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).

Ontology

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

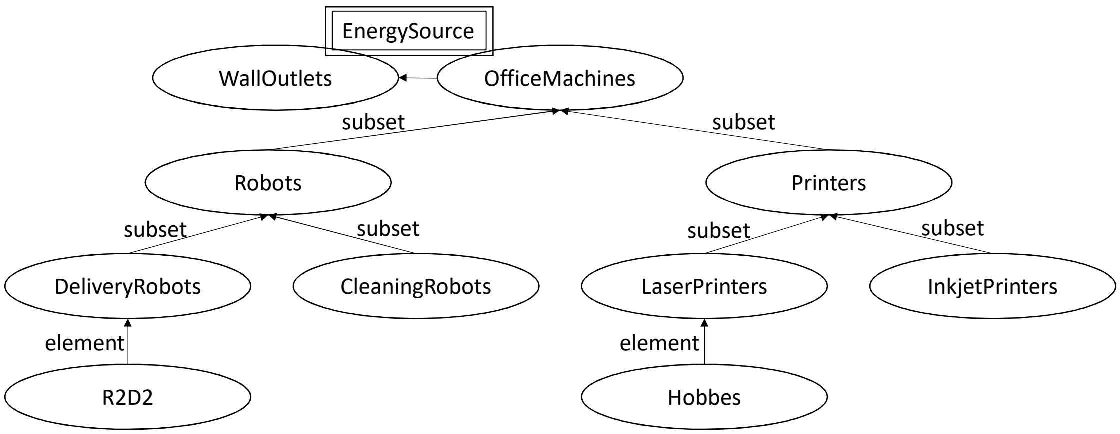
Example: Taxonomic Knowledge

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

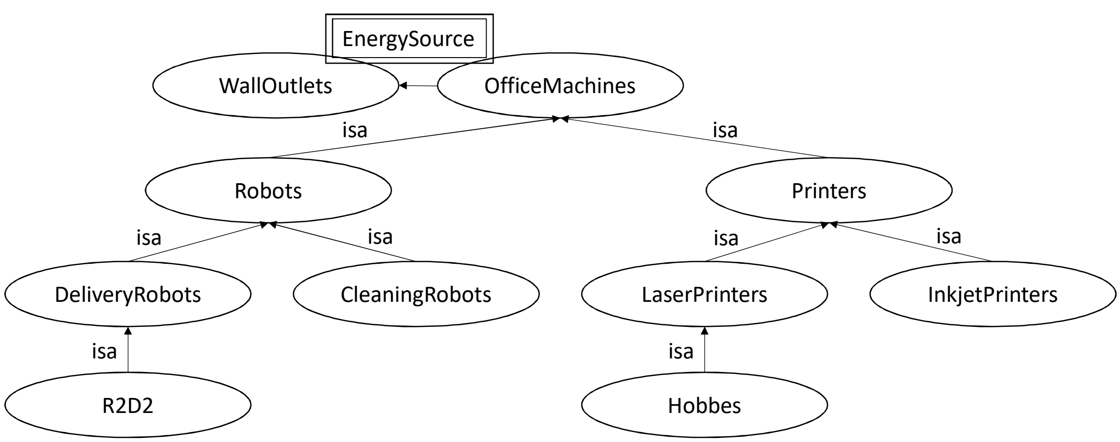
Example: Taxonomic Knowledge

- Knowledge base in first-order logic
  - FORALL x IsOfficeMachine(x) IMPLIES EnergySource(x, WallOutlet)
  - FORALL x IsPrinter(x) IMPLIES IsOfficeMachine(x)
  - FORALL x IsLaserPrinter(x) IMPLIES IsPrinter(x)
  - IsLaserPrinter(Hobbes)
- We can use resolution to show that the knowledge base entails
  - EnergySource(Hobbes, 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.

