Lecture:
Semantic Nets, Frames, Conceptual Graphs

Knowledge Representation as a medium for human expression

- An intelligent system must have KRs that can be interpreted by humans.
  - We need to be able to encode information in the knowledge base without significant effort.
  - **We need to be able to understand what the system knows and how it draws its conclusions.**

Knowledge Representation

- **Logic** (propositional, predicate)
- **Network representation**
  - Semantic nets
- **Structured representation**
  - Frames
- **Issues in KR**
  - Hierarchies, inheritance, exceptions
- **Advantages and disadvantages**

Semantic Networks

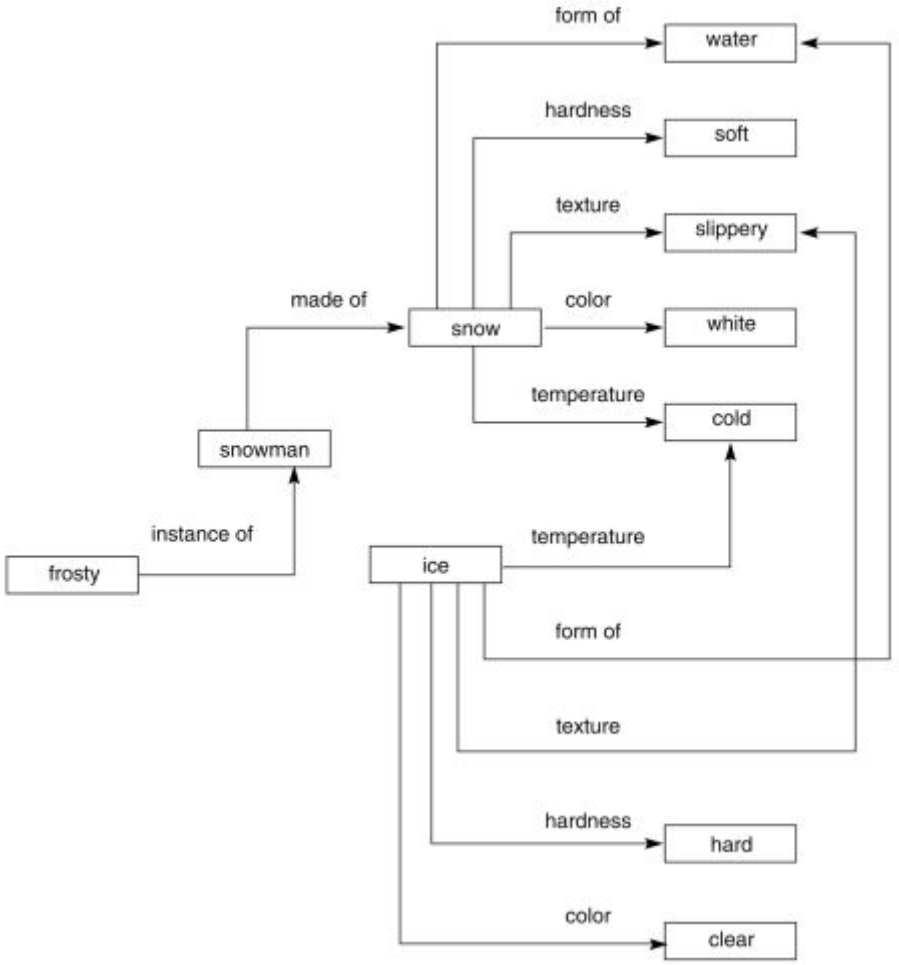
- First introduced by Quillian back in the late-60s

  M. Ross Quillian. "Semantic Memories", In M. M. Minsky, editor, *Semantic Information Processing,* pages 216-270. Cambridge, MA: MIT Press, 1968

- **Semantic network** is simple representation scheme which uses a graph of labeled nodes and labeled directed arcs to encode knowledge
  - Nodes – objects, concepts, events
  - Arcs – relationships between nodes
- **Graphical depiction** associated with semantic networks is a big reason for their popularity

