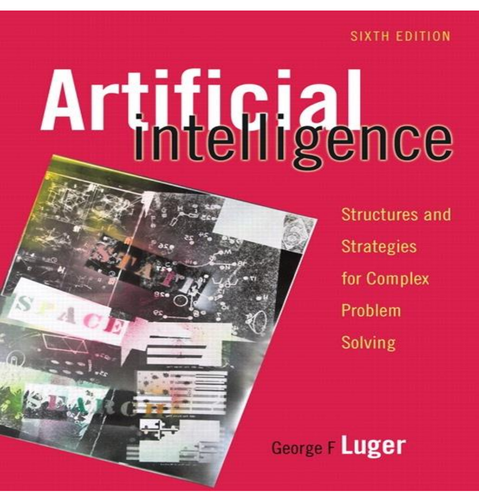
7

Knowledge Representation



George F Luger

ARTIFICIAL INTELLIGENCE *6th edition*

Structures and Strategies for Complex Problem Solving

Fig 7.1 Semantic network developed by Collins and Quillian in their research on human information storage and response times (Harmon and King, 1985)

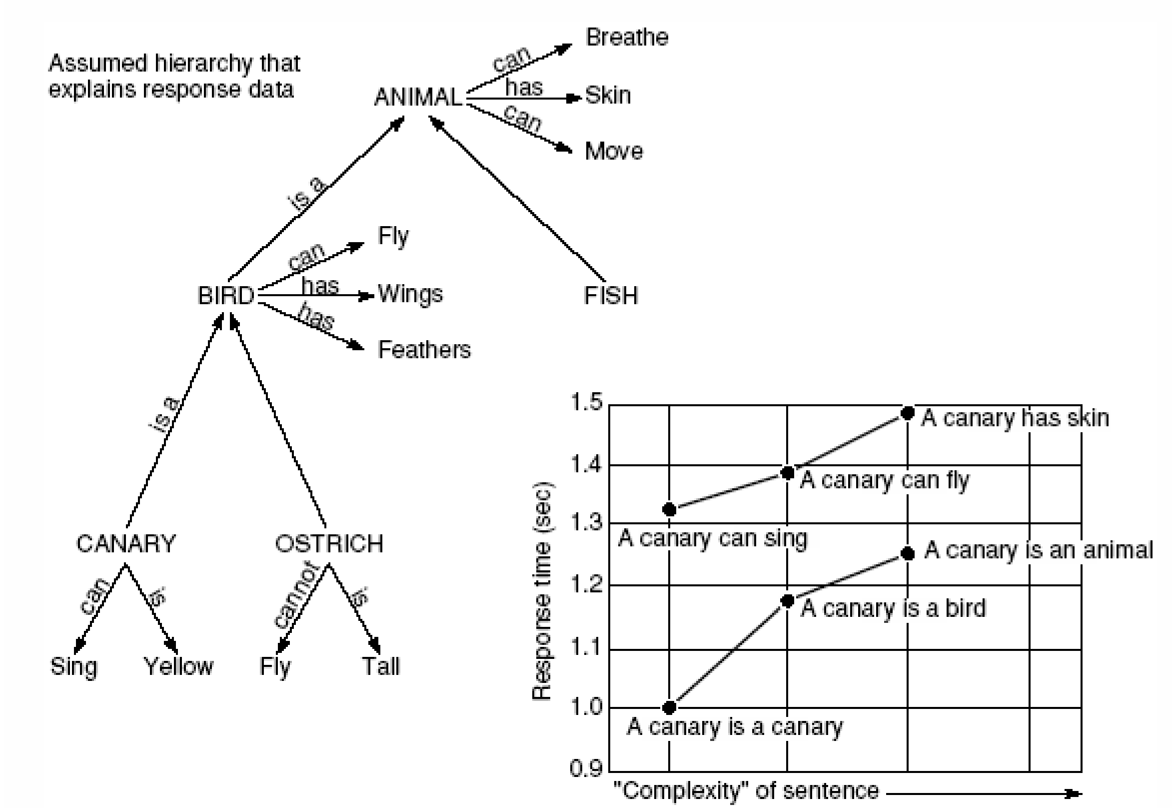


Fig 7.2 Network representation of properties of snow and ice

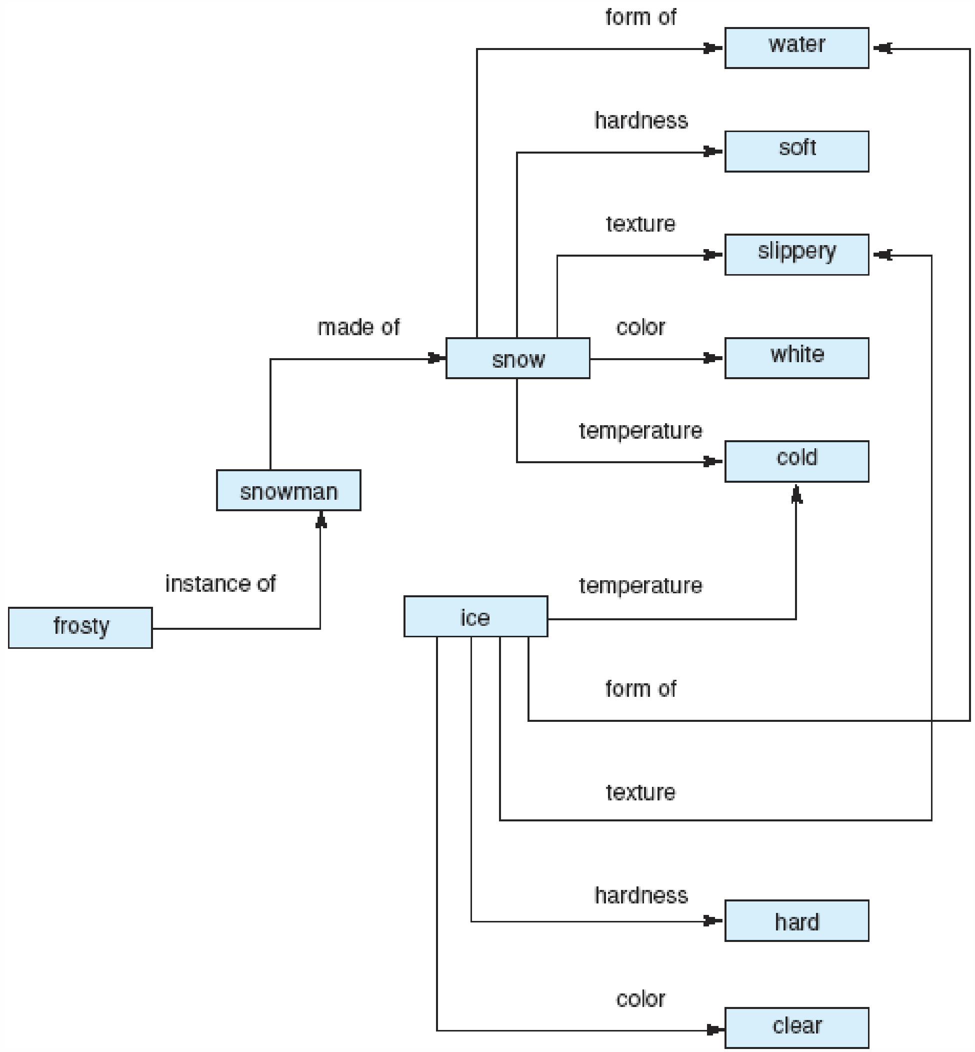


Fig 7.3 three planes representing three definitions of the word "plant" (Quillian, 1967).

