Artificial Intelligence
Chapter 18
Representing Commonsense Knowledge

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Outline

- The Commonsense World
- Time
- Knowledge Representations by Networks
- Additional Readings and Discussion

18.1 The Commonsense World

- What Is Commonsense Knowledge?
  - Most people know the fact that a liquid fall out if the cup is turned upside down. But how can we represent it ?
  - Commonsense knowledge
    - If you drop an object, it will fall.
    - People don't exist before they are born.
    - Fish live in water and will die if taken out.
    - People buy bread and milk in a grocery store.
    - People typically sleep at night.

18.1.2 Difficulties in Representing Commonsense Knowledge

- How many will be needed by a system capable of general human-level intelligence? No on knows for sure.
- No well-defined frontiers
- Knowledge about some topics may not be easily captured by declarative sentences.
  - Description of a human face
- Many sentences we might use for describing the world are only approximations.

18.1.3 The Importance of Commonsense Knowledge

- Machine with commonsense
  - The knowledge such a robot would have to have!
- Commonsense knowledge for expert systems
  - To recognize outside of the specific area, to predict more accurately.
- Commonsense for expanding the knowledge of an expert system
- To understanding natural language

18.1.4 Research Areas

- Currently not available system with commonsense but,
  - Object and materials : describing materials and their properties
  - Space : formalizing various notions about space
  - Physical properties : mass, temperature, volume, pressure, etc.
  - Physical Processes and events : modeling by differential equations v.s. qualitative physics without the need for exact calculation
  - Time : developing techniques for describing and reasoning about time

18.2 Time

- How are we to think about time?
  - Real line: extending both into infinite past and infinite future
  - Integer: countable from beginning with 0 at 'big bang'
- [James 1984, Allen 1983]
  - Time is something that events and processes occur in.
  - "Interval" : containers for events and processes.
- Predicate calculus used for describing interval
  - Occurs(E, I) : some event or process E, occupies the interval I.
  - Interval has starting and ending time points.