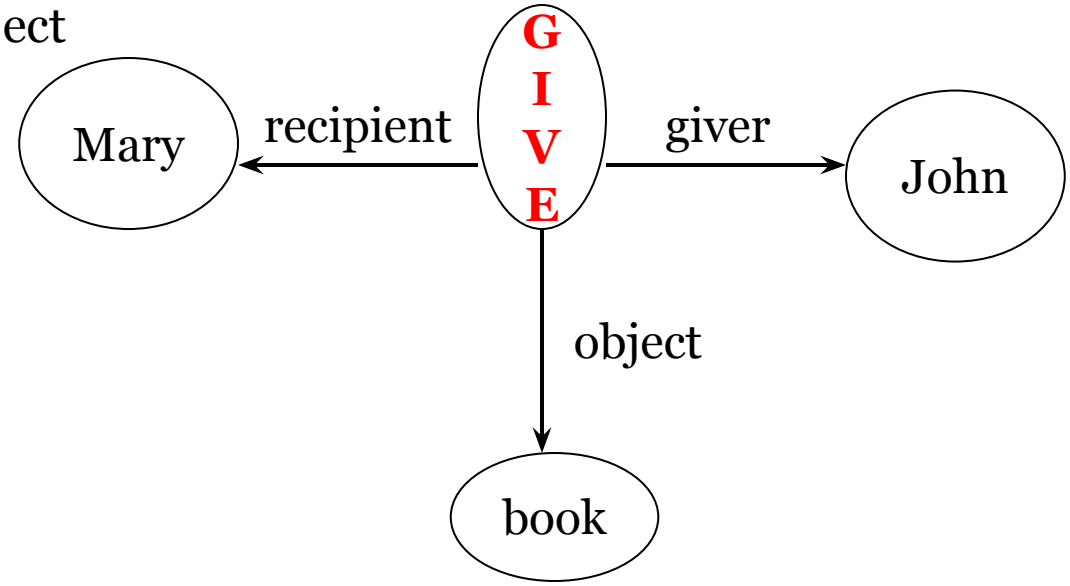
A brief look at semantic networks

- A semantic network is an irregular graph that has concepts in vertices and relations on arcs.
- Relations can be ad-hoc, but they can also be quite general, for example, “is a” (ISA), “a kind of” (AKO), “an instance of”, “part of”.
- Relations often express physical properties of objects (colour, length, and lots of others).
- Most often, relations link two concepts.



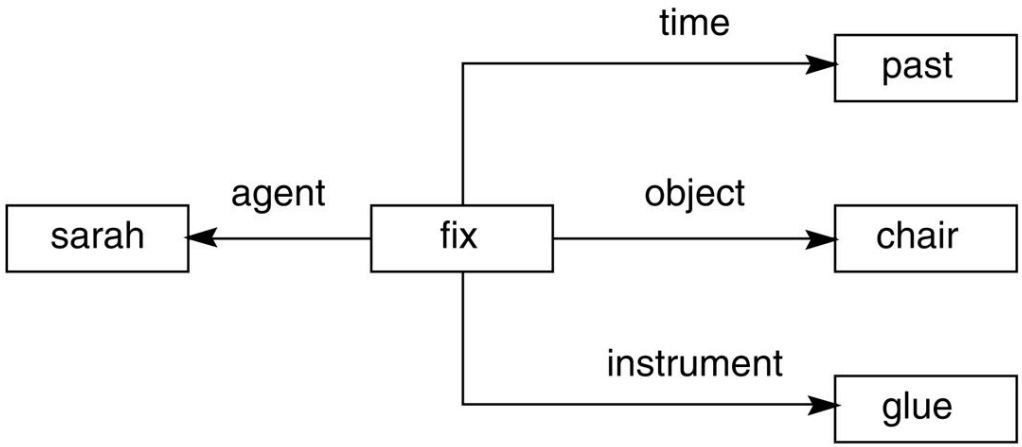
Non-binary relations

- We can represent the generic *give* event as a relation involving three things:
  - A giver
  - A recipient
  - An object



