Introduction to Knowledge Representation Formalisms

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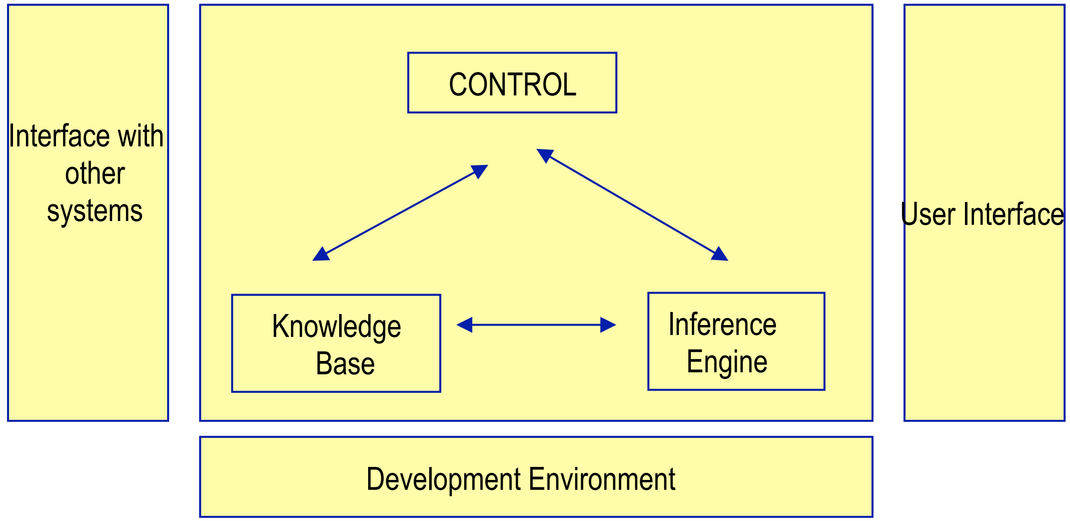
Architecture of a Knowledge-based System

Other interacting systems:
- Databases
- ...



- Explanation
- Knowlege capture

- Knowledge-based system generation tools
- Programming languages

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	*Set theory*
Constants	**Universe of discourse**
•a →	•Socrates
•b →	•Plato
•c →	•Aristotle
Predicate symbols	
•h →	person = {Socrates, Plato, Aristotle}
•m →	mortal = {Socrates, Plato, Aristotle}
•t →	masterOf = {(Socrates, Plato), (Plato, Aristotle)}
Formulae	
$\forall x\, (h(x) \rightarrow m(x))$ →	person $\subset$ mortal
$\exists x\, \exists y\, (h(x) \wedge h(y) \wedge t(x, y))$ →	masterOf $\neq \emptyset$ in the domain of persons
$h(a) \wedge h(b) \wedge h(c)$ →	Socrates, Plato, Aristotle $\in$ person

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.

    $\forall x\ \forall y\ (box(x) \wedge inside\ (x,h27) \wedge box(y) \wedge inside\ (y,h28) \rightarrow smallerThan(x,y))$
  - All boxes in the same room are of the same size.

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

      $box(a) \wedge room(h27) \wedge room(h28) \wedge (inside(a,h27) \vee inside\ (a,h28))$
    - ii) Box B is inside room 27.

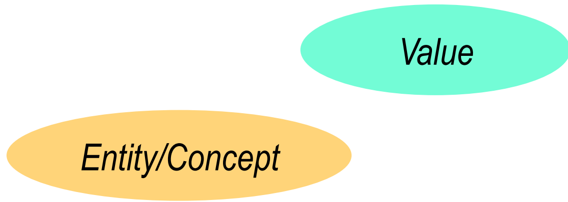
      $box(b) \wedge inside(b,h27)$
    - iii) Box B is not smaller than box A.

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

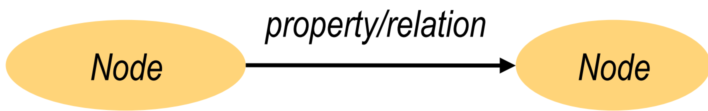
    $inside(a,h27)?$

Semantic Network. Basic elements

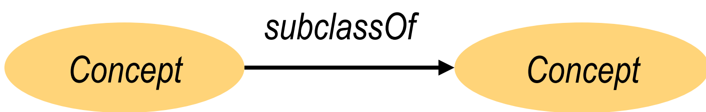
- Nodes
  - They represent entities or concepts, or values