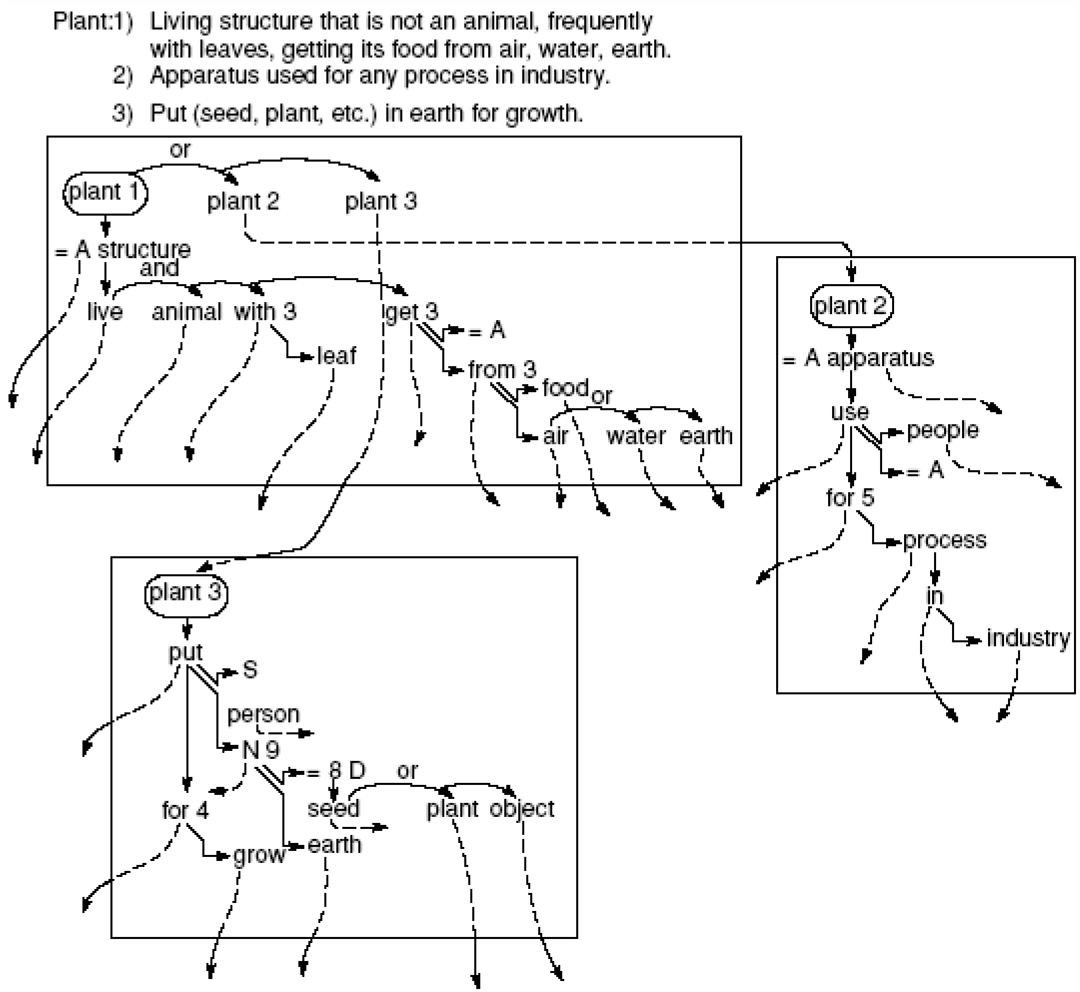


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Fig 7.4 Intersection path between “cry” and “comfort” (Quillian 1967).

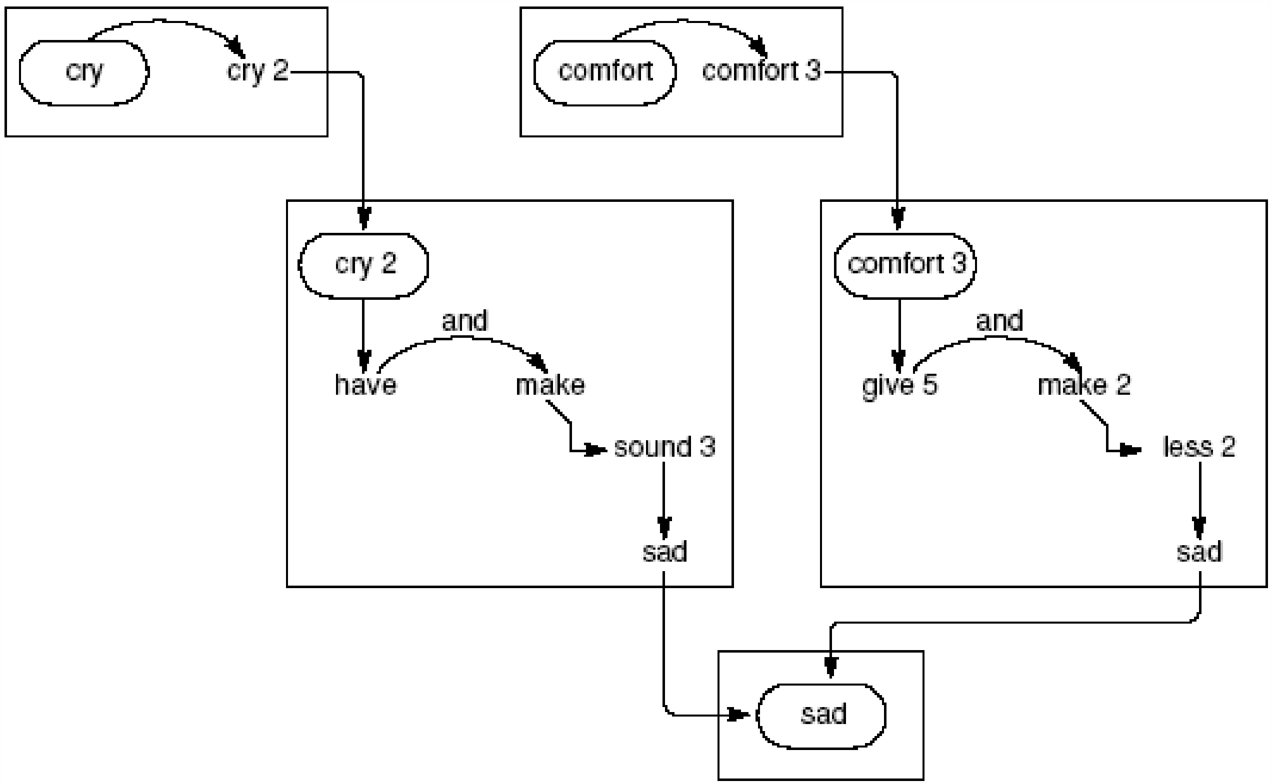
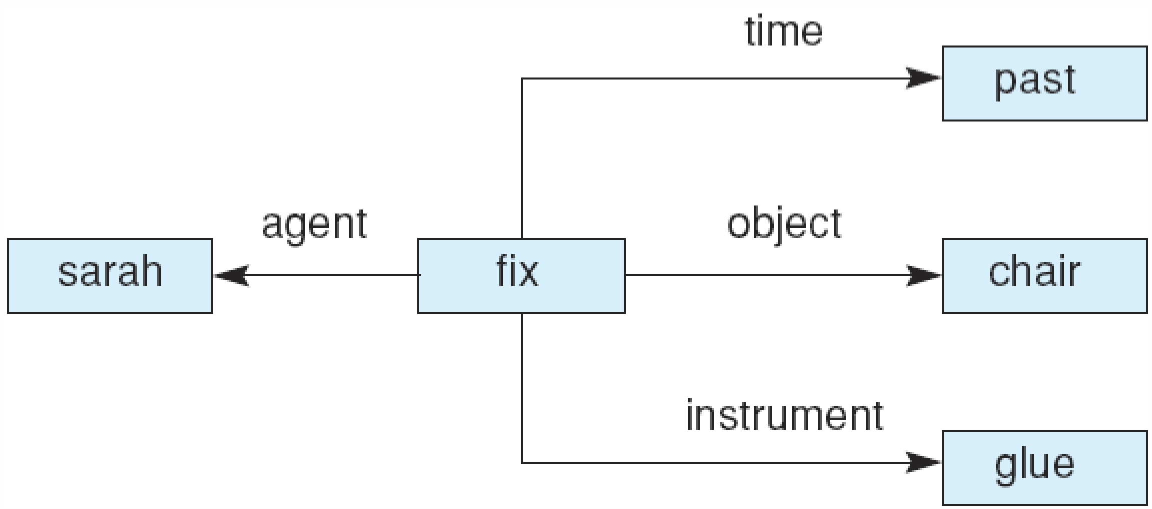


Fig 7.5 Case frame representation of the sentence "Sarah fixed the chair with glue."



Conceptual dependency theory of four primitive conceptualizations

ACTs	**actions**
PPs	**objects (picture producers)**
AAs	**modifiers of actions (action aiders)**
PAs	**modifiers of objects (picture aiders)**

For example, all actions are assumed to reduce to one or more of the primitive ACTs. These primitives, listed below, are taken as the basic components of action, with more specific verbs being formed through their modification and combination.

ATRANS	**transfer a relationship (give)**
PTRANS	**transfer physical location of an object (go)**
PROPEL	**apply physical force to an object (push)**
MOVE	**move body part by owner (kick)**
GRASP	**grab an object by an actor (grasp)**
INGEST	**ingest an object by an animal (eat)**
EXPEL	**expel from an animal's body (cry)**
MTRANS	**transfer mental information (tell)**
MBUILD	**mentally make new information (decide)**
CONC	**conceptualize or think about an idea (think)**
SPEAK	**produce sound (say)**
ATTEND	**focus sense organ (listen)**

Fig 7.6 Conceptual dependencies (Schank and Rieger, 1974).

$PP \Leftrightarrow ACT$	indicates that an actor acts.
$PP \Leftrightarrow PA$	indicates that an object has a certain attribute.
$ACT \xleftarrow{O} PP$	indicates the object of an action.
$ACT \xleftarrow{R} \begin{cases} \rightarrow PP \\ \leftarrow PP \end{cases}$	indicates the recipient and the donor of an object within an action.
$ACT \xleftarrow{D} \begin{cases} \rightarrow PP \\ \leftarrow PP \end{cases}$	indicates the direction of an object within an action.
$ACT \xleftarrow{1} \Updownarrow$	indicates the instrumental conceptualization for an action.
$\begin{array}{c} X \\ \Uparrow \\ Y \end{array}$	indicates that conceptualization X caused conceptualization Y. When written with a C this form denotes that X COULD cause Y.
$PP \Leftarrow \begin{cases} \rightarrow PA2 \\ \leftarrow PA1 \end{cases}$	indicates a state change of an object.
$PP1 \leftarrow PP2$	indicates that PP2 is either PART OF or the POSSESSOR OF PP1.

Fig 7.8 Some bacis conceptual dependencies and their use in representing more complex English sentences, adapted from Schank and Colby (1973).

