Semantic Networks

A representation is a set of **syntactic** and **semantic** conventions that make it possible to describe things.

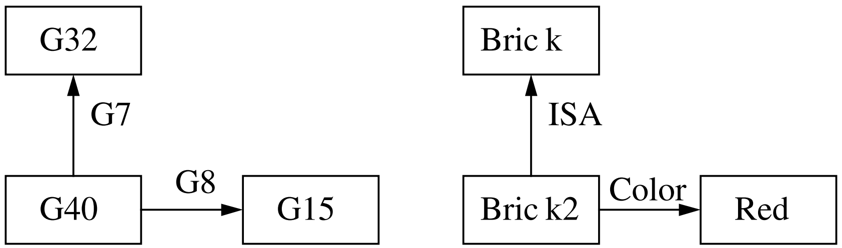
The **syntax** of a representation specifies the symbols that may be used and the ways those symbols may be arranged.

The **semantics** of a representation specifies how meaning is embodied in the symbols and the symbol arrangements allowed by the syntax.

The syntax of a semantic net is simple:

objects are denoted by **nodes**
relations are denoted by **links**

A node-and-link net is not necessarily a semantic net. To be a semantic net, there must be semantics.



(a) (b)

Semantic Networks

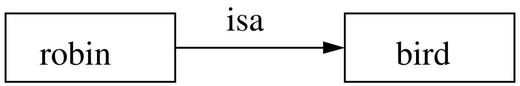
Semantic networks make explicit entities and relationships.

Entities are the basic objects in the system.

Relationships indicate how pairs of entities relate.

Relationships are usually binary
Relationships have an associated semantics

Example: "All robins are birds."



isa links indicate class membership.

bird is a member of the class robin.

Note that relationships in a semantic network are directional.

Semantic Networks

Networks implicity represent relationships between multiple entities.

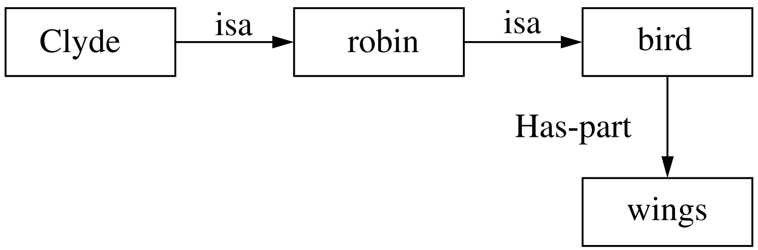
By defining a chain rule for isa, it is possible to relate Clyde and bird.

Can determine "Clyde isa bird" without the need to explicitly represent relationship.

Chaining of isa links is an example of inheritance. Inheritance increases the power of representations by reducing the need to explicitly describe relationships.

isa links can be used to create complex taxonomic structures. (Taxonomies are classification structures.)

Also necessary to describe properties of particulare entities in a taxonomy.

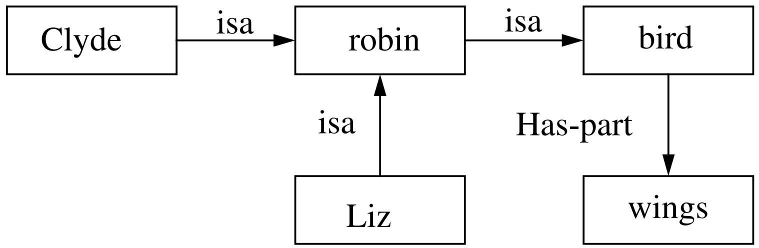


Semantic Networks

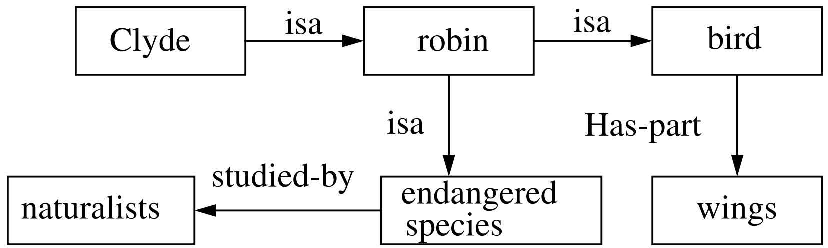
Inheritance makes it possible to infer properties about entities.

E.g. "Clyde has-part wing."

Inheritance makes representations compact.



Inheritance is not always desirable.



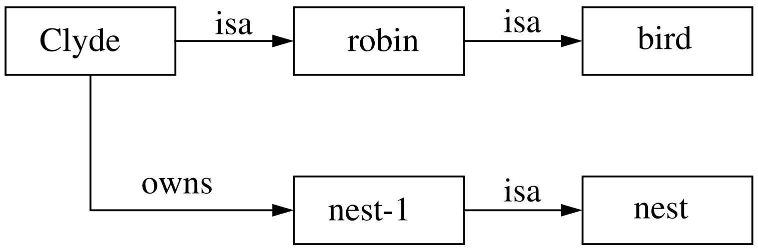
The class robins is studied by naturalist

The entity Clyde may or may not be studied by naturalists.