- 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

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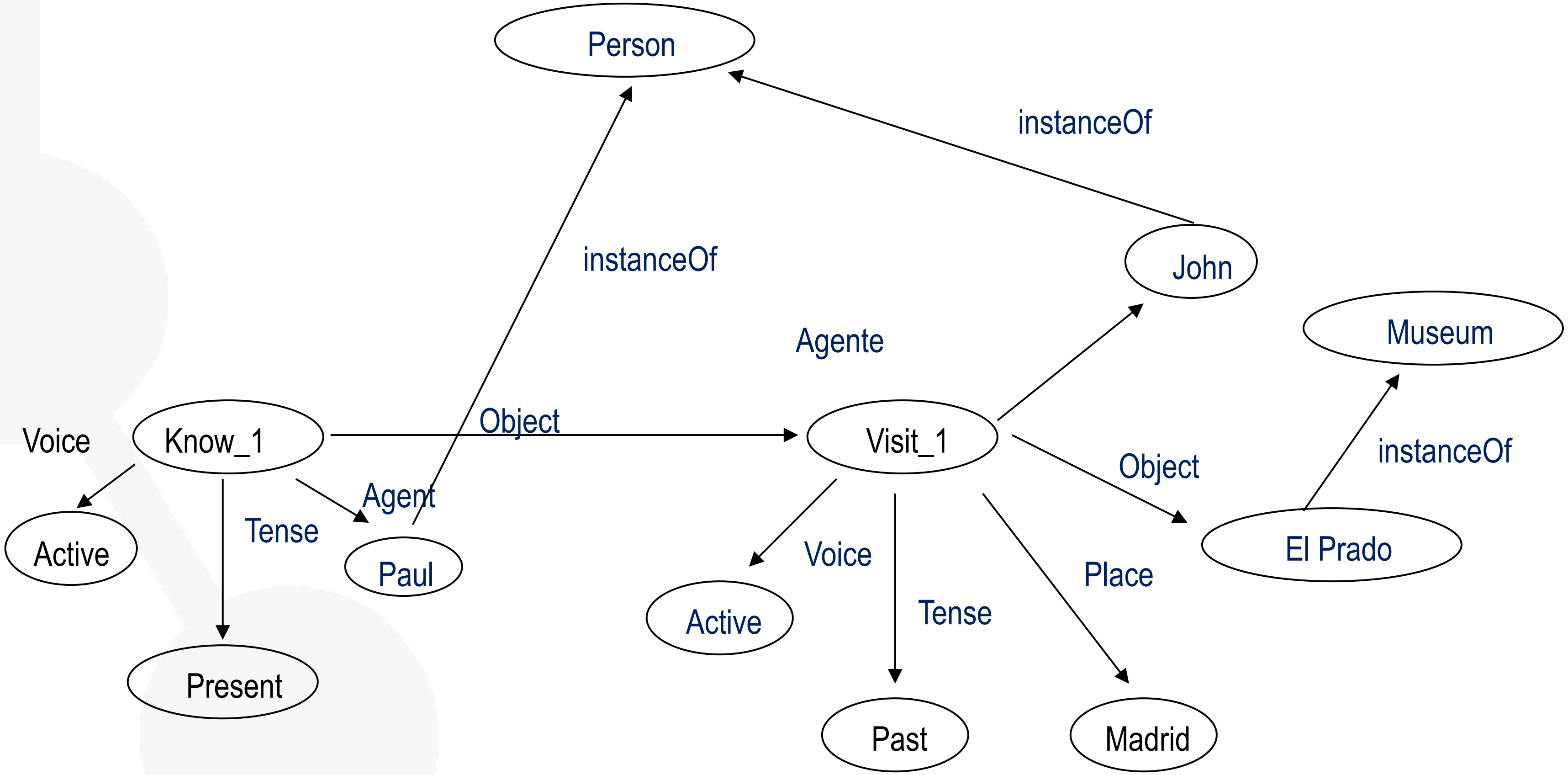
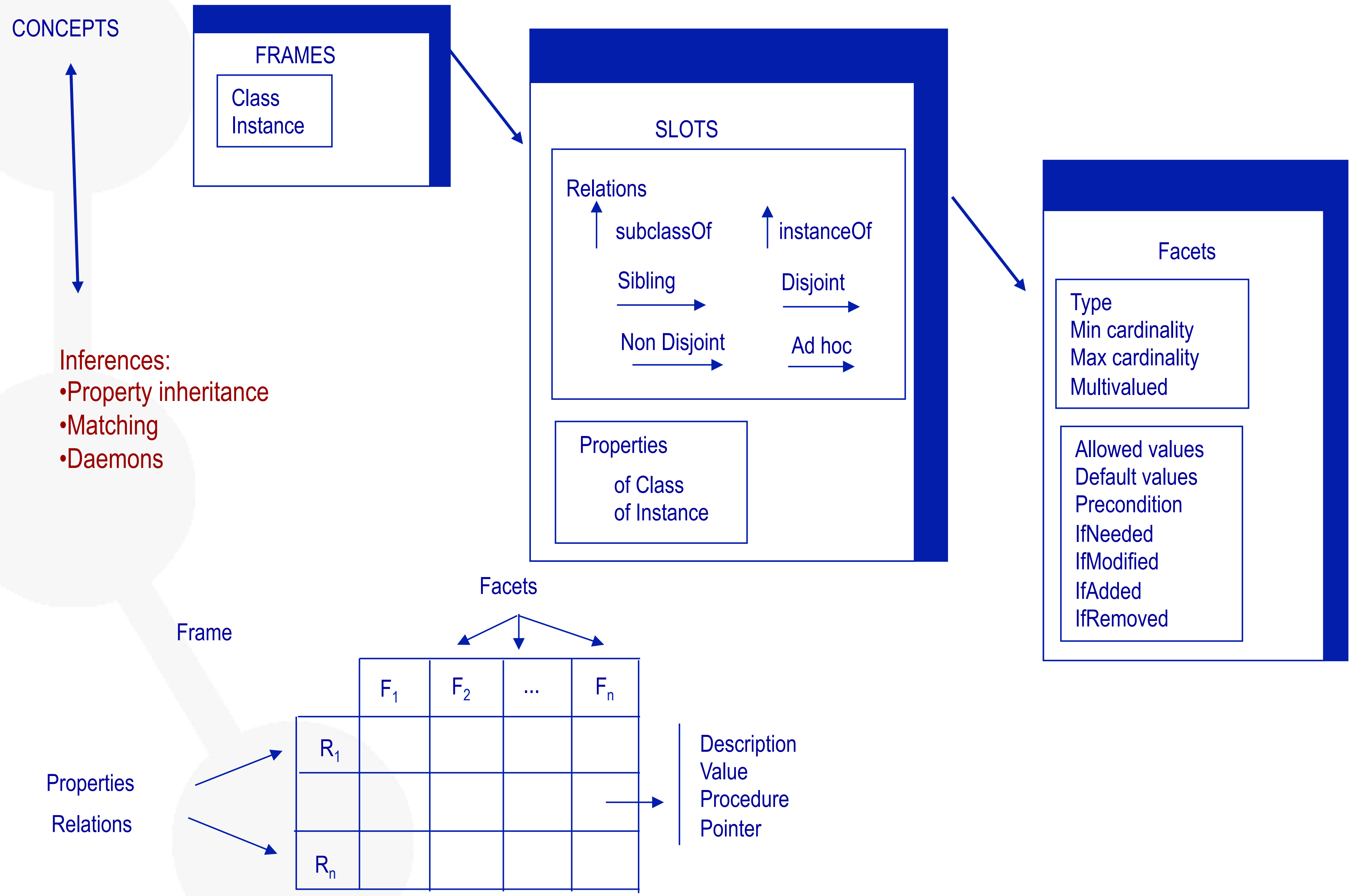
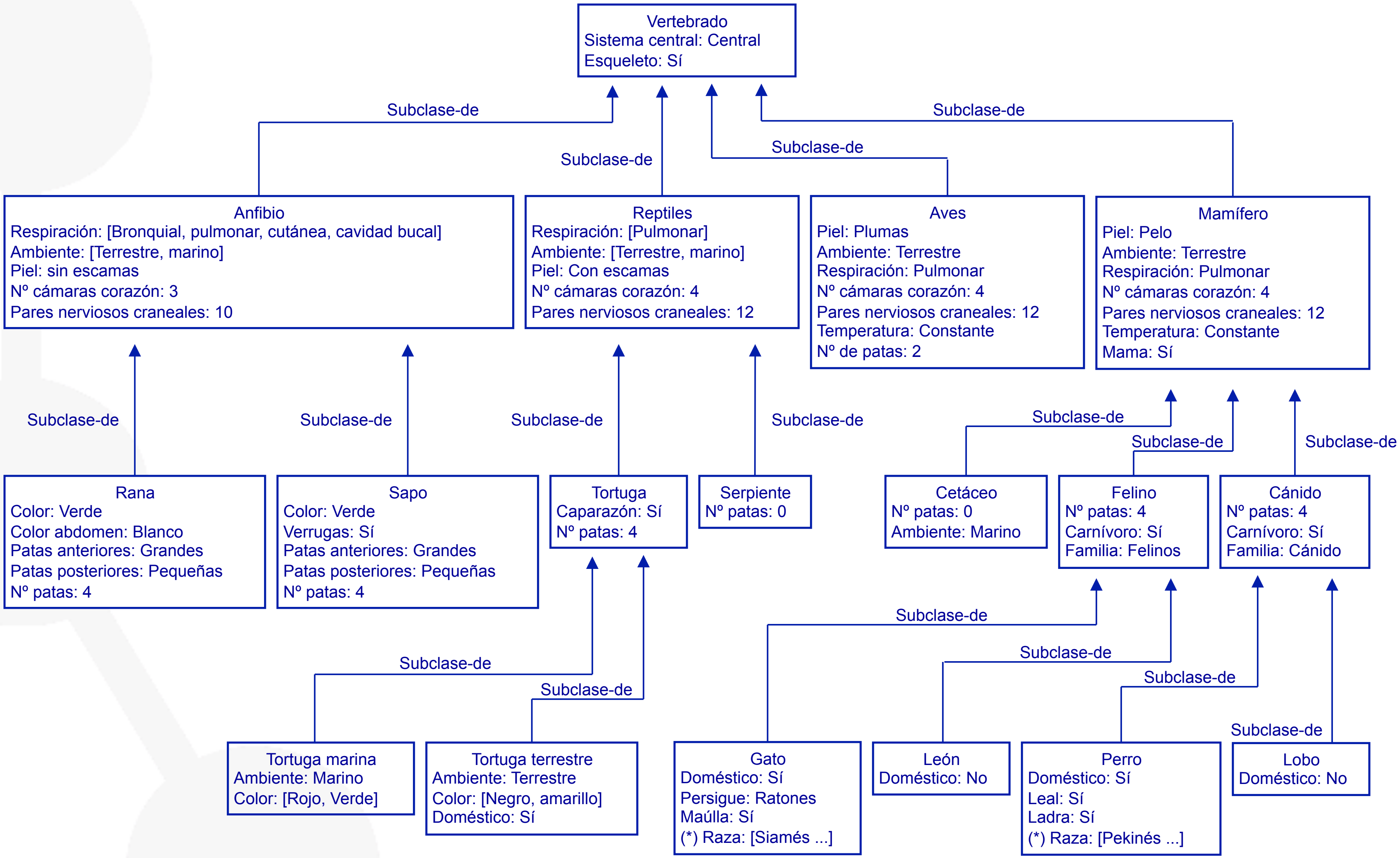