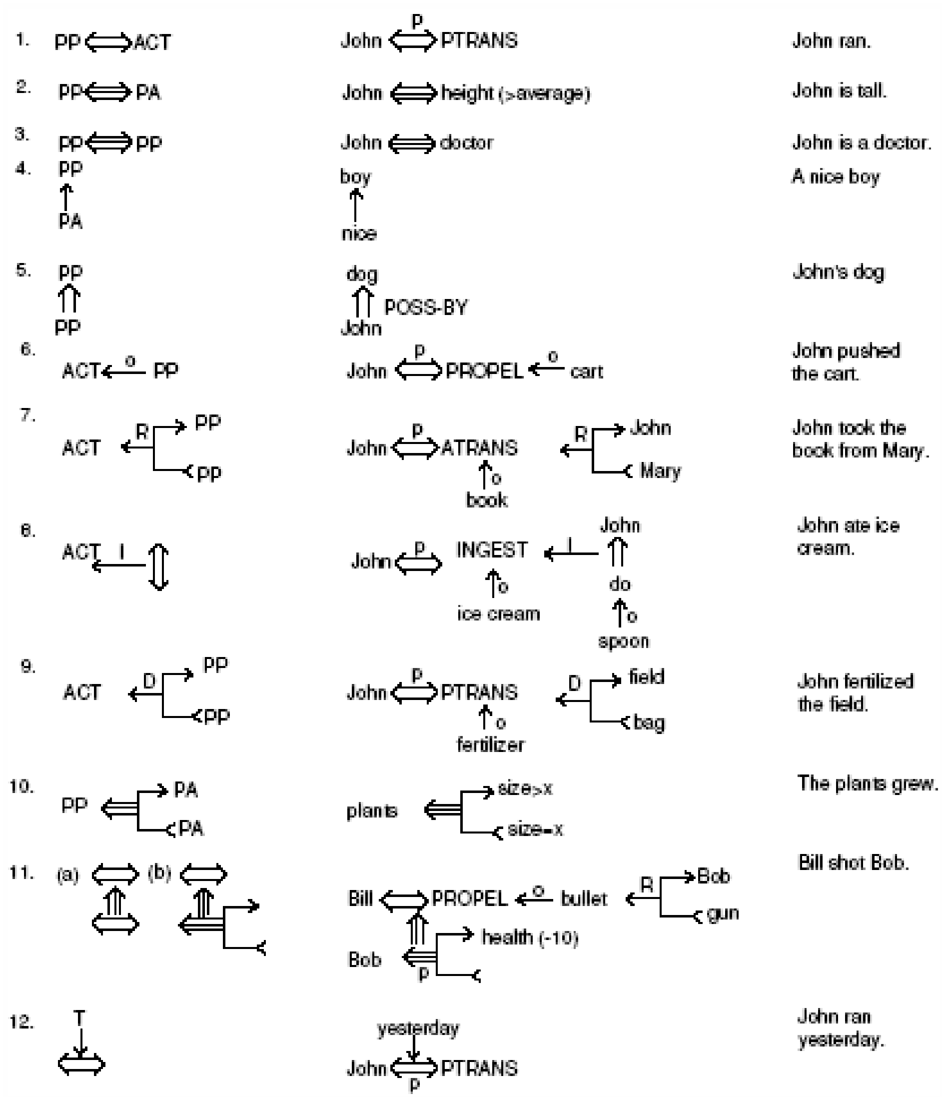


Fig 7.9 Conceptual dependency representing "John ate the egg" (Schank and Rieger 1974).

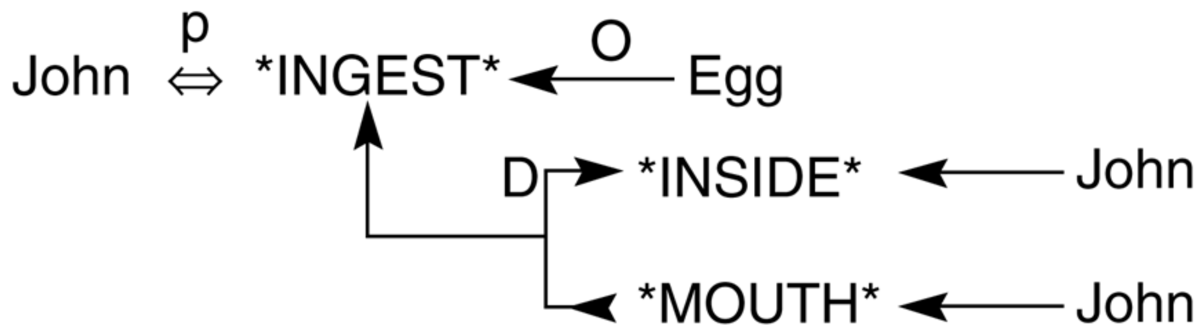


Fig 7.10 Conceptual dependency representation of the sentence "John prevented Mary from giving a book to Bill" (Schank and Rieger 1974).

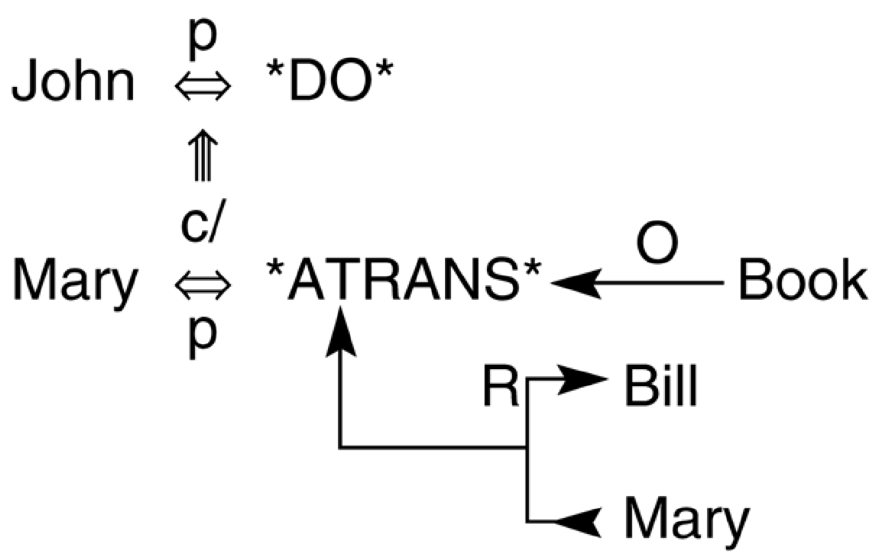
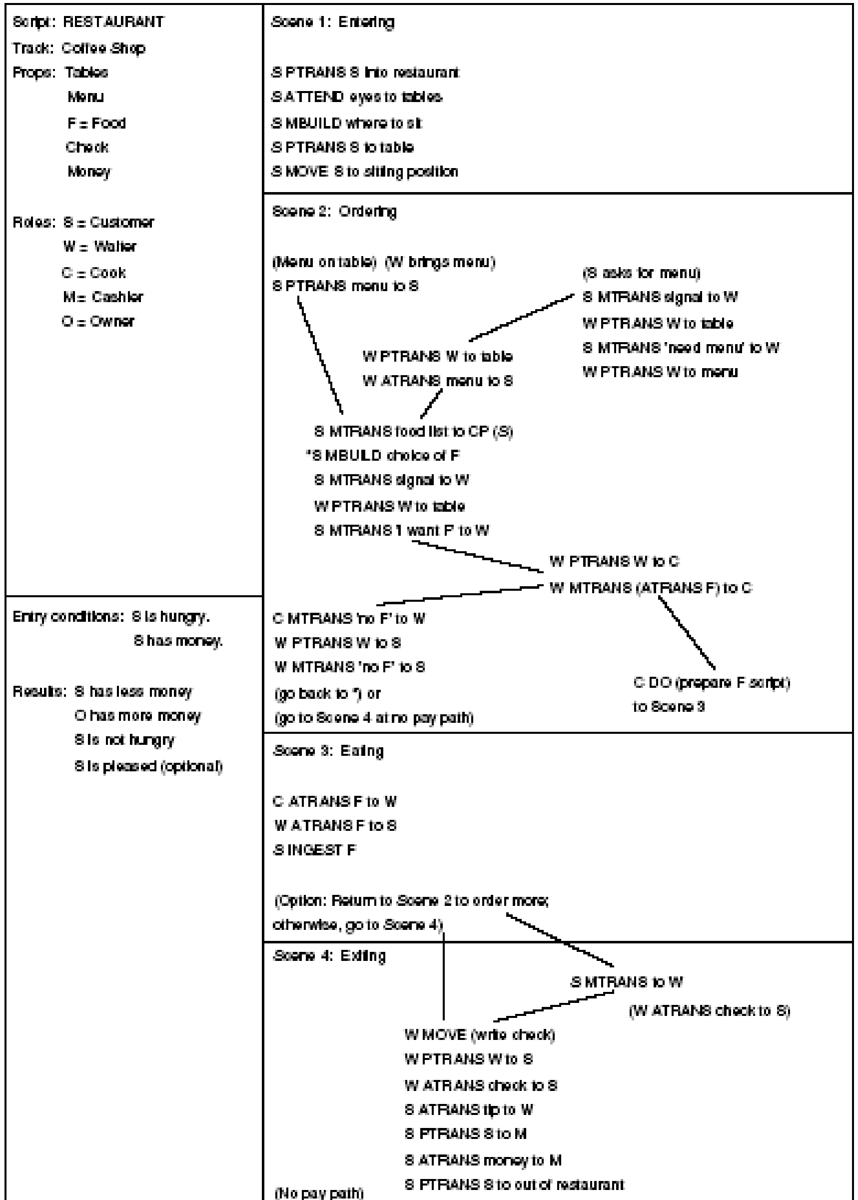


Fig 7.11 a restaurant script (Schank and Abelson, 1977).