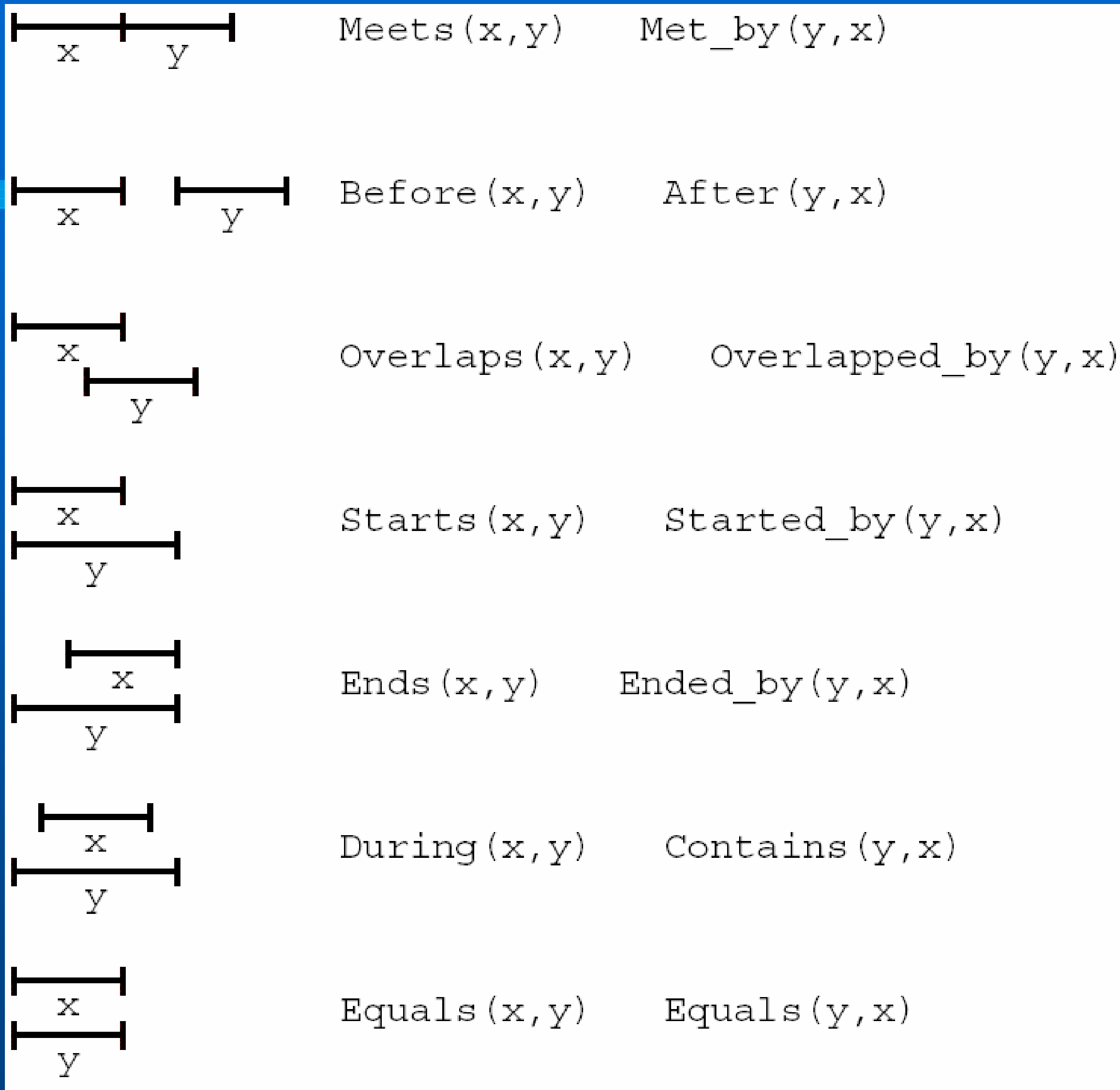

Figure 18.1 Relation between Intervals

18.3 Knowledge Representation by Networks
18.3.1 Taxonomic Knowledge

- The entities of both commonsense and expert domains can be arranged in hierarchical structures that organize and simplify reasoning.
- CYC system [Guha & Lenat 1990]
- Taxonomic hierarchies : encoded either in networks or data structure called *frames*.
- Example
  - "Snoopy is a laser printer, all laser printers are printers, all printers are machines."

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Laser_printer(Snoopy)
(∀x)[Laser_printer(x) ⊃ Printer(x)]
(∀x)[Printer(x) ⊃ Office_machine(x)]
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18.3.2 Semantic Networks

- Definition : graph structures that encode taxonomic knowledge of objects and their properties
- Two kinds of nodes
  - Nodes labeled by relation constants corresponding to either taxonomic categories or properties
  - Nodes labeled by object constants corresponding to objects in the domain
- Three kinds of arcs connecting nodes
  - Subset arcs (*isa* links)
  - Set membership arcs (*instance* links)
  - Function arcs