Frames. Basic elements





Vertebrado
Sistema central: Central
Esqueleto: Sí
Subclase-de
Subclase-de
Subclase-de
Subclase-de
Anfibio
Respiración: [Bronquial, pulmonar, cutánea, cavidad bucal]
Ambiente: [Terrestre, marino]
Piel: sin escamas
Nº cámaras corazón: 3
Pares nerviosos craneales: 10
Reptiles
Respiración: [Pulmonar]
Ambiente: [Terrestre, marino]
Piel: Con escamas
Nº cámaras corazón: 4
Pares nerviosos craneales: 12
Aves
Piel: Plumas
Ambiente: Terrestre
Respiración: Pulmonar
Nº cámaras corazón: 4
Pares nerviosos craneales: 12
Temperatura: Constante
Nº de patas: 2
Mamífero
Piel: Pelo
Ambiente: Terrestre
Respiración: Pulmonar
Nº cámaras corazón: 4
Pares nerviosos craneales: 12
Temperatura: Constante
Mama: Sí
Subclase-de
Subclase-de
Subclase-de
Subclase-de
Subclase-de
Subclase-de
Subclase-de
Rana
Color: Verde
Color abdomen: Blanco
Patas anteriores: Grandes
Patas posteriores: Pequeñas
Nº patas: 4
Sapo
Color: Verde
Verrugas: Sí
Patas anteriores: Grandes
Patas posteriores: Pequeñas
Nº patas: 4
Tortuga
Caparazón: Sí
Nº patas: 4
Serpiente
Nº patas: 0
Cetáceo
Nº patas: 0
Ambiente: Marino
Felino
Nº patas: 4
Carnívoro: Sí
Familia: Felinos
Cánido
Nº patas: 4
Carnívoro: Sí
Familia: Cánido
Subclase-de
Subclase-de
Subclase-de
Subclase-de
Subclase-de
Subclase-de
Tortuga marina
Ambiente: Marino
Color: [Rojo, Verde]
Tortuga terrestre
Ambiente: Terrestre
Color: [Negro, amarillo]
Doméstico: Sí
Gato
Doméstico: Sí
Persigue: Ratones
Maúlla: Sí
(*) Raza: [Siamés ...]
León
Doméstico: No
Perro
Doméstico: Sí
Leal: Sí
Ladra: Sí
(*) Raza: [Pekinés ...]
Lobo
Doméstico: No