Semantic Networks



Semantic Networks



Semantic Networks

A —subset→ B	FORALL x (A(x) IMPLIES B(x))	Cats —subset→ Mammals
A —element→ B	B(A)	Bill —element→ Cats
A —R→ B	R(A,B)	Bill —Age→ 12
A —[R]→ B	FORALL x (A(x) IMPLIES R(x,B))	Birds —[Legs]→ 2
A —[[R]]→ B	FORALL x EXISTS y (A(x) IMPLIES (B(y) AND R(x,y)))	Birds —[[Parent]]→ Birds

Semantic Networks

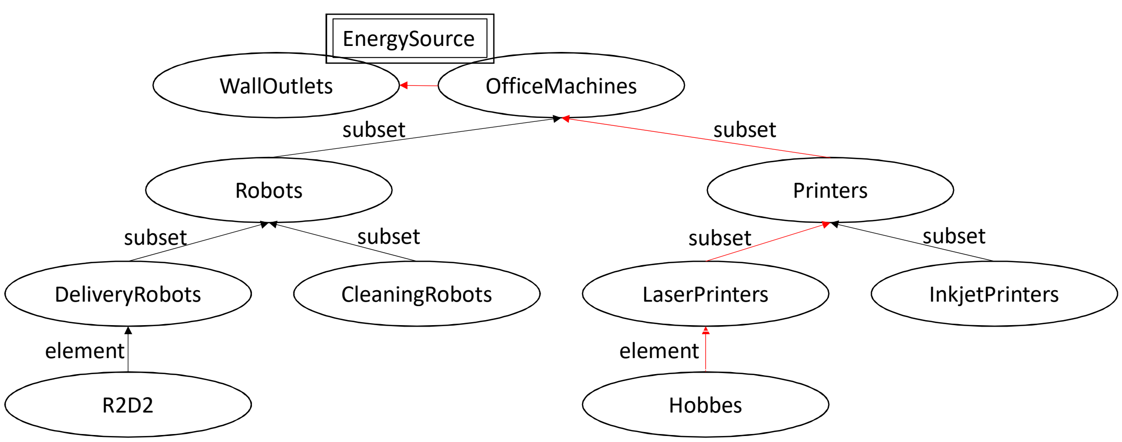
- How would you depict “R2D2 is not a cleaning robot”?
- How would you depict “R2D2 is a delivery or cleaning robot”?

Semantic Networks

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

Semantic Networks

- What's the energy source of Hobbes?

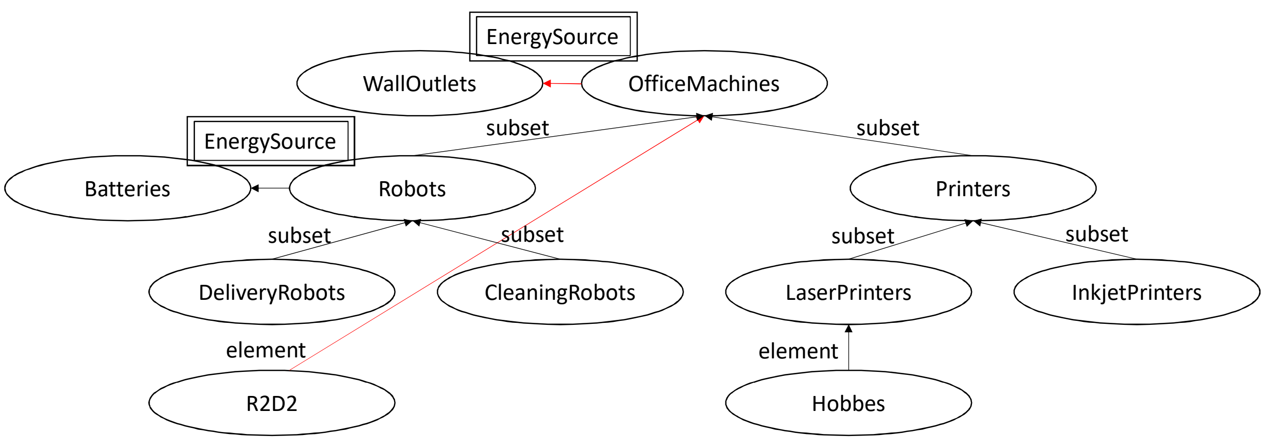


Semantic Networks

- “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 AND KB’ ⊨ S whenever KB ⊨ S.
  - For example, IsBird(Tweety) AND BrokenWing(Tweety) ⊨ CanFly(Tweety) if IsBird(Tweety) ⊨ CanFly(Tweety).
  - However, default reasoning can be done easily with semantic networks.