A frame includes:

1. *Frame identification information.*
2. *Relationship of this frame to other frames.* The "hotel phone" might be a special instance of "phone," which might be an instance of a "communication device."
3. *Descriptors of requirements for a frame.* A chair, for instance, has its seat between 20 and 40 cm from the floor, its back higher than 60 cm, etc. These requirements may be used to determine when new objects fit the stereotype defined by the frame.
4. *Procedural information on use of the structure described.* An important feature of frames is the ability to attach procedural code to a slot.
5. *Frame default information.* These are slot values that are taken to be true when no evidence to the contrary has been found. For instance, chairs have four legs, telephones are pushbutton, or hotel beds are made by the staff.
6. *New instance information.* Many frame slots may be left unspecified until given a value for a particular instance or when they are needed for some aspect of problem solving. For example, the color of the bedspread may be left unspecified.

Fig 7.12 Part of a frame description of a hotel room. "Specialization" indicates a pointer to a superclass.

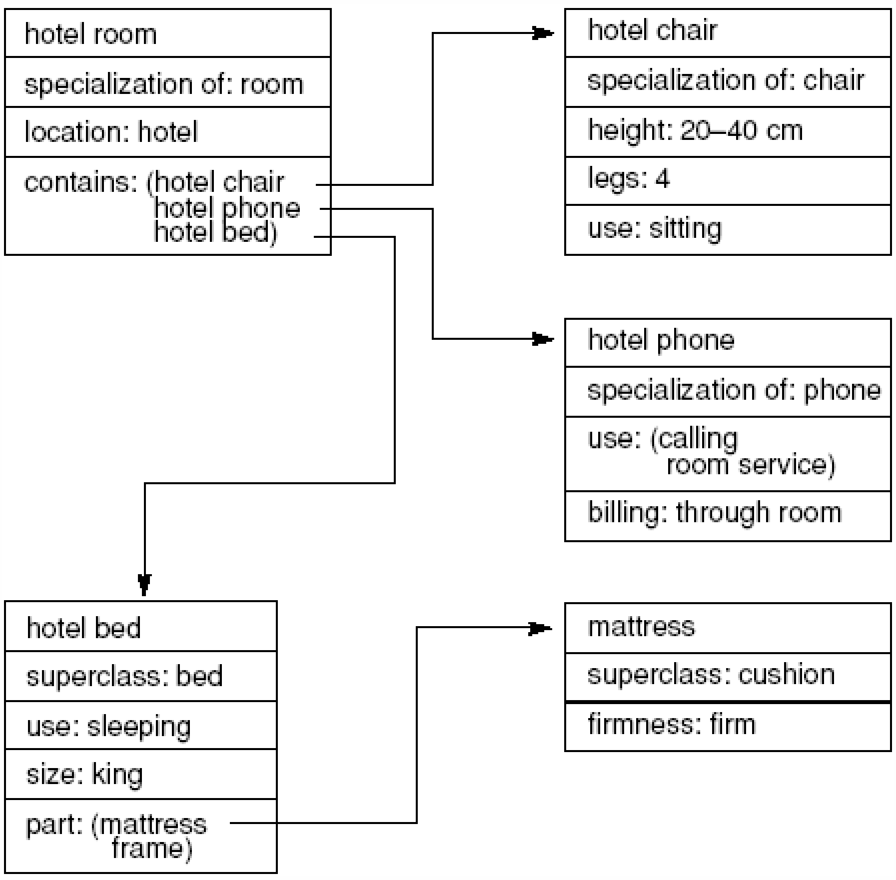


Fig 7.13 Spatial frame for viewing a cube (Minsky, 1975).

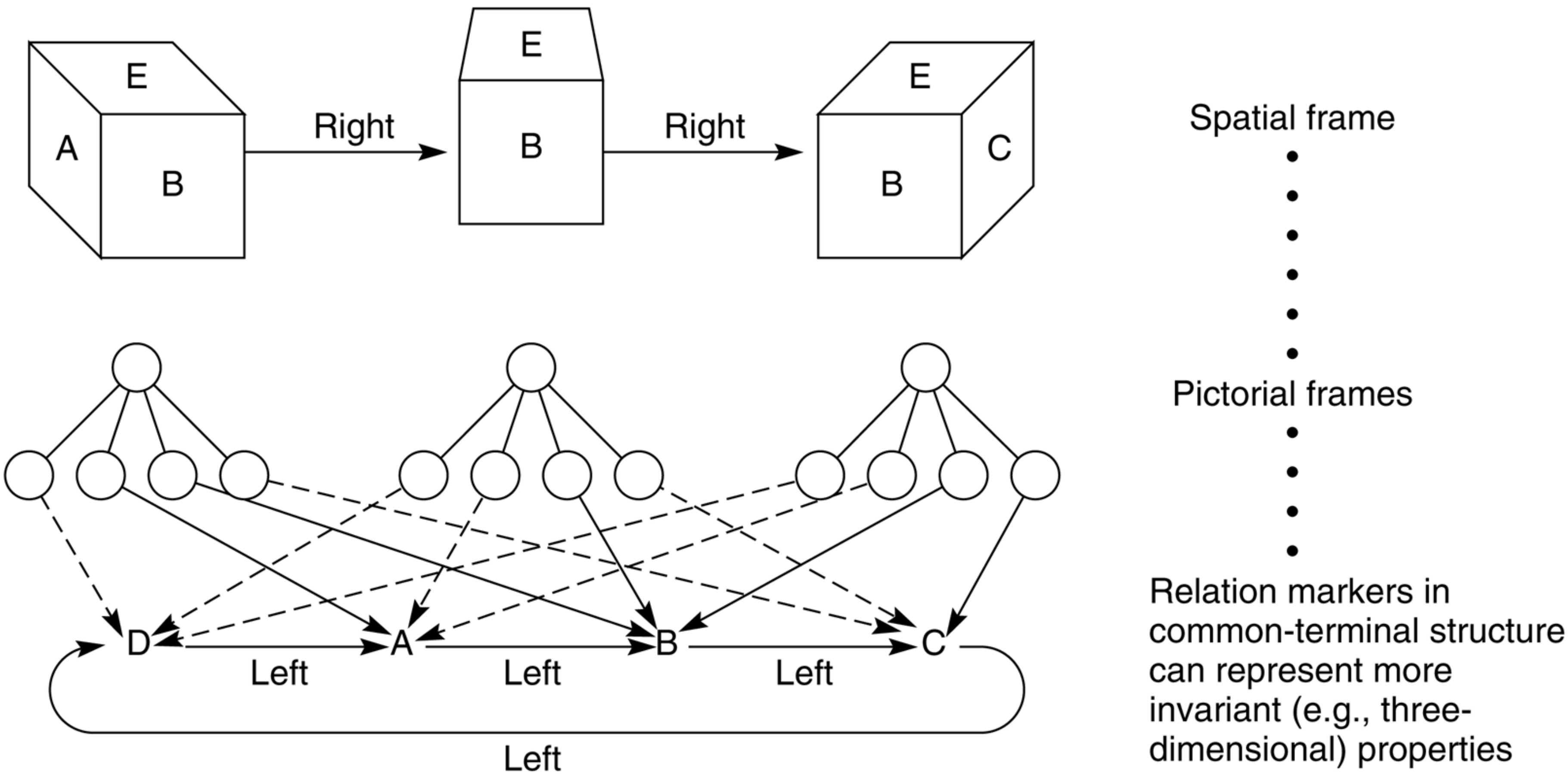


Fig 7.14 Conceptual relations of different arities.

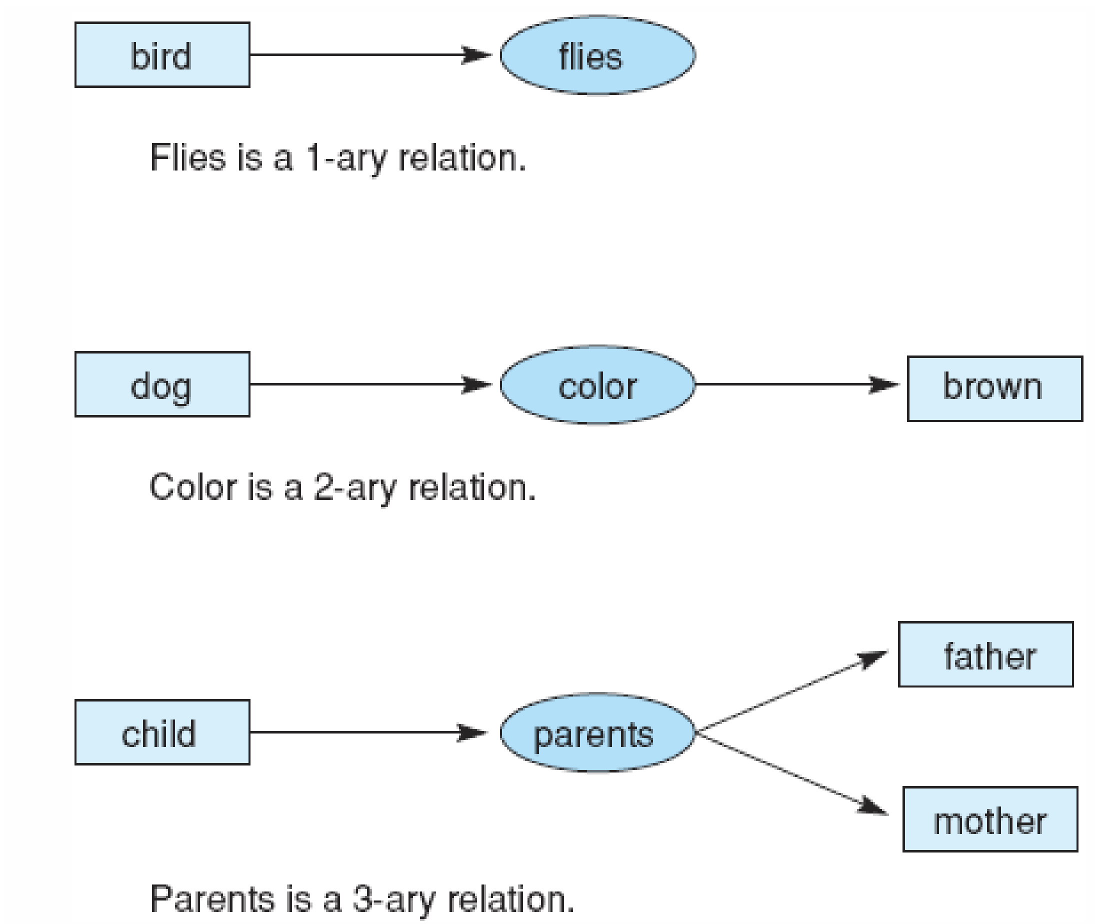


Fig 7.15 Graph of “Mary gave John the book.”