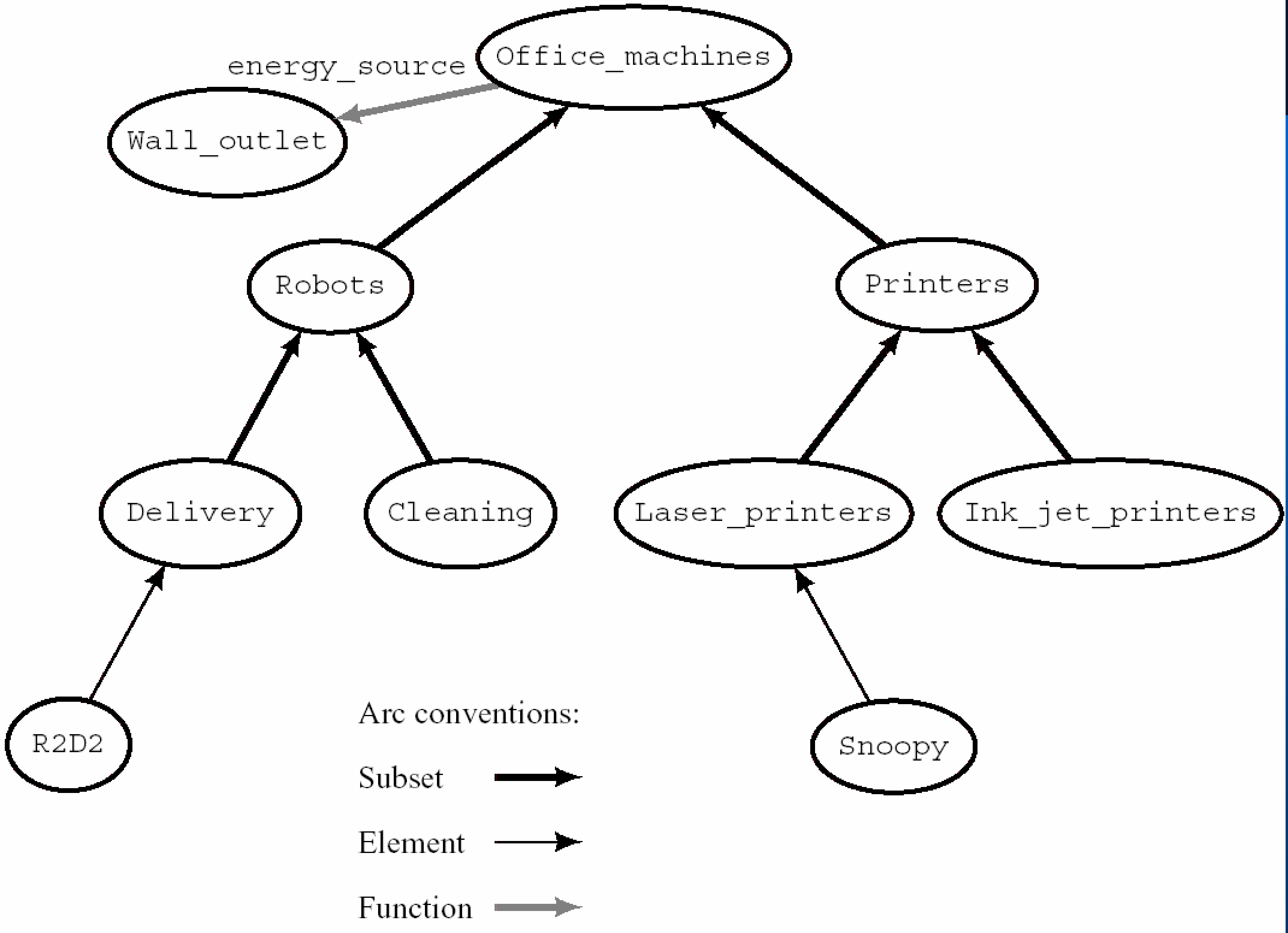
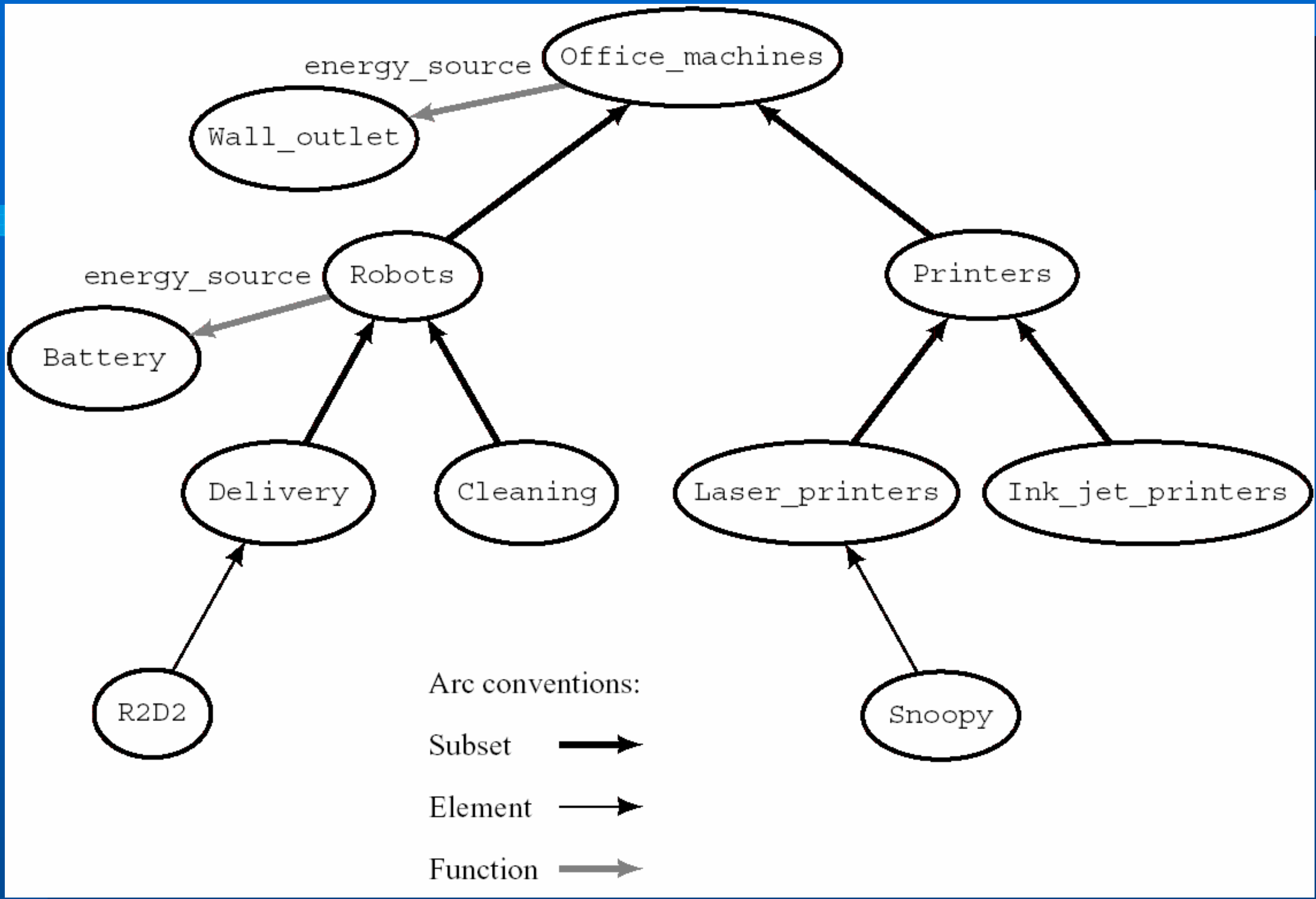


