

Ontologies and Semantic Networks

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Russell and Norvig, 3rd Edition, Section 12.5.1

These slides are new and can contain mistakes and typos.
Please report them to Sven (skoenig@usc.edu).

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Ontology

- Ontology = a model for describing the world that consists of a set of types, properties, and relationship types

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Example: Taxonomic Knowledge

- “All office machines get their energy from wall outlets.”
- “All printers are office machines.”
- “All laser printers are printers.”
- “Hobbes is a laser printer.”

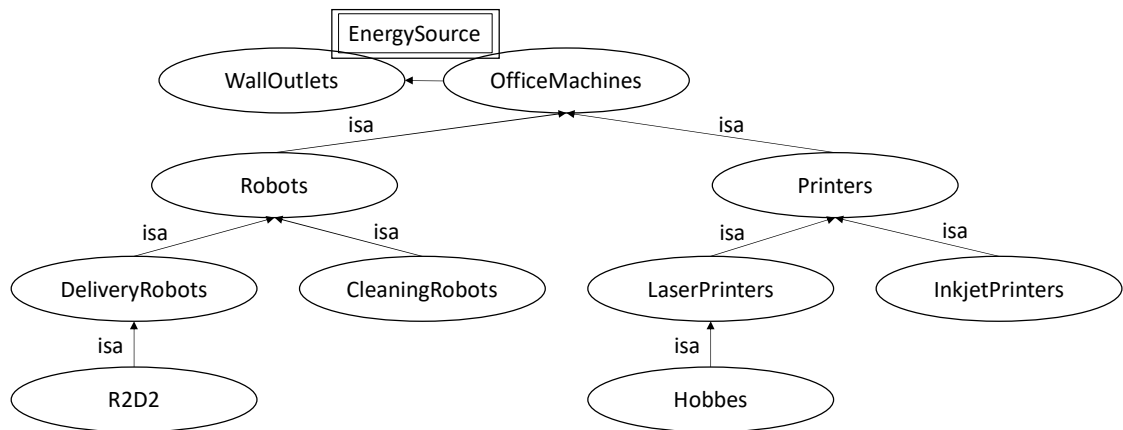
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Example: Taxonomic Knowledge

- Knowledge base in first-order logic
 - $\text{FORALL } x \text{ IsOfficeMachine}(x) \text{ IMPLIES EnergySource}(x, \text{WallOutlet})$
 - $\text{FORALL } x \text{ IsPrinter}(x) \text{ IMPLIES IsOfficeMachine}(x)$
 - $\text{FORALL } x \text{ IsLaserPrinter}(x) \text{ IMPLIES IsPrinter}(x)$
 - $\text{IsLaserPrinter}(\text{Hobbes})$
- We can use resolution to show that the knowledge base entails
 - $\text{EnergySource}(\text{Hobbes}, \text{WallOutlet})$
- But the knowledge base and resolution are difficult to understand by non-experts and resolution is often slow (and non-trivial to implement), so we are looking for alternative ways to represent knowledge and reason with it.

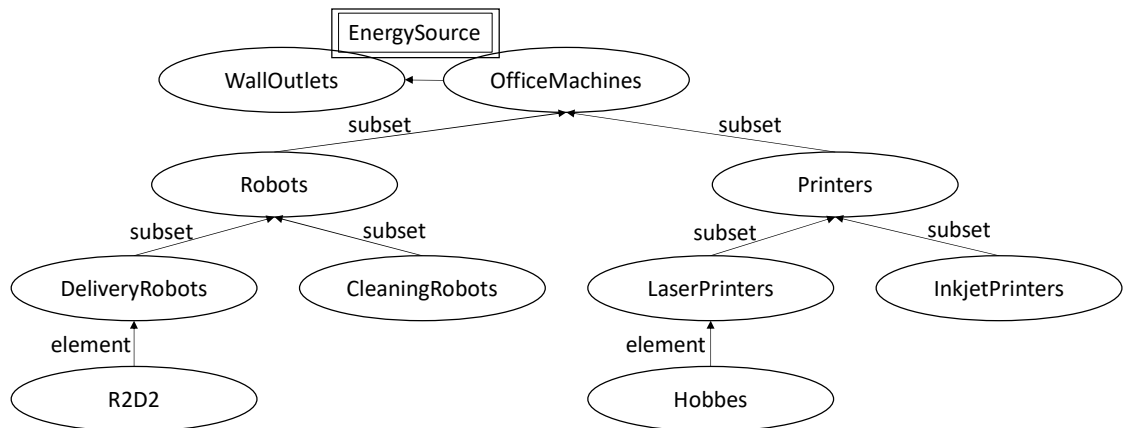
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Semantic Networks