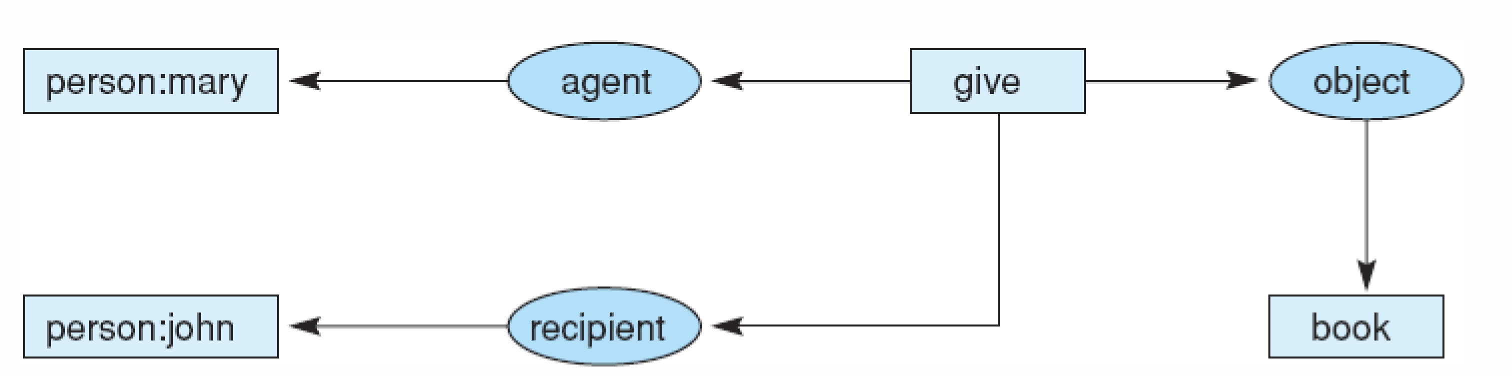


Fig 7.16 Conceptual graph indicating that the dog named Emma is brown.

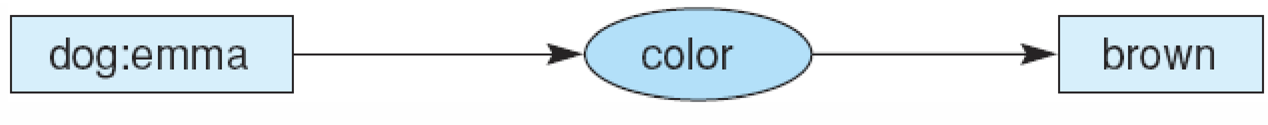


Fig 7.17 Conceptual graph indicating that a particular (but unnamed) dog is brown.

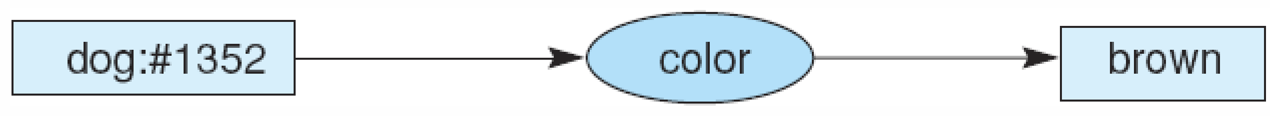


Fig 7.18 Conceptual graph indicating that a dog named Emma is brown.

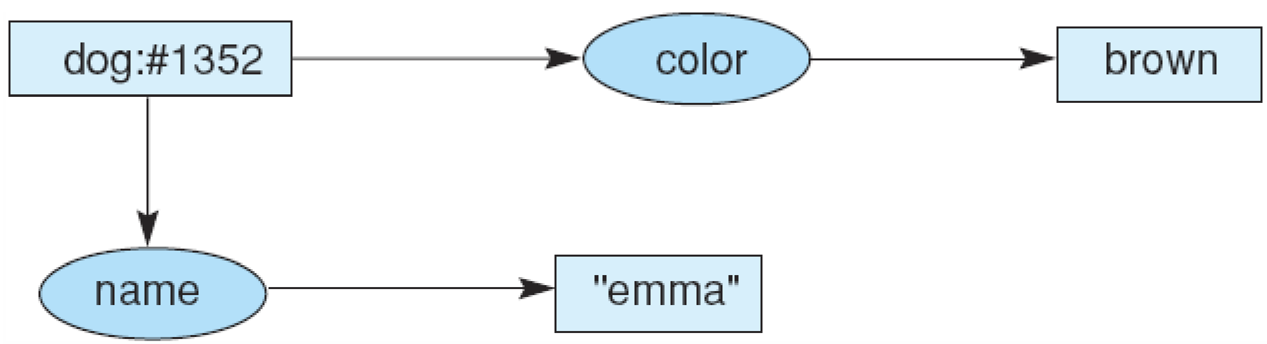


Fig 7.19 Conceptual graph of a person with three names.

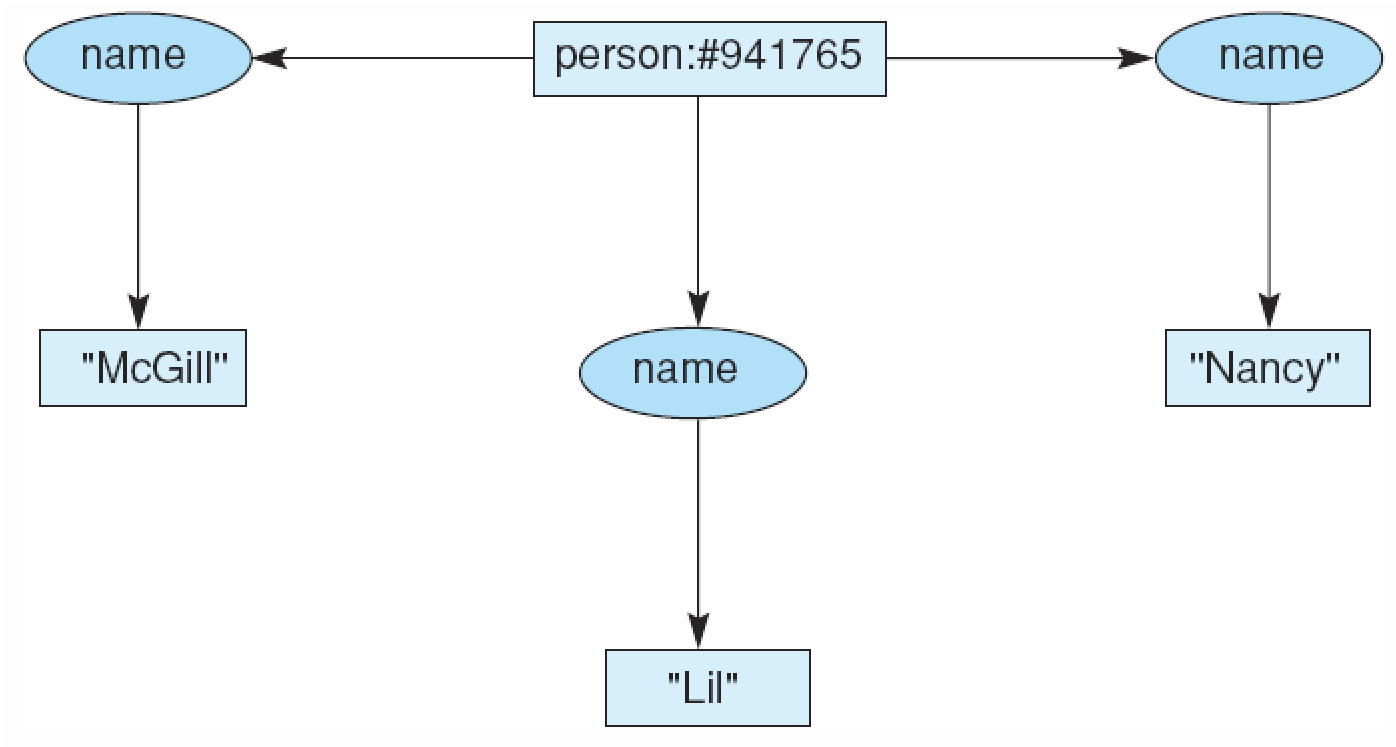


Fig 7.20 Conceptual graph of the sentence “The dog scratches its ear with its paw.”

