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Chapter 10
Knowledge Representation

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KR

- Last 3 chapters: syntax, semantics, and proof theory of propositional and first-order logic
- Chapter 10: what *content* to put into an agent's KB
- How to represent knowledge of the world

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Natural Kinds

- Some categories have strict definitions (triangles, squares, etc)
- Natural kinds don't
- Define a cup (distinguishing it from bowls, mugs, glasses, etc)
- Bachelor: is the Pope a bachelor?
- But logical treatment can be useful (can extend with typicality, uncertainty, fuzziness)

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Upper Ontologies

- An ontology is similar to a dictionary but with greater detail and structure
- Ontology: concepts, relations, axioms that formalize a field of interest
- Upper ontology: only concepts that are meta, generic, abstract; cover a broad range of domain areas
- IEEE Standard Upper Ontology Working Group
- Semantic Web paper, CYC project

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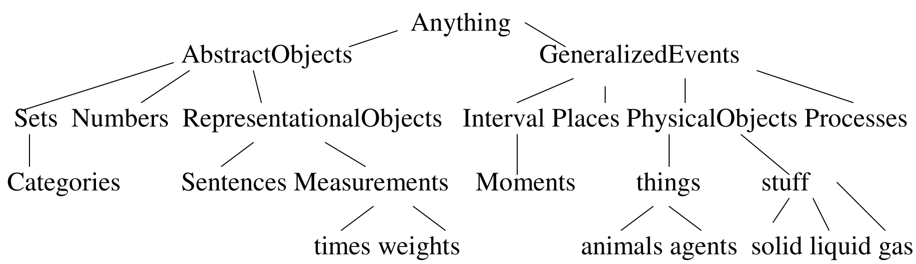

Lower concepts are specializations of their parents

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Categories and Objects

- I want to marry a Swedish woman
  - Category of Swedish woman?
  - A particular woman who is Swedish?
- Choices for representing categories: predicates or reified objects
- basketball(b) vs member(b,basketballs)
- Let's go with the reified version…

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Facts about categories and objects in FOL

- An *object* is a member of a *category*
- A *category* is a subclass of another *category*
- All members of a category have some properties (necessary properties)
- Members of a category can be recognized by some properties (sufficient properties)
- A category as a whole has some properties

Note: idealization of real categories

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Other Relationships

- disjoint (no members in common)
- exhaustive decomposition of a category (all members are in at least one of the sets)
- Partition: disjoint, exhaustive decomposition
- Examples in lecture

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Composite Objects

- partof(england,europe)
- All X,Y,Z ((partof(X,Y) ^ partof(Y,Z)) → partof(X,Z))
- Heavy(bunchOf({apple1,apple2,apple3}))
- Before continuing: inspiration for creative reification!
- From Through the Looking Glass

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Measures

- Diameter(basketball12) = inches(9.5)
- All XY ((member(X,dimestore) ^ sells(X,Y)) → cost(Y) = $(1))
- member(db1,dollarbills)
- member(db2,dollarbills)
- denomination(db1) = $(1)
- denomination(db2) = $(1)

There are multiple dollar bills, but a single $(1)

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Ordinal Comparisons

- But often scales are not so precisely defined
- Often, ordinal comparisons among members of categories are useful
- member(p1,poems) ^ member(p2,poems) ^ beauty(p1) < beauty(p2)

We don't have to say p1 has beauty 54.321

Qualitative physics: reasoning about physical systems without detailed equations and numerical simulations.

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Actions, Situations, Events, Time, Situation Calculus

- Next time

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Inheritance

- If a property is true of a class, it is true of all subclasses of that class
- If a property is true of a class, it is true of all objects that are members of that class
- (If a property is true of a class, it is true of all objects that are members of subclasses of that class)
- There are exceptions

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Semantic Networks

- Example of a special purpose KR
- Graphical aids for visualizing the knowledge base
- Efficient algorithms for inferring properties based on category membership
- Often, correspond to a subset of first-order logic
- Many variants
- All distinguish among individual objects, categories of objects and relations among objects

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Example

- See figure 10.9
- Specify what edges and nodes mean
- In Figure 10.9, individuals and categories look the same
- memberOf(indiv,category)
- sisterOf(indiv,indiv)
- subsetOf(category,category)
- hasMother(indiv,indiv)

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Semantic Networks

- How about hasMother(persons,femalePersons)?
- Nope: hasMother is a relation between individuals
- cat1--[label]→ cat2 means:
- all X X in cat1 → [all Y label(X,Y) → Y in cat2]

(So, this does not say that each person has a mother)

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Semantic Networks

- cat – label → value
- All X X in cat → label(X,value)

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Inheritance

- Inheritance is efficient and convenient
- Trace paths from individuals to categories, inheriting properties as you go
- In Figure 10.9, how many legs does John have? Most specific (nearest) information wins
  - Default information

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Semantic Networks

- In a semantic network, only binary relations are possible
- A richer representation is possible by reifying propositions and events
- This forces creation of a rich ontology of reified concepts; many current ideas originated in semantic network systems

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Description Logics

- Evolved from semantic networks
  - *Old:* emphasis on taxonimc structure
  - *New:* formalization, emphasis on tractability

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Mental Events

- Beliefs, Knowledge, Desires, Intentions..
- Useful in NLP, Planning

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