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

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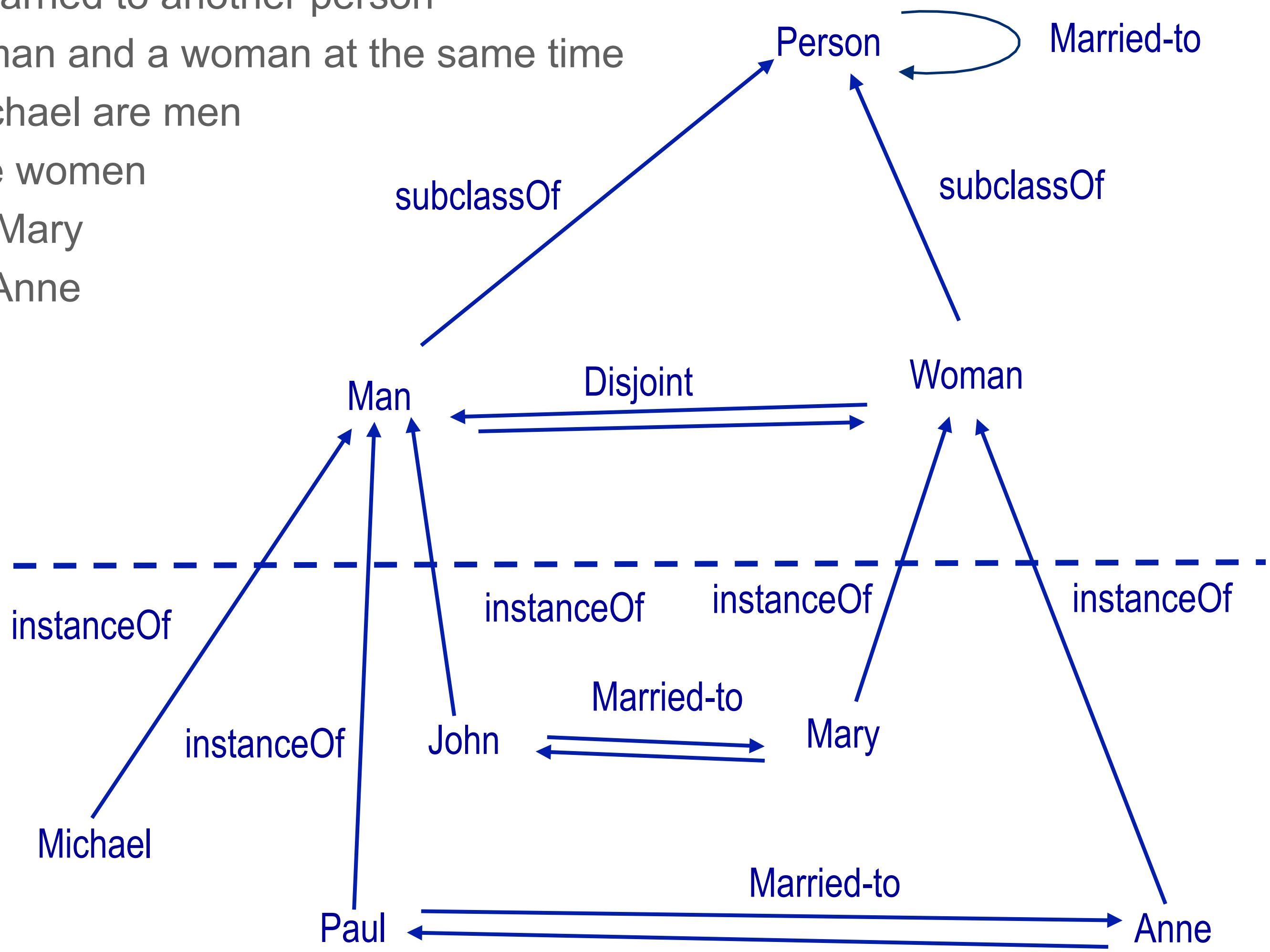
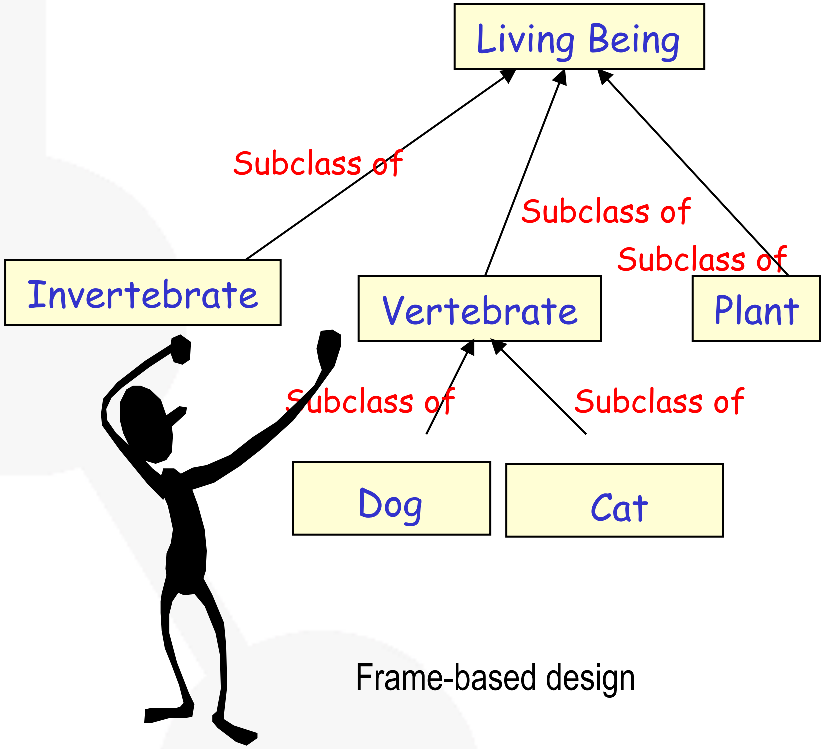
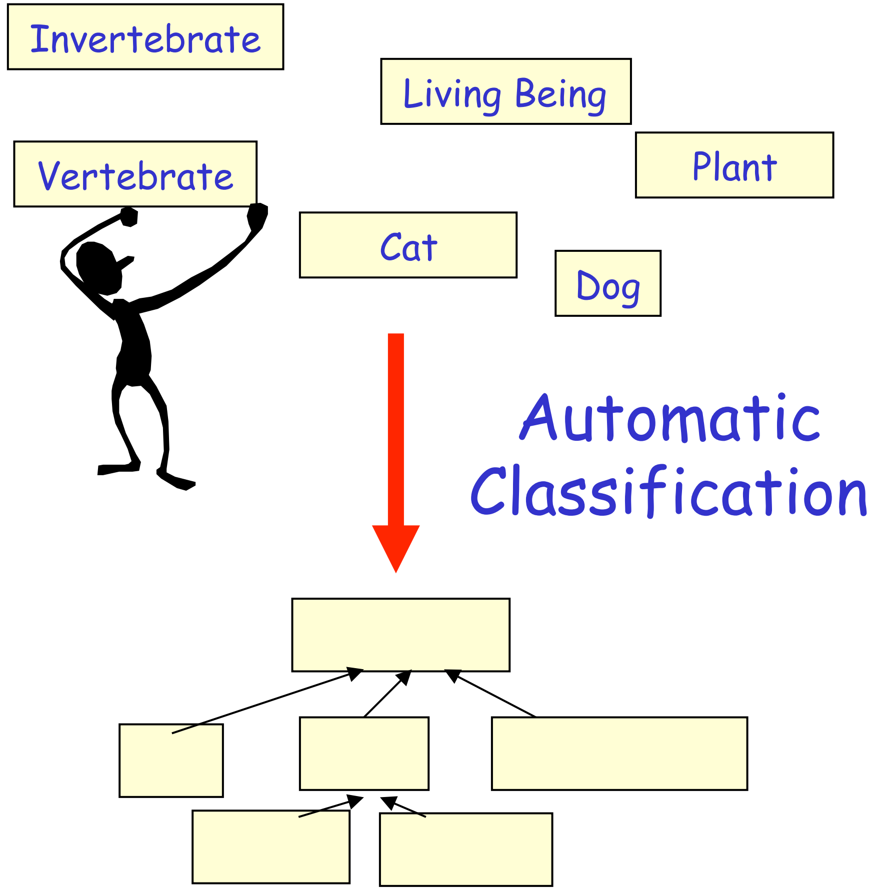