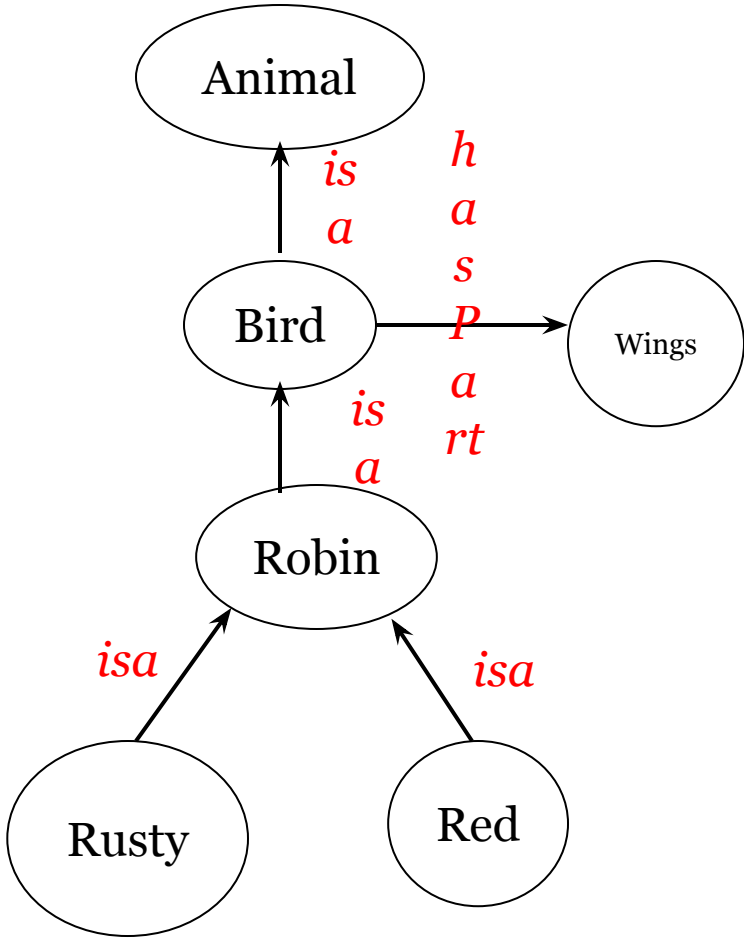
… semantic networks

- General semantic relations help represent the meaning of simple sentences in a systematic way.
- A sentence is centred on a verb that *expects* certain arguments.
- For example, verbs usually denotes actions (with *agents*) or states (with passive *experiencers*, for example, “he dreams” or “he is sick”).



Inheritance

- Inheritance is one of the main kind of reasoning done in semantic nets
- The **ISA** (is a) relation is often used to link a class and its superclass.
- Some links (e.g. **haspart**) are inherited along **ISA** paths
- The semantics of a semantic net can be relatively informal or very formal
  - Often defined at the implementation level



Advantages of Semantic nets

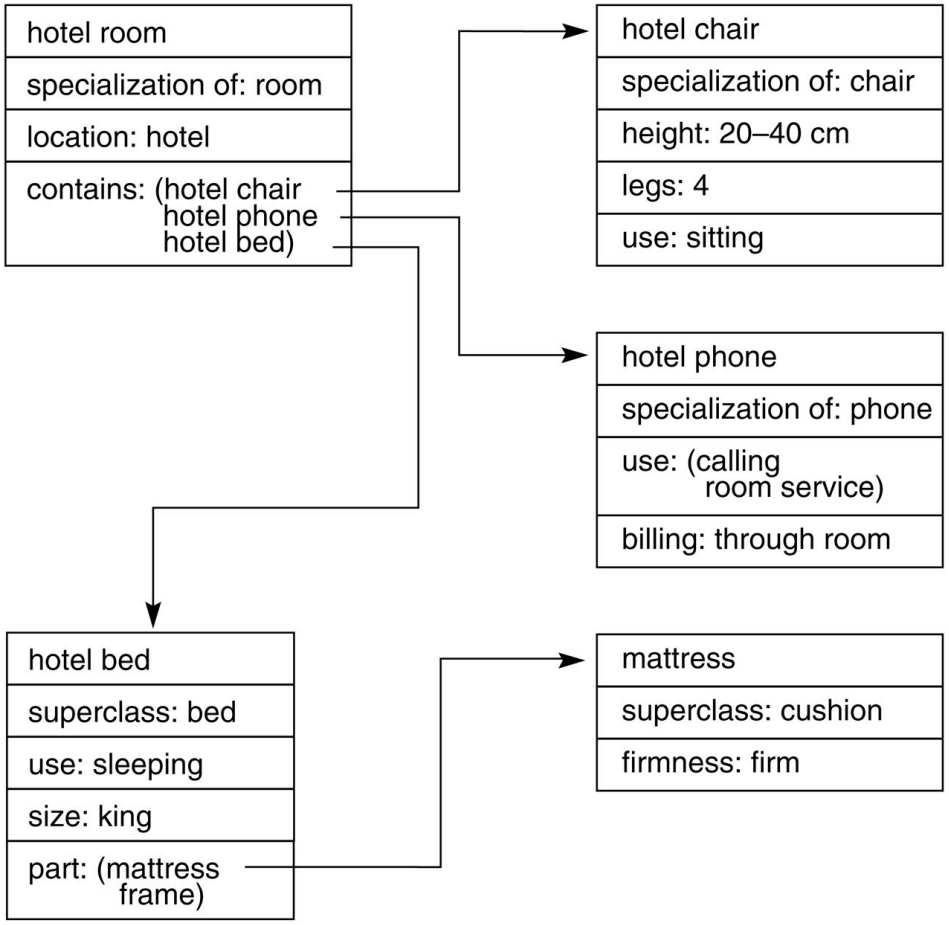
- Easy to visualize
- Formal definitions of semantic networks have been developed.
- Related knowledge is easily clustered.
- Efficient in space requirements
  - Objects represented only once
  - Relationships handled by pointers

