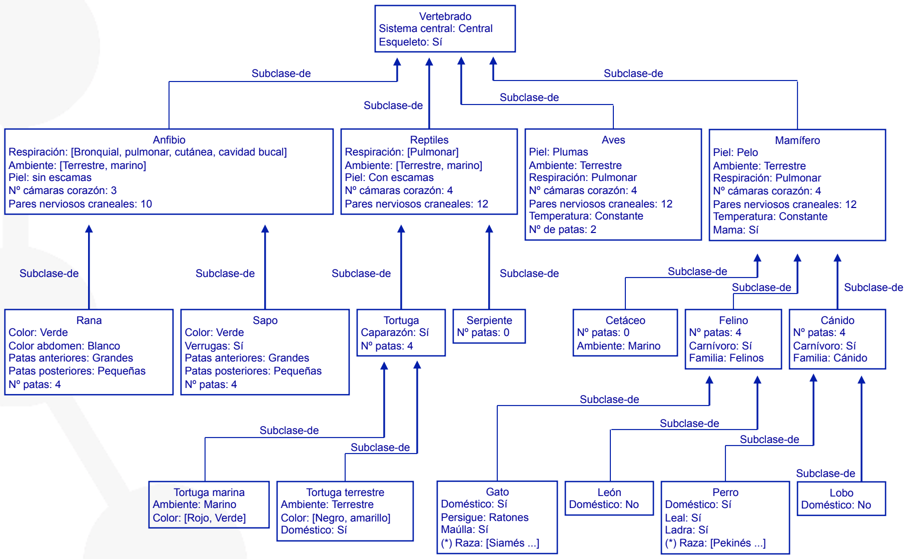
Semantic networks. Example. Solution

- Paul and John are persons
- El Prado is a museum
- Paul knows that John visited El Prado in Madrid



Frames. Basic elements



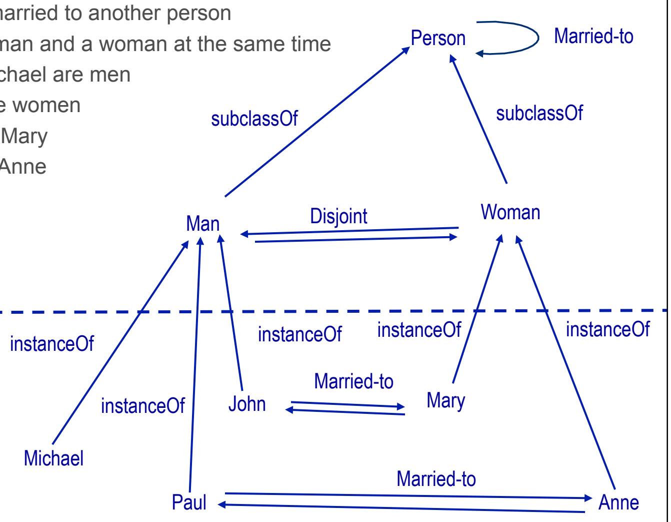


Frames. Example

- Men and women are persons
- A person can be married to another person
- Nobody can be a man and a woman at the same time
- John, Paul and Michael are men
- Mary and Anne are women
- John is married to Mary
- Paul is married to Anne

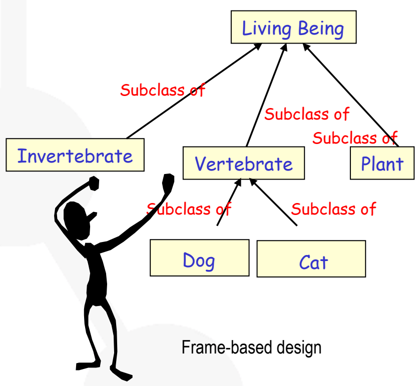
Frames. Example

- Men and women are persons
- A person can be married to another person
- Nobody can be a man and a woman at the same time
- John, Paul and Michael are men
- Mary and Anne are women
- John is married to Mary
- Paul is married to Anne