Description Logics. Basic elements

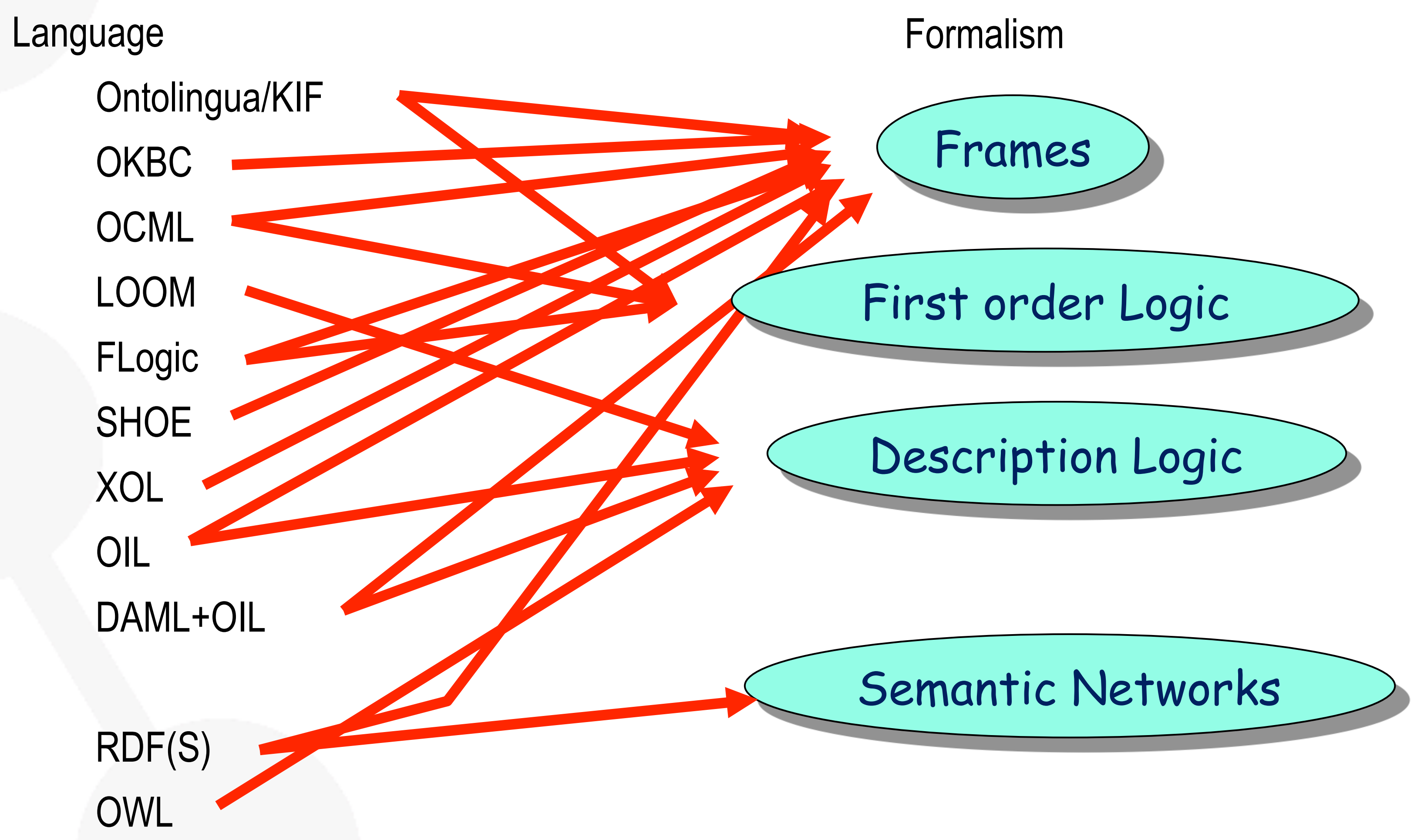
- A subset of first order logic with good reasoning properties
- Automatic classification