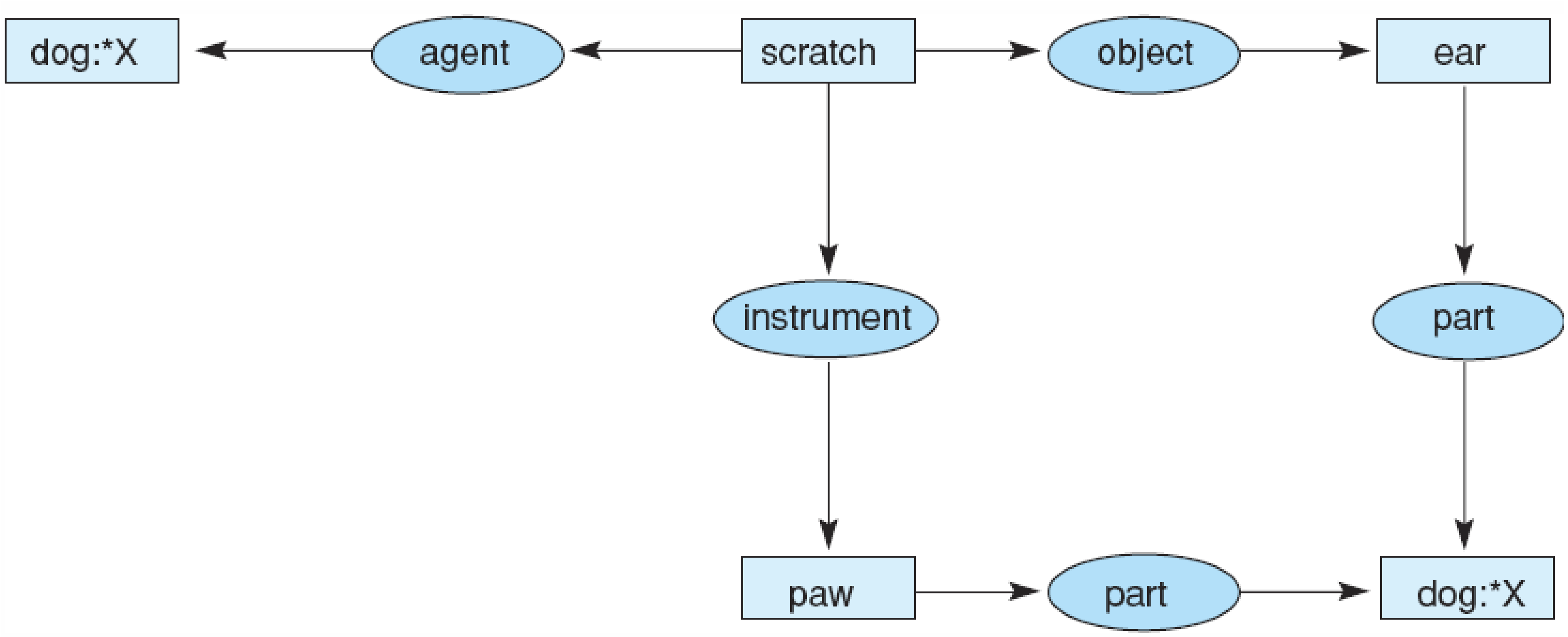


Fig 7.21 A type lattice illustrating subtypes, supertypes, the universal type, and the absurd type. Arcs represent the relationship.

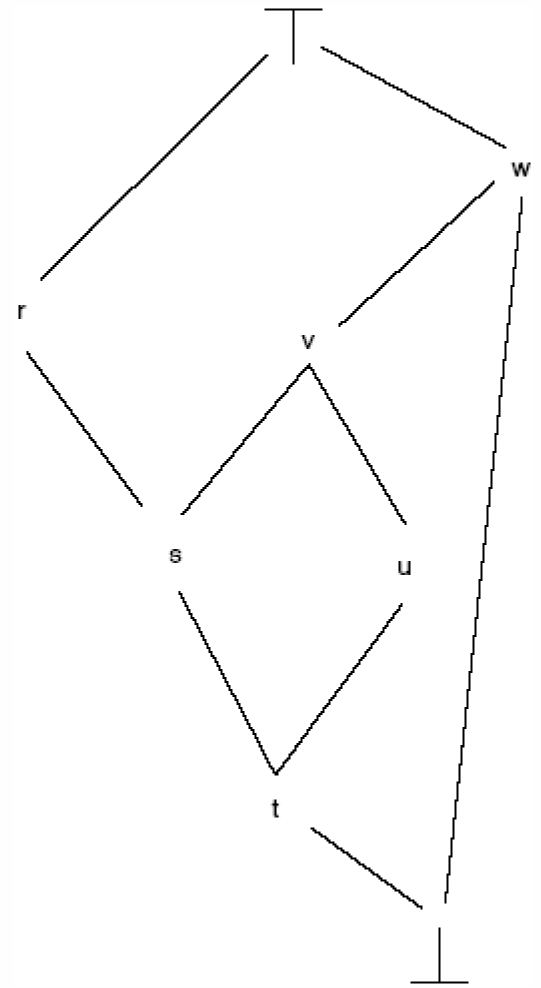


Fig 7.22 Examples of restrict, join, and simplify operations.

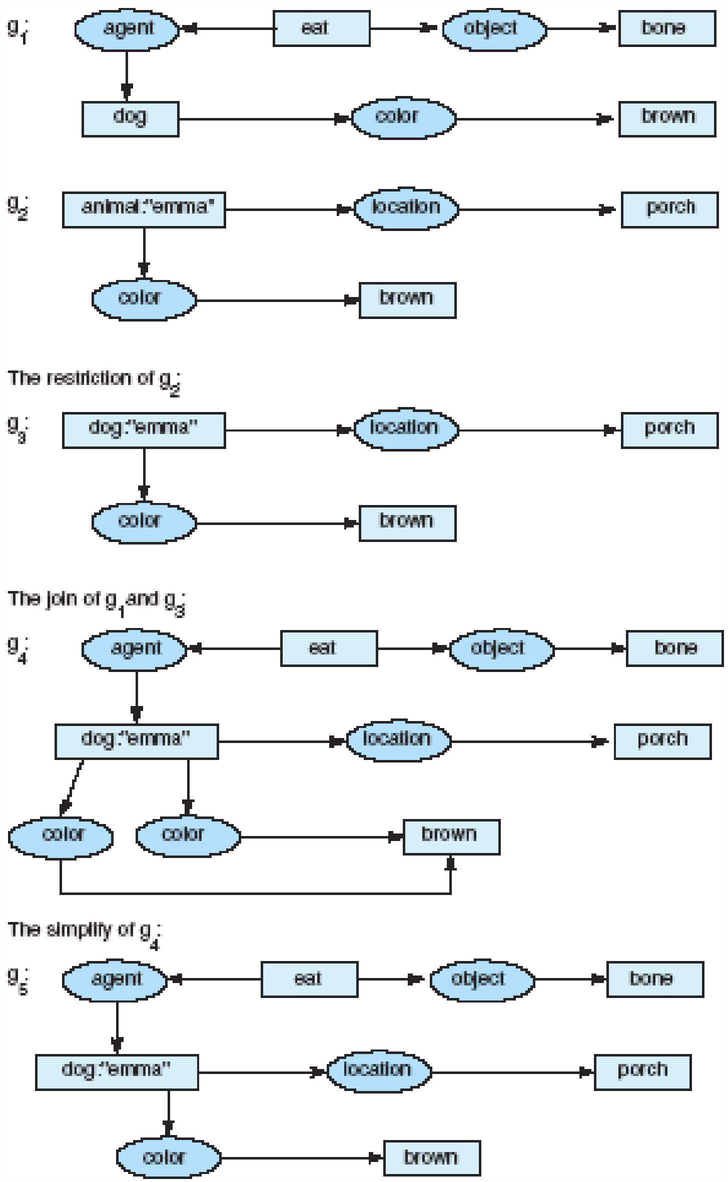


Fig 7.23 Inheritance in conceptual graphs.

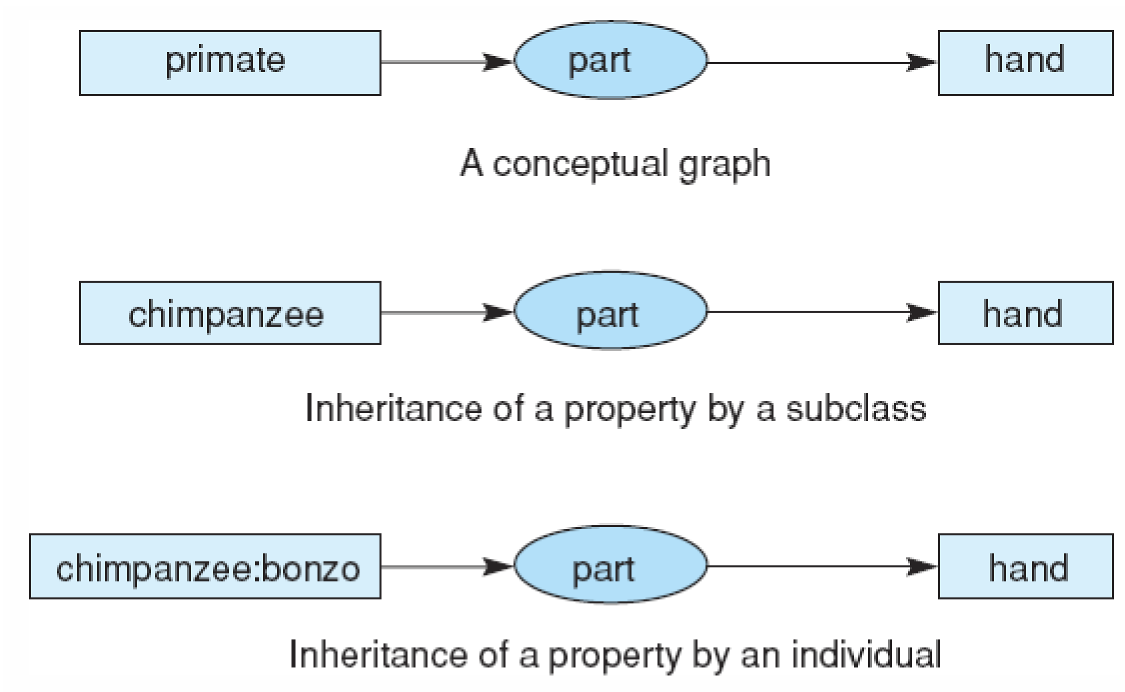


Fig 7.24 Conceptual graph of the statement “Tom believes that Jane likes pizza,” showing the use of a propositional concept.