Disadvantages of Semantic nets

- Inheritance (particularly from multiple sources and when exceptions in inheritance are wanted) can cause problems.
- Facts placed inappropriately cause problems.
- No standards about node and arc values

Frames and frame systems

- A frame represents a concept;
- a frame system represents an organization of knowledge about a set of related concepts.
- A frame has slots that denote properties of objects. Some slots have *default* fillers, some are empty (may be filled when more becomes known about an object).
- Frames are linked by relations of specialization/generalization and by many ad-hoc relations.



Frames

3 components of a frame

- frame name
- attributes (slots)
- values (fillers: list of values, range, string, etc.)

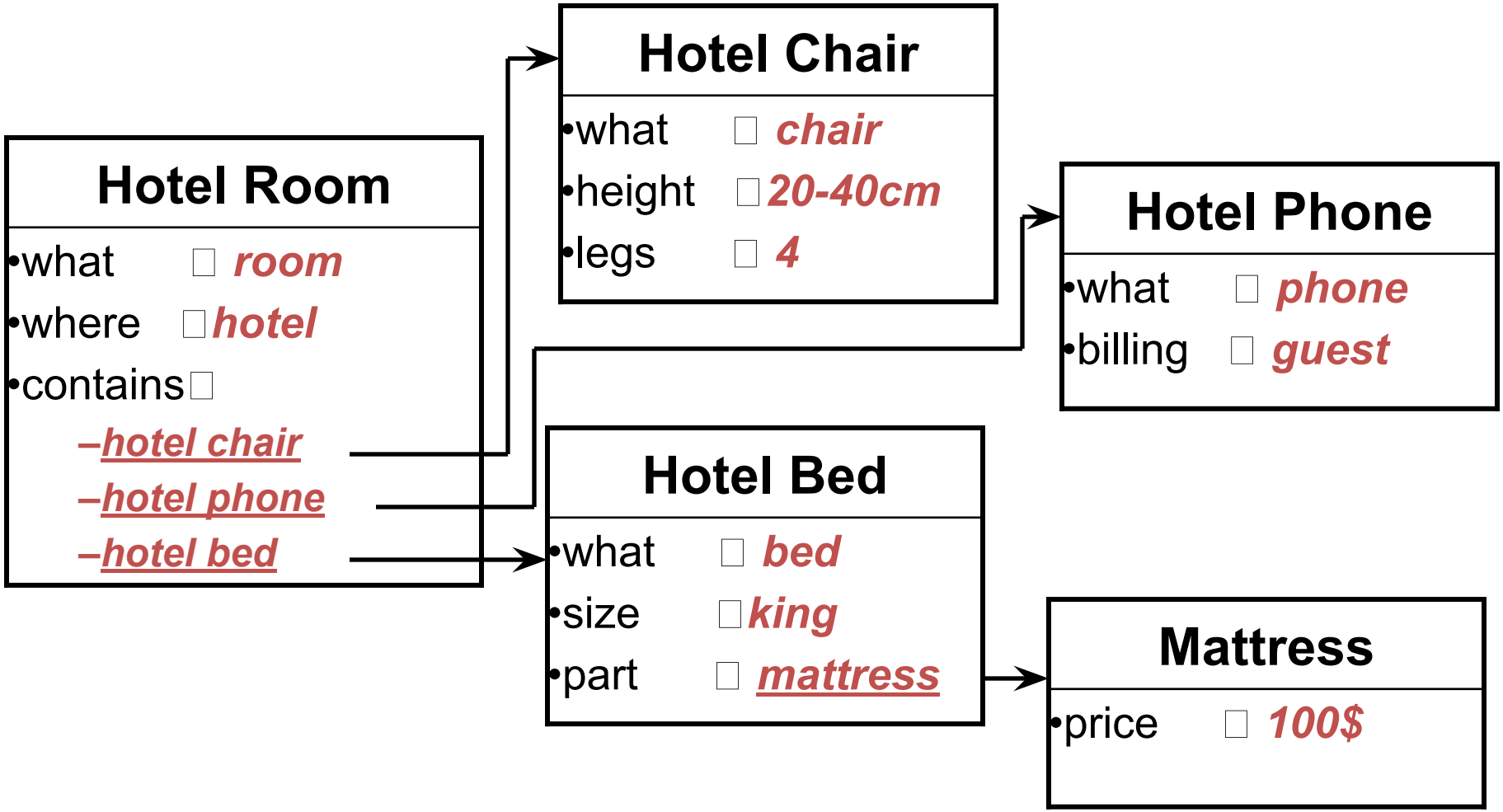
Book Frame	
Slot	*Filler*
•Title	*AI. A modern Approach*
•Author	*Russell & Norvig*
•Year	*2003*