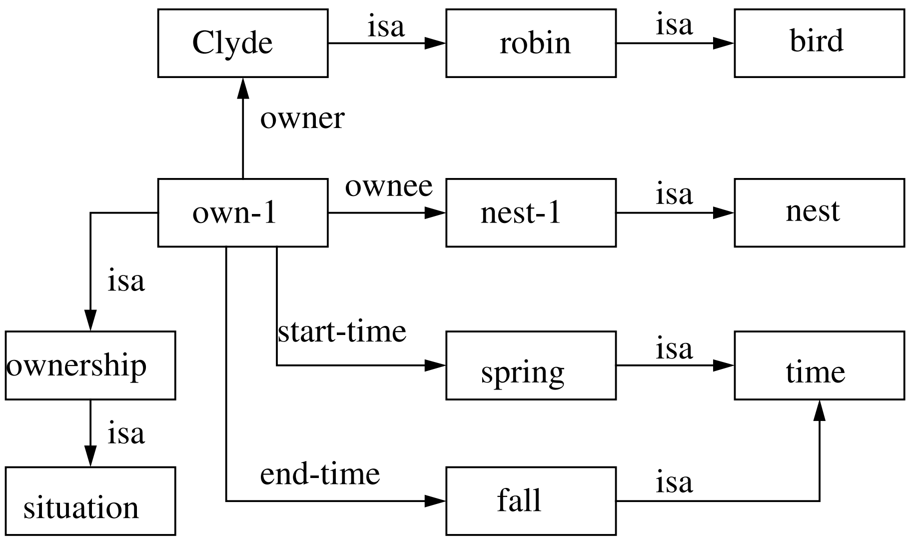
Semantic Networks

Relationships involving complex predicates are difficult to represent in sematic networks .

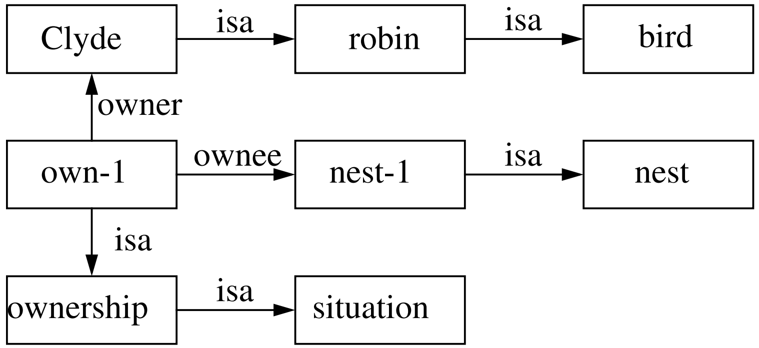
E.g. "Clyde owns a nest."



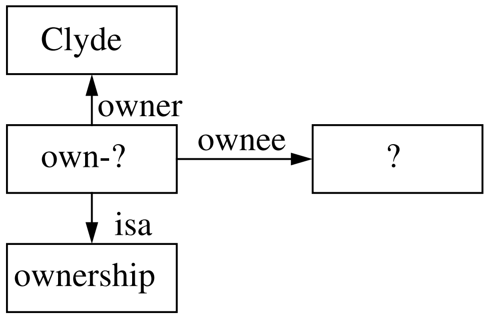
Muc h harder to represent "Clyde owns a nest from spring until fall."



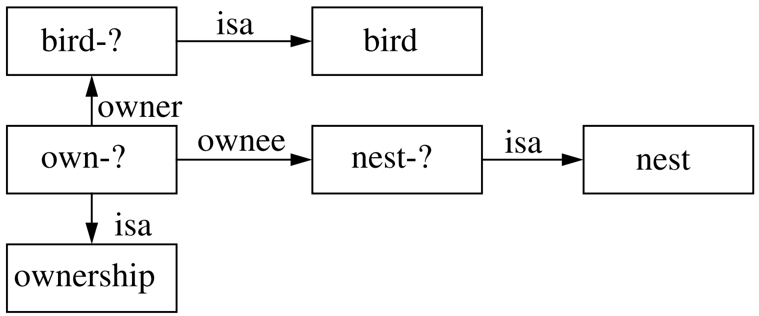
Reasoning with Semantic Networks



What does Clyde own?



Is there a bird who owns a nest?



Frame-based representation

Frames extend the basic concepts of semantics networks by providing a more structured description of entities .

- Frames are nodes
- Frame-subframe relationships are links

Frames are used to represent information about stereotypical situation.

- A frame typically represents information about a class of entities .
- Frames have variables that can take on a range of values .
- The instantiation of a frame represents a particular instance of the class of entities .
    - Instantiation involved the assignment of values to variables .