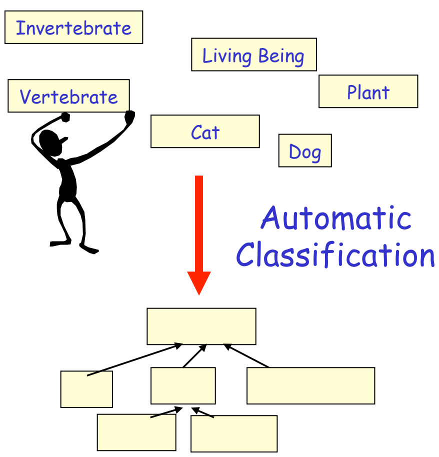


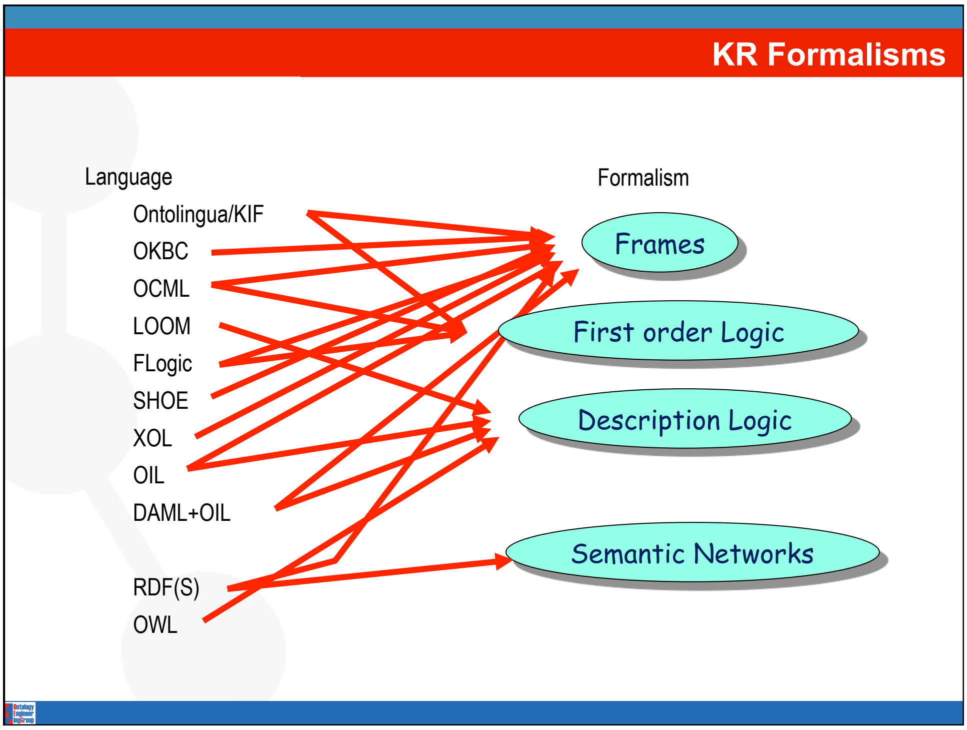
Description Logics. Basic elements

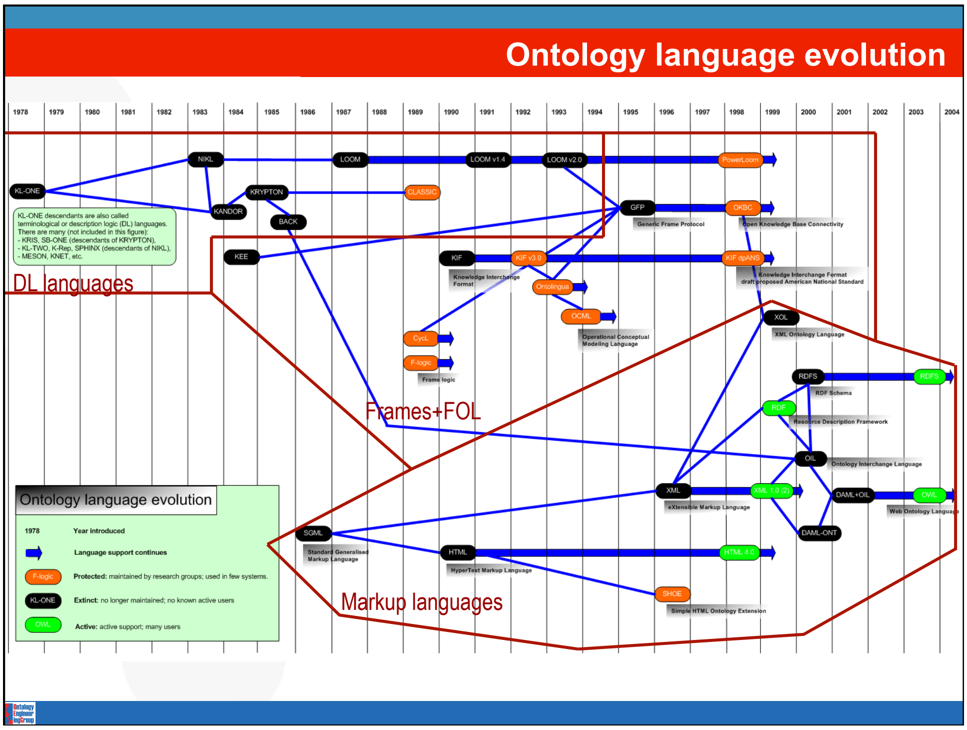
- A subset of first order logic with good reasoning properties
- Automatic classification



Frame-based design




KR Formalisms
Language
Formalism
Ontolingua/KIF
OKBC
OCML
LOOM
FLogic
SHOE
XOL
OIL
DAML+OIL
RDF(S)
OWL
Frames
First order Logic
Description Logic
Semantic Networks
Ontology Engineering Group


Ontology language evolution
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
KL-ONE
NIKL
LOOM
LOOM v1.4
LOOM v2.0
PowerLoom
KRYPTON
CLASSIC
KANDOR
BACK
KEE
GFP
Generic Frame Protocol
OKBC
Open Knowledge Base Connectivity
KIF
Knowledge Interchange Format
KIF v3.0
KIF dpANS
Knowledge Interchange Format draft proposed American National Standard
Ontolingua
OCML
Operational Conceptual Modeling Language
CycL
F-logic
Frame logic
XOL
XML Ontology Language
RDFS
RDF Schema
RDF
Resource Description Framework
OIL
Ontology Interchange Language
XML
eXtensible Markup Language
XML 1.0 (2)
DAML+OIL
OWL
Web Ontology Language
DAML-ONT
SGML
Standard Generalised Markup Language
HTML
HyperText Markup Language
HTML 4.0
SHOE
Simple HTML Ontology Extension
KL-ONE descendants are also called terminological or description logic (DL) languages.
There are many (not included in this figure):
- KRIS, SB-ONE (descendants of KRYPTON),
- KL-TWO, K-Rep, SPHINX (descendants of NIKL),
- MESON, KNET, etc.
DL languages
Frames+FOL
Markup languages
Ontology language evolution
1978 Year introduced
Language support continues
F-logic Protected: maintained by research groups; used in few systems.
KL-ONE Extinct: no longer maintained; no known active users
OWL Active: active support; many users
Ontology Engineering Group