Artificial Intelligence
(Semantic networks)

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Why semantic networks have evolved?

- Shift in motivation from modeling cognitive processes to addressing computational issues
- Shift in reasoning mechanisms suited to more careful definitions of primitives
- Regarding the original motivation Motivations
  - How should we view the world?
  - What are the recommended inferences?
  - Understand the structure of human memory, and its use in language understanding
  - What sort of representational format can permit the “meanings” of words to be stored, so that human like use of these meanings is possible?
Why semantic networks have evolved?

• **Regarding the representation formalism:**
  - (What) are the(re) primitives?
  - The primitives of a KR technology are those things “the interpreter is programmed in advance to understand”
  - What knowledge can we express?
  - What does a concept mean?
  - What we may see, or imagine.

• **Regarding the reasoning mechanism:**
  - What are the easy/automatic inferences?
  - How efficient can we make these?

• **motivations:**
  - claim that people use same memory structure for variety of tasks.
Advantages

- They allow us to structure the knowledge to reflect the structure of that part of the world which is being represented.
- The semantics, i.e. real world meanings, are clearly identifiable.
- There are very powerful representational possibilities as a result of “is a” and “is a part of” inheritance hierarchies.
- They can accommodate a hierarchy of default values (for example, we can assume the height of an adult male to be 178cm, but if we know he is a baseball player we should take it to be 195cm).
Ross Quillian (1966 and 1968) was among the early AI workers to develop a computational model which represented 'concepts' as hierarchical networks.

This model was amended with some additional psychological assumptions to characterize the structure of [human] semantic memory.

Semantic network (also called Associative Network) is simple representation scheme that uses a graph of labeled nodes and labeled directed arcs to encode knowledge.

Nodes are: objects, concepts, events
Arcs are: relationships between nodes

Graphical depiction associated with semantic networks is a big reason for their popularity.
Arcs define binary relations which hold between objects denoted by the nodes.

Corresponding Predicates:
- mother (john, sue).
- age (john, 5).
- wife (sue, max).
- age (max, 34), etc.

Figure: Semantic Net.
4 parts

**Lexical**: which symbols are allowed in the representation’s vocabulary

**Structural**: describes constraints on how the symbols can be arranged

**Procedural**: specifies the access procedures (to create, modify, answer questions)

**Semantic**: establishes the way of associating the meaning
Parts of a semantic representation

- **Lexical**: nodes to denote objects, links denote relation between objects, link-labels denote particular relations
- **Structural**: nodes are connected to each other by links.
- **Procedural**: procedures are: constructor procedure, reader procedure, writer procedure, and erasure procedure
- **Semantic**: nodes and links denote application specific entities
We can represent the generic GIVE event as a relation involving three things: (John gave Mary a Book)
- A giver
- A recipient
- An object
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 super-class.

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).

Figure: Hierarchical Semantic network
Concepts can be represented as hierarchies of interconnected concept nodes (e.g. animal, bird, canary).

Any concept has a number of associated attributes at a given level (e.g. animal → has skin; eats etc.)

Some concept nodes are super-ordinates of other nodes (e.g. animal → bird) and some are subordinates (canary → bird)

For reasons of cognitive economy, subordinates inherit all the attributes of their super-ordinate concepts

Some instances of a concept are excepted from the attributes that help [humans] to define the super-ordinates (e.g. ostrich is excepted from flying)

Various [psychological] processes search these hierarchies for information about the concepts represented
A node can have any number of super-classes that contain it, enabling a node to inherit properties from multiple parent nodes and their ancestors in the network. Sometimes it may cause conflicting inheritance.

Conflicts like this are common in the real world. Hence, inheritance algorithm reports the conflict, rather than just traversing the tree and reporting the first answer it finds.

A Semantic networks must over-ride conflicts or resolve appropriately.

Figure: multiple Inheritance
Hierarchies that are not simple trees are called tangled hierarchies. These allow another type of inheritance conflict. For example:

Question: “Can Oliver fly?”

A better solution than having a specific “flies no” for all individual instances of an ostrich, would be to have an algorithm for traversing the algorithm which guarantees that specific knowledge will always dominate over general knowledge. How?
Instead, we can base our inheritance algorithm on the inferential distance, which can be used to define the concept of “closer” as follows:

“Node1 is closer to Node2 than Node3 if and only if Node1 has an inference path through Node2 to Node3, i.e. Node2 is in between Node1 and Node3”.

Closer nodes in this sense will be more specific than further nodes, and so we should inherit any defaults from them.

Notice that inferential distance only defines a partial ordering - so it will not be any help with the Nixon example.

In general, the inferential engine will be composed of many procedural rules like this to define how the semantic network should be processed.
Advantages/disadv. 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

Disadv.

- Inheritance (particularly from multiple sources and when exceptions in inheritance are wanted) can cause problems.
- No standards about node and arc values
- No internal structure of nodes
- No easy way to represent heuristic information
- Search may lead to combinatorial explosion especially for queries with negative results
• Treat WWW Identifiers (URI’s) as nodes
• Create a repository of triples describing these macros nodes semantically.
  - Traditional Meta-Data such as author, creation-date
  - Non traditional meta-data such as summary or peer review
• Use this network to retrieve Web resources based on their semantics
  - W3C standards are being evolved for this purpose:
  - RDF (resource description format), XML syntax
Applications

- Document Processing
- Question Processing
- Query Expansion
- Search
- Answer Generation
- Answer Selection
Problems

- Represent the relationships between quadrangle, parallelogram, rhombus, rectangle and square in the form of a semantic network. Is the semantic network unique, or are there many different forms it can take? Now represent the same items as a series of frames.

- How would you represent the following statements using semantic networks:
  - “John tells his students a lot of useful things.”
  - “Andrea tells John’s students an enormous number of useful things.”

Suppose you wanted to build an AI system that was able to work out who tells John’s students the greatest number of useful things. How could you do that?