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Semantic Networks



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Semantic Networks

$A \xrightarrow{\text{subset}} B$ $\text{FORALL } x (A(x) \text{ IMPLIES } B(x))$

Cats $\xrightarrow{\text{subset}}$ Mammals

$A \xrightarrow{\text{element}} B$ $B(A)$

Bill $\xrightarrow{\text{element}}$ Cats

$A \xrightarrow{R} B$ $R(A,B)$

Bill $\xrightarrow{\text{Age}}$ 12

$A \xrightarrow{\boxed{R}} B$ $\text{FORALL } x (A(x) \text{ IMPLIES } R(x,B))$

Birds $\xrightarrow{\boxed{\text{Legs}}}$ 2

$A \xrightarrow{\boxed{\boxed{R}}} B$ $\text{FORALL } x (A(x) \text{ IMPLIES EXISTS } y (B(y) \text{ AND } R(x,y)))$

Birds $\xrightarrow{\boxed{\boxed{\text{Parent}}}}$ Birds

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Semantic Networks

- How would you depict “R2D2 is not a cleaning robot”?
- How would you depict “R2D2 is a delivery or cleaning robot”?

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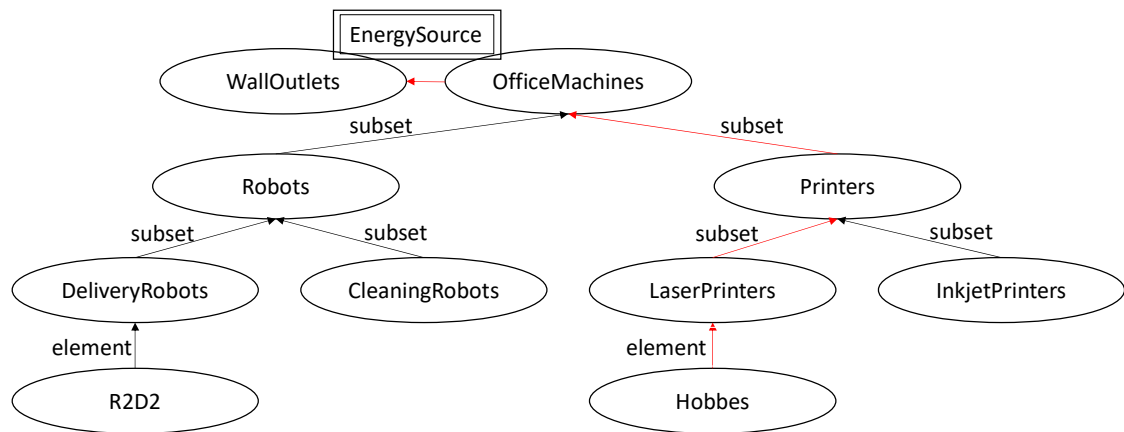
Semantic Networks

- A special purpose reasoning procedure (“pointer following”) makes reasoning about properties easy, using the inheritance of properties.

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Semantic Networks

- What’s the energy source of Hobbes?



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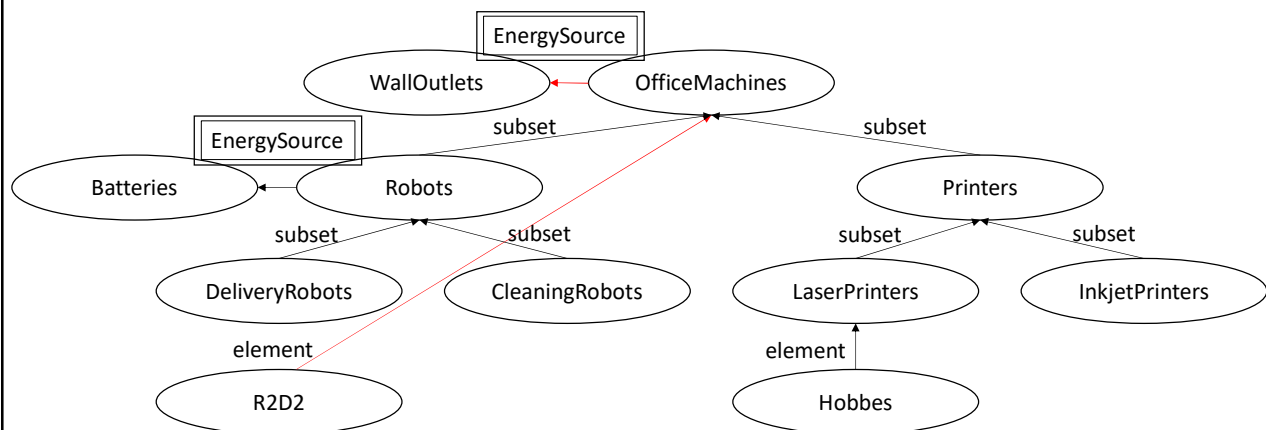
Semantic Networks