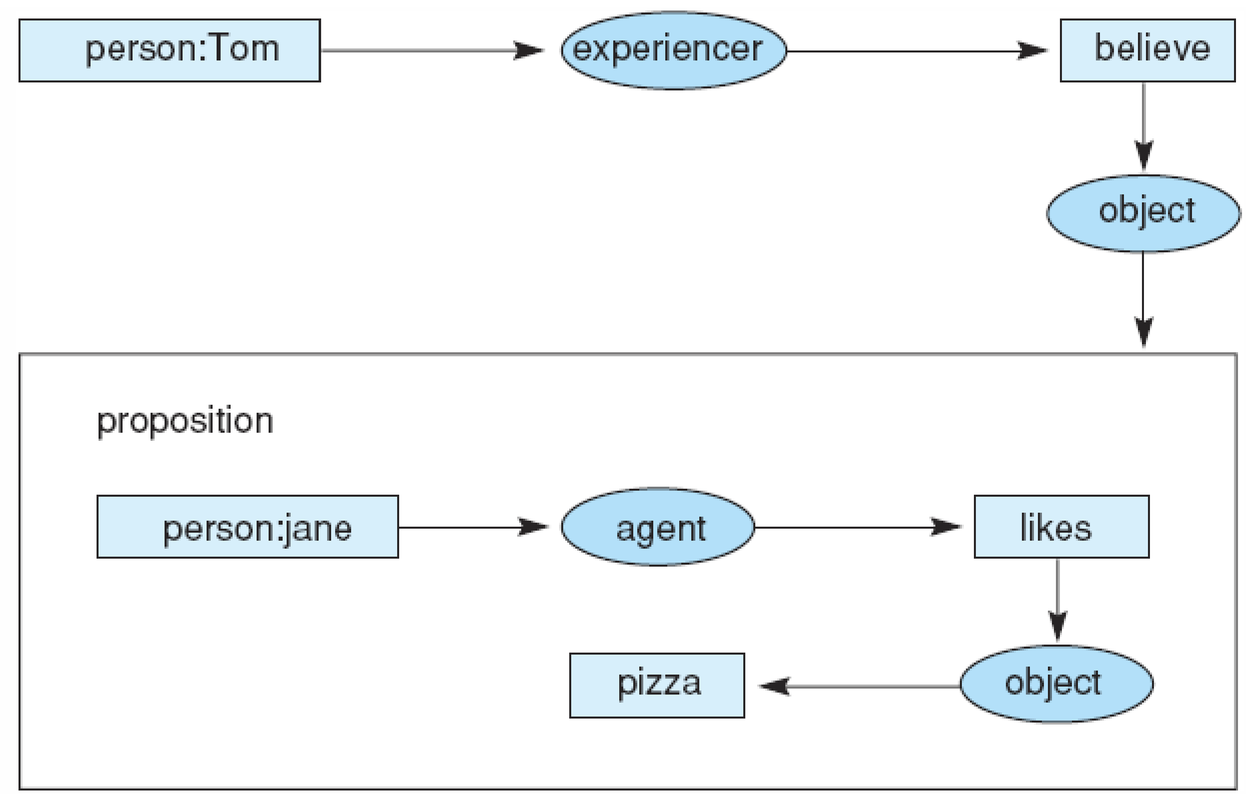


Fig 7.25 Conceptual graph of the proposition "There are no pink dogs."

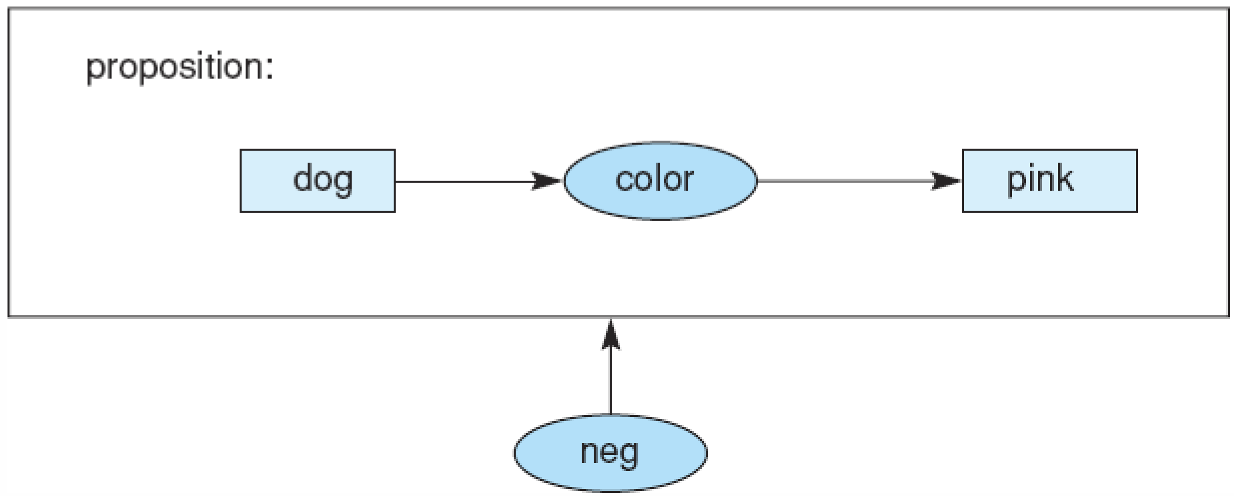


Fig 7.26 The functions of the three-layered subsumption architecture from Brooks (1991a). The layers are described by the AVOID, WANDER, and EXPLORE behaviours.

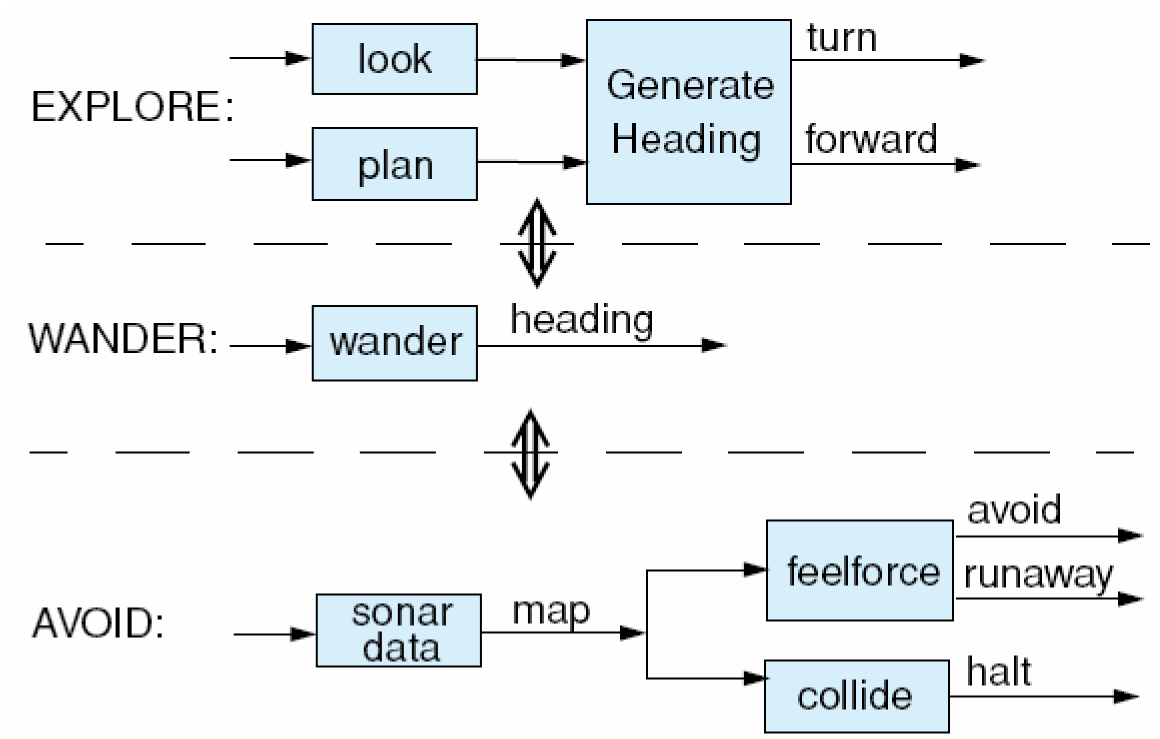


Fig 7.27 A possible state of the copycat workspace. Several examples of bonds and links between the letters are shown; adapted from Mitchell (1993).