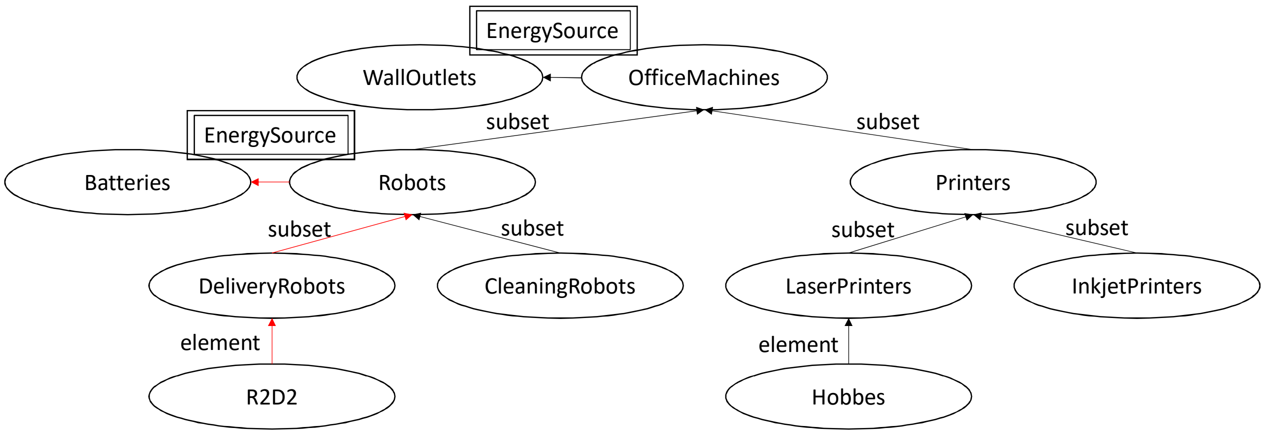
Semantic Networks

- “R2D2 is an office machine.”



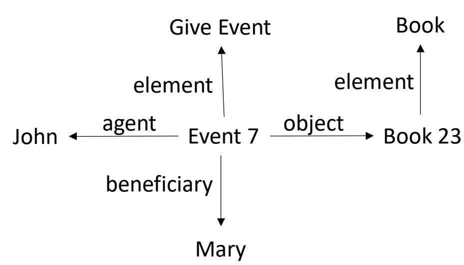
Semantic Networks

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



Semantic Networks

- Semantic networks can represent stories.
- "John gave a book to Mary."



Semantic Networks

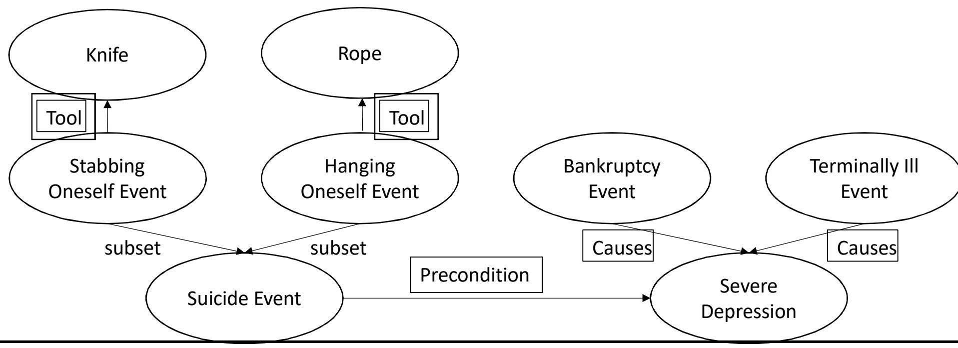
- Spreading activation ("marker passing") can reason about stories represented with semantic networks.
  - Activation is the arousal level of a node.
  - Nodes mentioned in the story are activated.
  - Whenever a node receives activation, a fraction of that activation spreads with or against the semantic links connected to the node.
  - The higher the activation of a node, the more easily the corresponding concept can be accessed from memory.

Warning

- Dark story. Don't do this at home! Call a crisis line instead!