Figure 18.2 A Semantic network

18.3.3 Nonmonotonic Reasoning in Semantic Networks

- Reasoning in ordinary logic is monotonic.
  - Because adding axioms to a logical system does not diminish the set of theorems that can be proved.
- We must retract the *default inference* if new contradictory knowledge arrives.
  - Default inference : barring knowledge to the contrary, we are willing to assume are true.
- Example of nonmonotonic reasoning : *cancellation of inheritance*.
  - By default, the energy source of office machines is electric wall outlet. But the energy source of a robot is a battery.



- Figure 18.3 A Semantic Network for Default Reasoning
  - Adding another function arc
  - Contradiction from *property inheritance* can be resolved by the way in which information about the most specific categories takes precedence over less specific categories.

18.3.4 Frames

- Frame is a Data structure which has a name and a set of attribute-value pairs (*slots*).
  - The frame name corresponds to a node in a semantic network.
  - The attributes (*slot names*) correspond to the names of arcs associated with this node
  - The values (*slot fillers*)correspond to nodes at the other ends of these arcs.
- Semantic networks and frames do have difficulties in expressing certain kinds of knowledge
  - Disjunctions, negations, nontaxonomic knowledge
- Hybrid system : KRYPTON, CLASSIC
  - Use *terminological logic* (employing hierarchical structures to represnent entities, classes, and properties and logical expressions for other information).