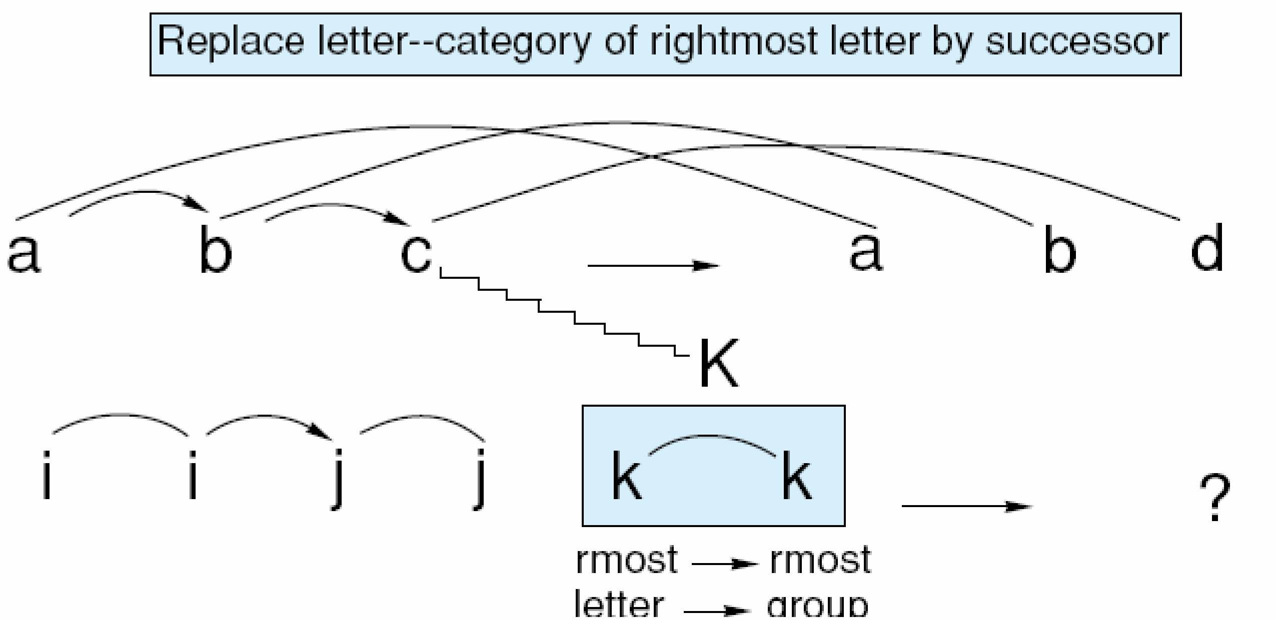


Fig 7.28 A small part of copycat's slipnet with nodes, links, and label nodes shown; adapted from Mitchell (1993).

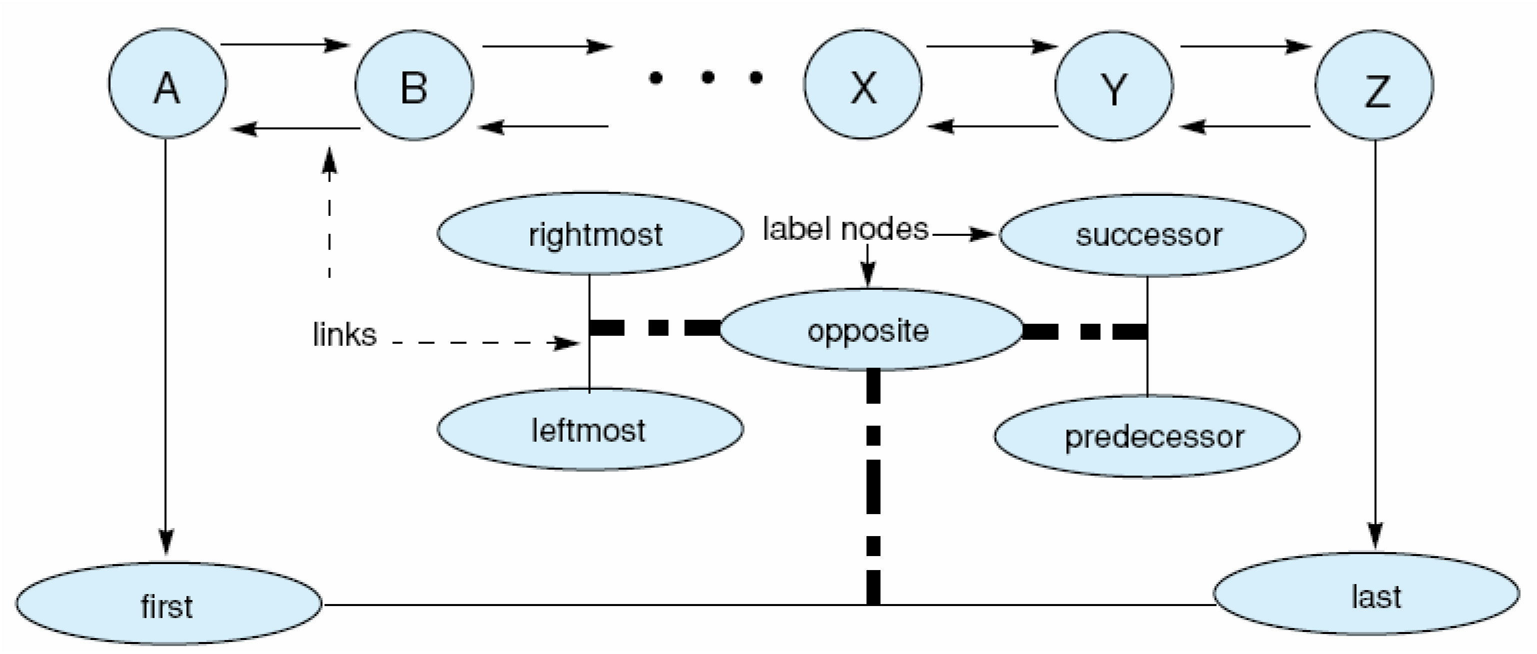


Fig 7.29 Two conceptual graphs to be translated into English.

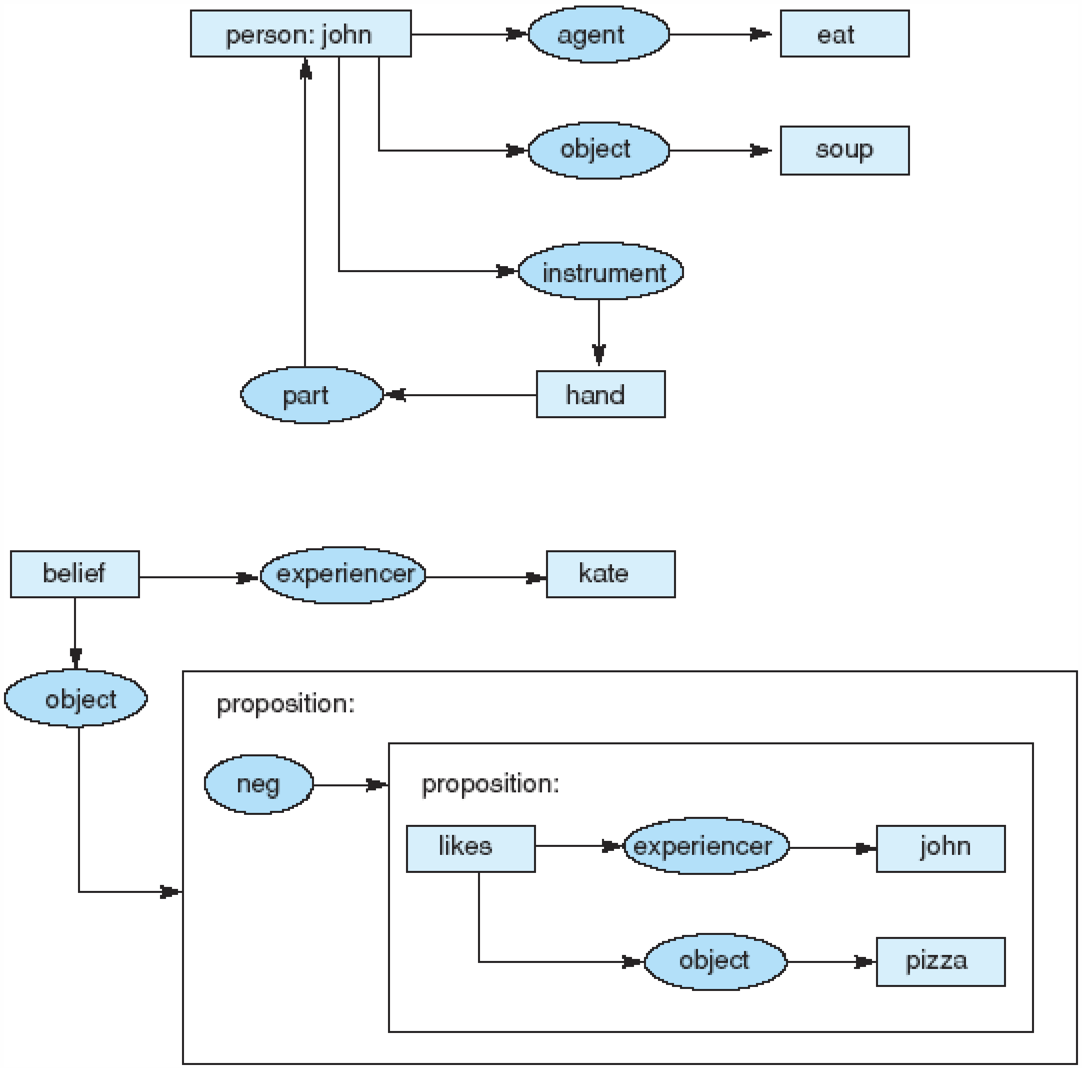


Fig 7.30 Example of analogy test problem.