Features of Frame Representation

- More natural support of values then semantic nets (each slots has constraints describing legal values that a slot can take)
- Can be easily implemented using object-oriented programming techniques
- Inheritance is easily controlled

Inheritance

- Similar to Object-Oriented programming paradigm



Benefits of Frames

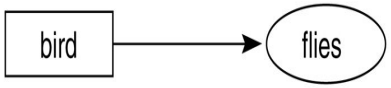
- Makes programming easier by grouping related knowledge
- Easily understood by non-developers
- Expressive power
- Easy to set up slots for new properties and relations
- Easy to include default information and detect missing values

Drawbacks of Frames

- No standards (slot-filler values)
- More of a general methodology than a specific representation:
  - Frame for a class-room will be different for a professor and for a maintenance worker
- No associated reasoning/inference mechanisms

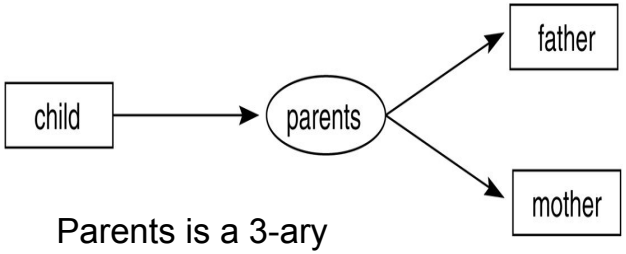
Conceptual graphs

- John Sowa created the conceptual graph notation in 1984. It has substantial philosophical and psychological motivation.
- It is still quite a popular knowledge representation formalism, especially in semantic processing of language, and a topic of interesting research.
- Conceptual graphs can be expressed in first-order logic but due to its graphical form it may be easier to understand than logic.



Flies is a 1-ary relation.