Frame-based representation

A frame is a collection of **slots** which are attribute-value pairs . For a given frame , the attributes are fixed. Values can be constants , variables , or other frames .

Specialized slots are used to relate different frames .

- Specialization-of
    - Isa hierarchy
- Default
    - Expectations
    - Makes likely values explicit without
- If-needed
    - Procedural attachment- Procedures which, when executed, will determine the value of a slot.
- If-added
    - Procedure which should be executed when a particular slot is assigned a value .
    - Used to handle exception conditions .

Frame-based representation

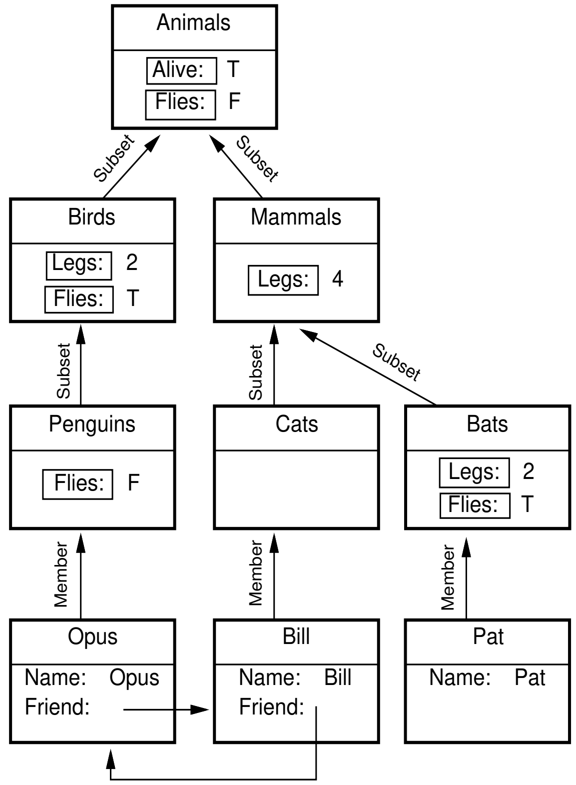
Example of three simple frame structures

CHAIR frame:
Specialization-of: FURNITURE
Number -of-legs: an integer (DEF AULT=4)
Style-of-bac k: straight, cushioned, ...
Number -of-arms: 0, 1, or 2

JOHN' s-CHAIR frame
Specialization-of: CHAIR
Number -of-legs: 4
Style-of-bac k: cushioned
Number -of-arms: 0

REST AURANT frame:
Specialization-of: Business-establishment
Type:
range: (Cafe , Seat-yourself , To-be-seated)
default: to-be-seated
if-needed: IF stac k-of-tra ys THEN Cafe
IF w ait-to-be-seated sign
THEN T o-be-seated
Otherwise Seat-yourself
Food-style:
range: (Burgers , Chinese , American, ...)
default: Chinese
if-added: (Update range slot)

A frame-based network



(a) A frame-based knowledge base

Rel(Alive,Animals,T)
Rel(Flies,Animals,F)

Birds $\subset$ Animals
Mammals $\subset$ Animals

Rel(Flies,Birds,T)
Rel(Legs,Birds,2)
Rel(Legs,Mammals,4)

Penguins $\subset$ Birds
Cats $\subset$ Mammals
Bats $\subset$ Mammals

Rel(Flies,Penguins,F)
Rel(Legs,Bats,2)
Rel(Flies,Bats,T)

Opus $\in$ Penguins
Bill $\in$ Cats
Pat $\in$ Bats

Name(Opus,"Opus")
Name(Bill,"Bill")
Friend(Opus,Bill)
Friend(Bill,Opus)
Name(Pat,"Pat")

(b) Translation into first-order l

- **A frame-based network and a translation of the network into FOL. Boxed relation names in the network correspond to relations holding for all members of the set of objects.**

Link types in semantic networks

- Links that indicate **subset** or **member** relationships

- link that says a relation R holds between two objects .

- link that says R holds between every element of the class A and the object B

- link that says R holds between every element of A and some element of B .

Link Type	Semantics	Example
$A \xrightarrow{Subset} B$	$A \subset B$	$Cats \subset Mammals$
$A \xrightarrow{Member} B$	$A \in B$	$Bill \in Cats$
$A \xrightarrow{R} B$	$R(A,B)$	$Bill \xrightarrow{Age} 12$
$A \xrightarrow{\boxed{R}} B$	$\forall x \;\; x \in A \Rightarrow R(x,B)$	$Birds \xrightarrow{\boxed{Legs}} 2$
$A \xrightarrow{\boxed{\boxed{R}}} B$	$\forall x \;\; \exists y \;\; x \in A \Rightarrow y \in B \wedge R(x,y)$	$Birds \xrightarrow{\boxed{\boxed{Parent}}} Birds$

- To deal with exceptions , change the semantic translation of a boxed-R link from A to B to mean that ***every member of A must have an R relation to B unless there is some intervening A ' for which Rel(R, A ', B')***.