- “Yesterday, I looked out of the window and saw a bird.”
 - Do you think that the bird I saw could (likely) fly?
 - Why do people jump to conclusions here? They reason with defaults.
- “Let me continue. It had a broken wing and sat on the ground.”
 - If you thought that the bird could fly, you now need to revise your conclusion.
 - This cannot be done (in straight-forward ways) with first-order logic since first-order logic is monotonic, meaning that $KB \text{ AND } KB' \models S$ whenever $KB \models S$.
 - For example, $\text{IsBird}(\text{Tweety}) \text{ AND } \text{BrokenWing}(\text{Tweety}) \models \text{CanFly}(\text{Tweety})$ if $\text{IsBird}(\text{Tweety}) \models \text{CanFly}(\text{Tweety})$.
 - However, default reasoning can be done easily with semantic networks.

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Semantic Networks

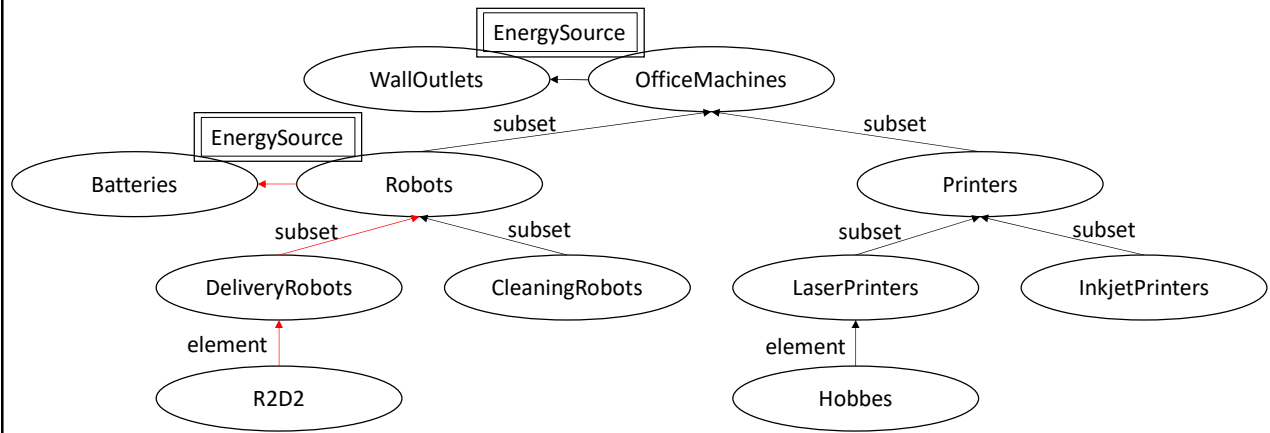
- “R2D2 is an office machine.”



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Semantic Networks

- “Let me continue. In fact, R2D2 is a delivery robot.”



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Frames (very similar to semantic networks)

Printers	
SubsetOf:	OfficeMachines
SupersetOf:	{LaserPrinters, InkjetPrinters}
EnergySource:	WallOutlet
Creator:	Sven Koenig
Date:	Sep 10, 2018

Hobbes	
ElementOf:	LaserPrinters
EnergyConsumption:	180 Watt/hour
EnergyCostPerHour:	Utility:EnergyCost * this:EnergyConsumption
Creator:	Sven Koenig
Date:	Feb 23, 2015

→ spreadsheet-type calculation via “procedural attachment”
 → meta information

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Semantic Networks and Frames

- Properties (some versus first-order logic)
 - Knowledge base (appears) easy to understand by humans but semantics is often not well defined in practice
 - Problems with multiple inheritance of incompatible properties
 - More expressive than first-order logic with regard to default reasoning and procedural attachments
 - Less expressive (or more complicated) than first-order logic with regard to some logical operators such as negation and disjunction
 - Reasoning easy to implement and efficient but limited in capability due to special-purpose reasoning procedures
 - Some reasoning (such as inheritance) is easy to explain to non-experts