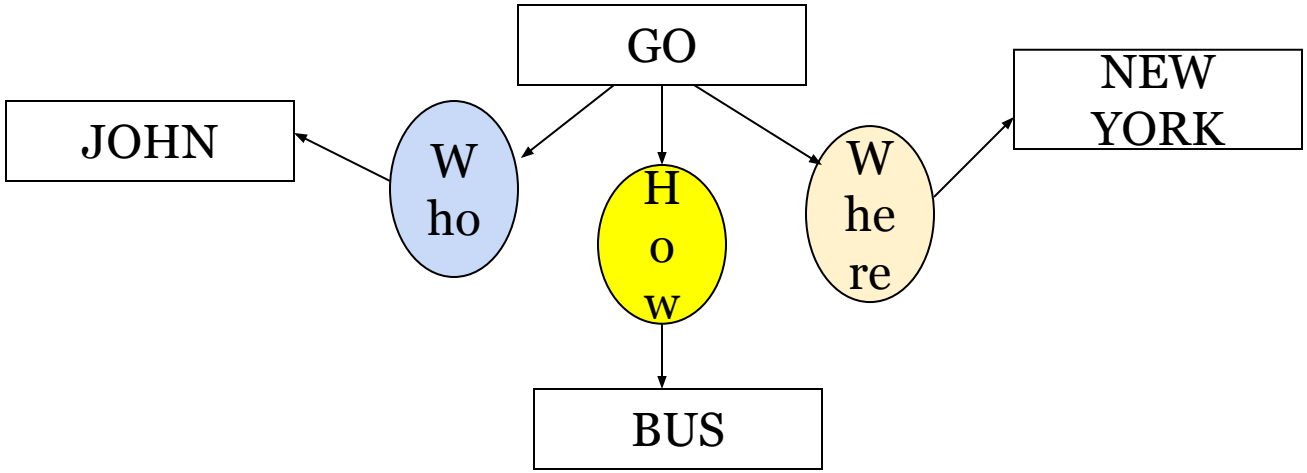
Color is a 2-ary relation.



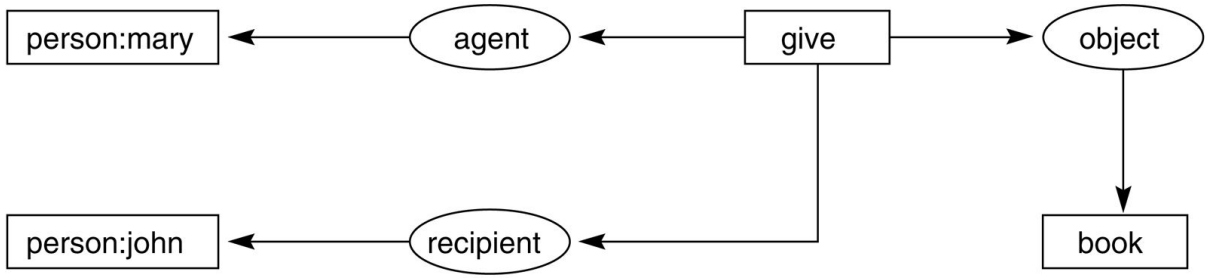
Parents is a 3-ary relation.

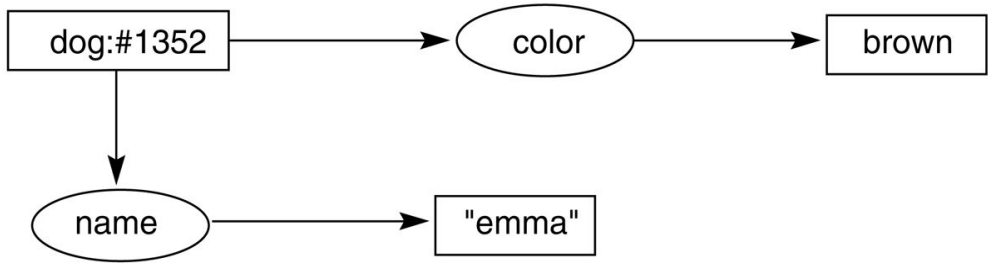
Conceptual Graphs

- *Conceptual graphs* are semantic nets representing the meaning of (simple) sentences in natural language
- Two types of nodes:
  - *Concept nodes*; there are two types of concepts, individual concepts and generic concepts
  - *Relation nodes*(binary relations between concepts)