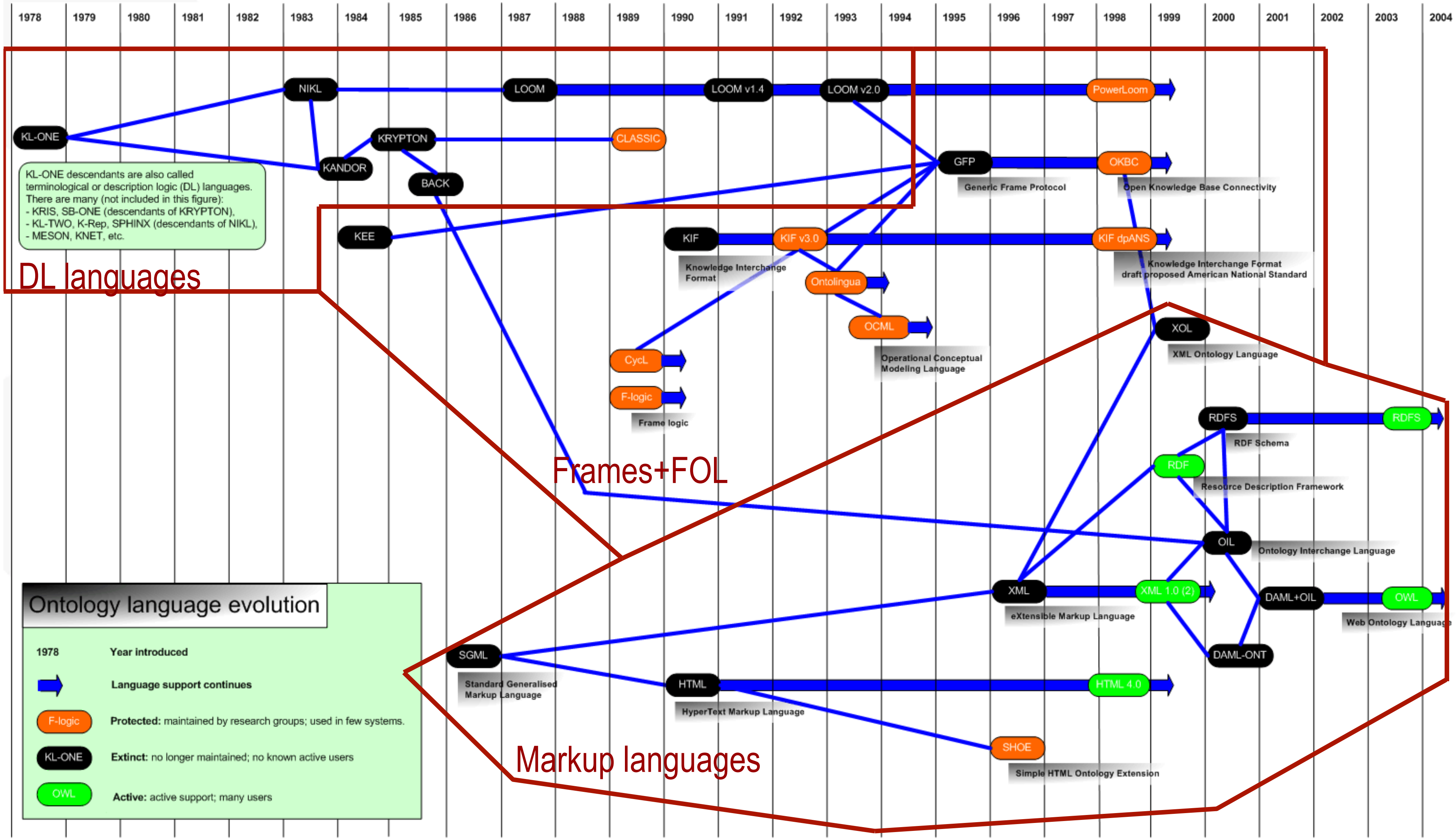
Frame-based design



KR Formalisms



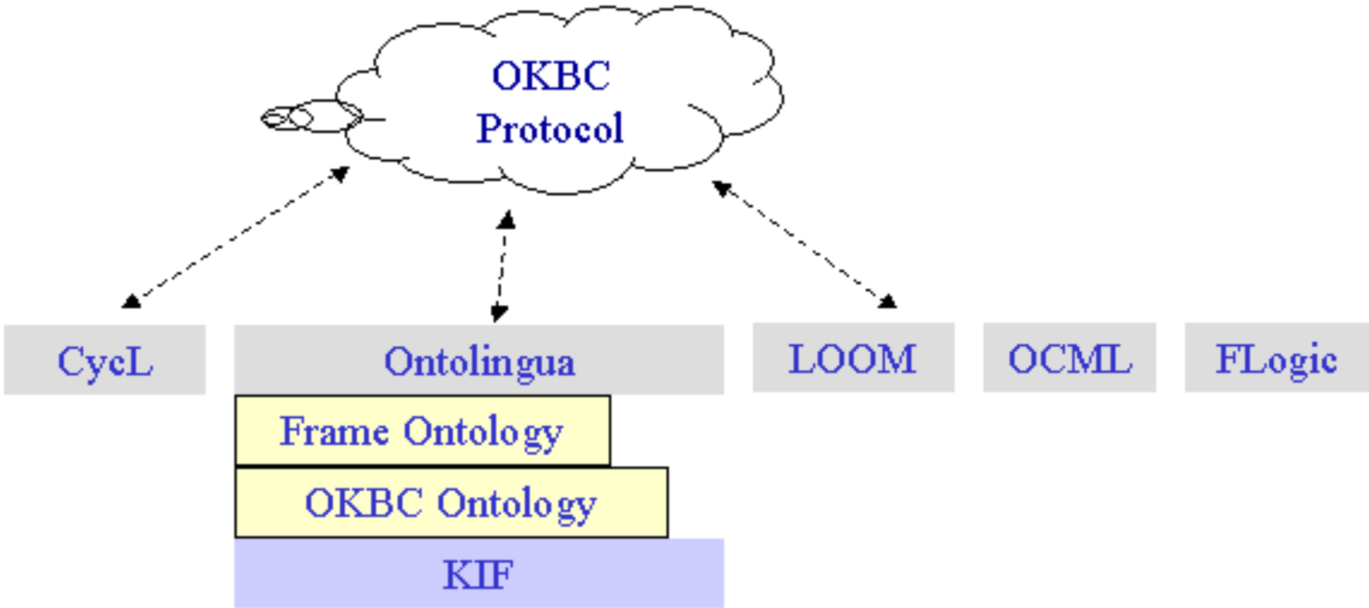
Ontology language evolution



Ontology Languages (I)

Traditional ontology languages

- Ontolingua/KIF
- OKBC
- OCML
- LOOM
- FLogic



Ontology Languages (II)

- Ontology markup languages
  - Standards & Recommendations of W3C
    - XML
    - RDF(S)
  - Ontology specification languages
    - SHOE
    - XOL
    - OIL
    - DAML+OIL
    - OWL