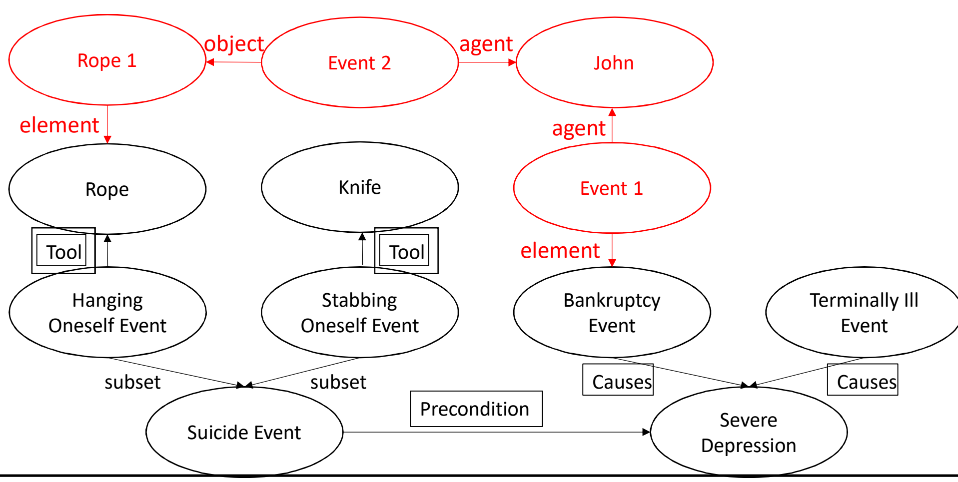
Semantic Networks

- Background knowledge is represented as a huge semantic network.



Semantic Networks

- “John went bankrupt. He grabbed a rope.”



Semantic Networks

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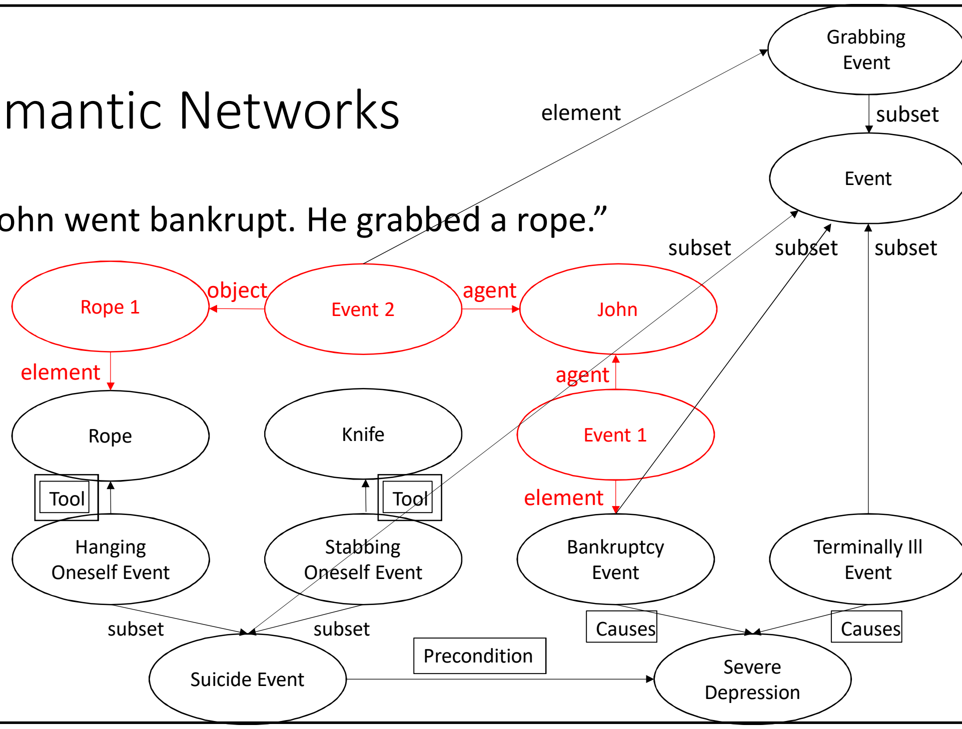

Frames (very similar to semantic networks)

Printers

SubsetOf:	OfficeMachines
SupersetOf:	{LaserPrinters, InkjetPrinters}
EnergySource:	WallOutlet
Creator:	Sven Koenig
Date:	Sep 22, 2015

Hobbes

ElementOf:	LaserPrinters
EnergyConsumption:	180 Watt/hour
EnergyCostPerHour:	Utility:EnergyCost * this:EnergyConsumption → spreadsheet-type calculation via “procedural attachment”
Creator:	Sven Koenig
Date:	Feb 23, 2005

(Creator, Date) → meta information

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