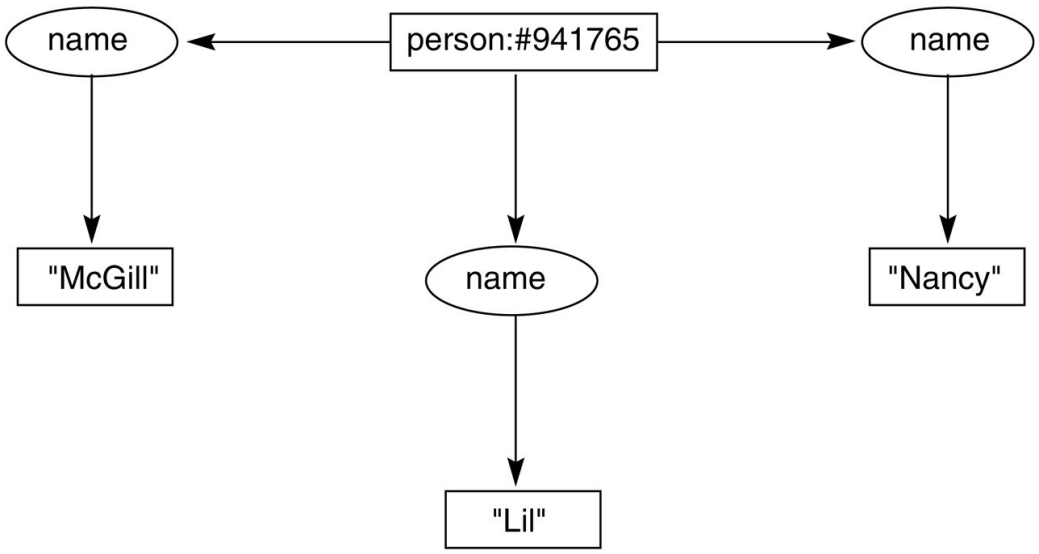
Conceptual graphs (2)



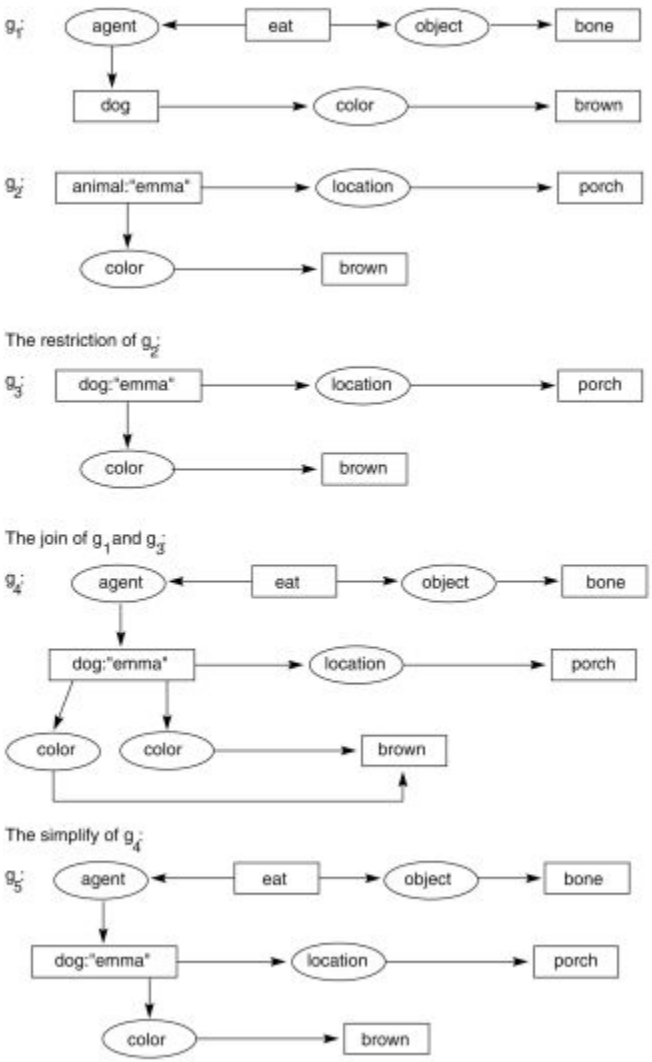


Conceptual graphs (3)

Her name was Magill, and she called herself Lil,
but everyone knew her as Nancy.



Conceptual graphs (5)



Specialization and type hierarchy

dogs are animals

(g_1) A brown dog eats a bone.

(g_2) ... Emma, the brown animal on the porch...

(g_3) ... Emma, the brown dog on the porch...

(g_4) Emma, the brown dog on the porch, eats a bone.

The challenge is to get this from text!