Semantic Data Modeling

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THE SEMANTIC WEB VISION

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Semantic Web Enabled B2B Electronic Commerce

- Businesses enter partnerships
- Standard abstract domain models
- Translation services for data exchange
- Software agents:
  - Auctioning
  - Negotiations
  - Drafting contracts

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Ontology

- Philosophy
  - The study of the nature of existence
- Computer Science
  - Explicit and formal specification of a conceptualization

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Typical Components of Ontologies

- Terms denote important concepts
  - e.g. professors, staff, students, courses, departments
- Relationships between these terms
  - e.g. a class C is a subclass of another class C’
  - e.g. all professors are staff members

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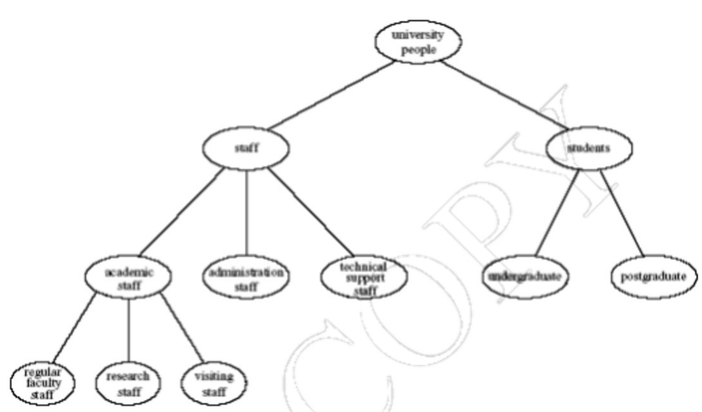
Example of a Class Hierarchy



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Further Components of Ontologies

- Properties:
  - e.g. X teaches Y
- Value restrictions
  - e.g. only faculty members can teach courses
- Disjointness statements
  - e.g. faculty and general staff are disjoint
- Logical relationships between objects
  - e.g. every department must include at least 10 faculty

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The Role of Ontologies

- Shared understanding of a domain: semantic interoperability
  - overcome differences in terminology
  - mappings between ontologies

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Web Ontology Languages

- RDF Schema
  - Data model for objects and relations between them
  - Describes properties and classes of RDF resources
  - Generalization hierarchies

Web Ontology Languages

- OWL
  - A richer ontology language
  - Relations between classes
    - e.g., disjointness
  - Cardinality
    - e.g., “exactly one”
  - Characteristics of properties
    - e.g., symmetry

Logic: Proof Theory

- Syntax:
  - Terms (entities)
    - `John, Joe, CS548, Fall2014`
  - Predicates (verbs)
    - `ancestor, enrolledIn`
  - Statements
    - `enrolledIn(John,CS548)`
    - `John enrolledIn CS548`
  - Logical Connectives (implication →)
    - `parent(X,Y)` → `ancestor(X,Y)`

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Logic: Proof Theory

- Inference Rules:
  - Modus Ponens: If I have
  - a proof of (P → Q) and
  - a proof of P
  - then I can prove Q
- Example
  - Rule: `parent(X,Y)` → `ancestor(X,Y)`
  - Fact: parent(Joe,Mary)
  - Deduce: ancestor(`Joe,Mary`)

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Logic: Proof Theory

- Example
  - Rule: `parent(X,Y)` $\rightarrow$ `ancestor(X,Y)`
  - Rule: `ancestor(X,Y) & ancestor(Y,Z)` $\rightarrow$ `ancestor(X,Z)`
  - Fact: `parent(Joe,Mary)`
  - Fact: `parent(Mary,Susan)`
  - Deduce: `ancestor(Joe,Mary)`
  - Deduce: `ancestor(Mary,Susan)`
  - Deduce: `ancestor(Joe,Susan)`

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Logic: Model Theory

- Semantics: meaning for the symbols
- Unary predicates = sets
  - **Predicate**: `faculty(X)`
  - **Interpretation**: set of faculty members {Joe,…}
- N-ary predicates = relations
  - **Predicate**: `parent(X,Y)`
  - **Interpretation**: set of pairs {(Joe,Mary), (Mary, Susan), …}

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Logic: Model Theory

- Logical entailment:
  - **Statement**: (`Researcher(X) → Faculty(X))`
  - **Interpretation**:
    `If X ∈ Researcher then X ∈ Faculty`
  - **Statement**:
    `parent(X,Y) → ancestor(X,Y)`
  - **Interpretation**:
    `If (X,Y) ∈ parent`
    `then (X,Y) ∈ ancestor`

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Ontology vs Logic

- Logic: general language for inference
  - Prove: if P is true, then Q is true
  - Computationally expensive
  - Godel’s Incompleteness Theorem
  - Datalog

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Ontology vs Logic

- Ontology languages: restricted
  - Entities, and relationships between them
  - Restricted implication
  - If $x \in A$, then $x \in B$ *if A subclass of B*
  - If $P(x,y)$, then $Q(x,y)$ *if P subproperty of Q*