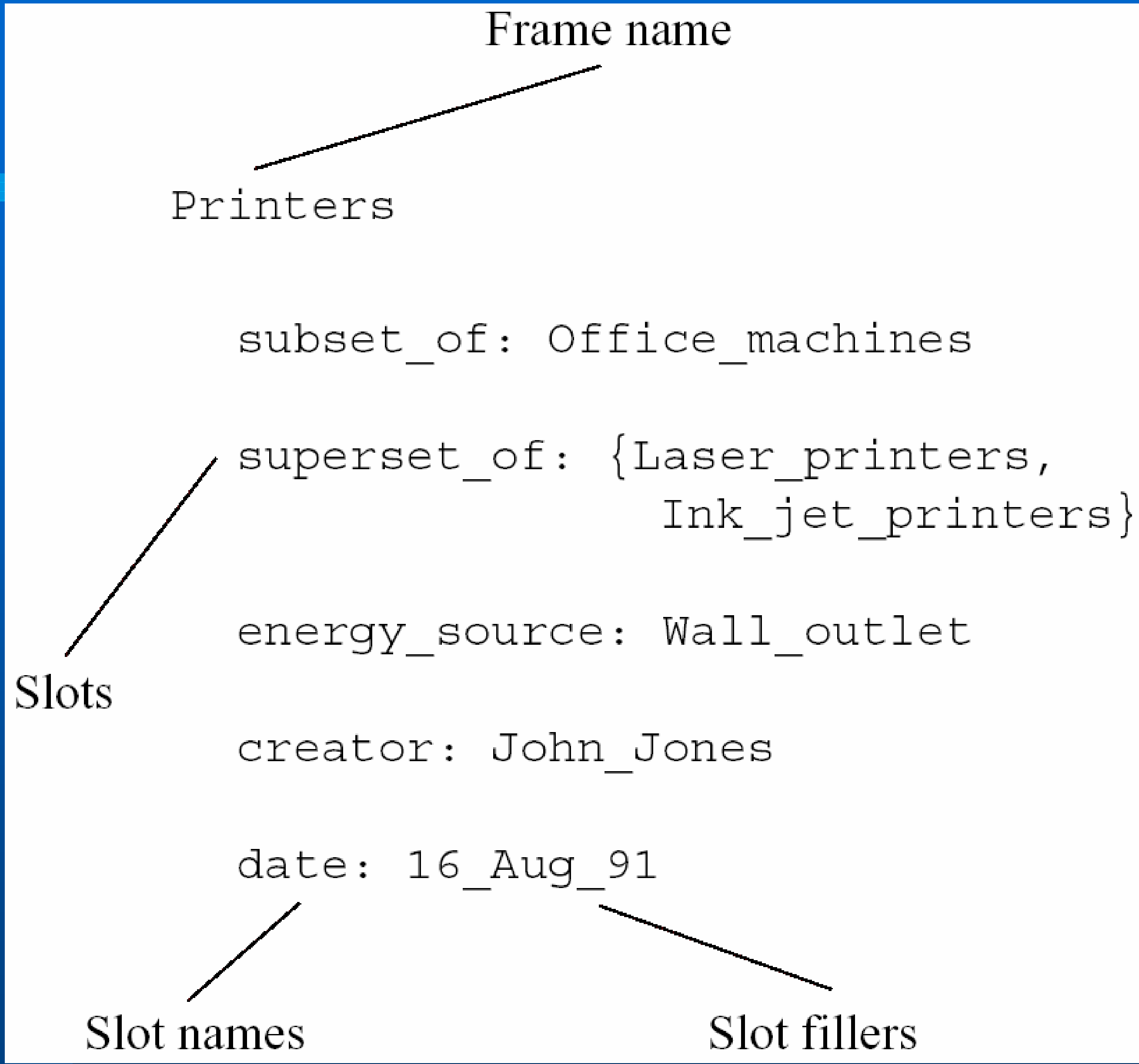


Figure 18.5 A Frame

Additional Reading and Discussion

- [Davis 1990, Hobbs & Moore 1985]
  - More commonsense representation and reasoning methods
- [Lenat & Guha 1990]
  - CYC
- [Sowa 1991]
  - Edited collection of papers
- [Ginsberg 1987]
  - Nonmonotonic reasoning
- [Gentner 1983]
  - Analogical reasoning