Slot and Filler

(Speech is representation of mind and writing is representation of speech)

Use of Slot and Filler Structure?

It enables attribute values to be retrieved quickly

- assertions are indexed by the entities
- binary predicates are indexed by first argument. *E.g. team(Mike-Hall , Cardiff)*.

Properties of relations are easy to describe

- It allows ease of consideration as it embraces aspects of object oriented programming.

So called because:

- A *slot* is an attribute value pair in its simplest form.
- A *filler* is a value that a slot can take -- could be a numeric, string (or any data type) value or a pointer to another slot.
- A *weak* slot and filler structure does not consider the *content* of the representation.

We will study two types:

  - Semantic Nets.
  - Frames.

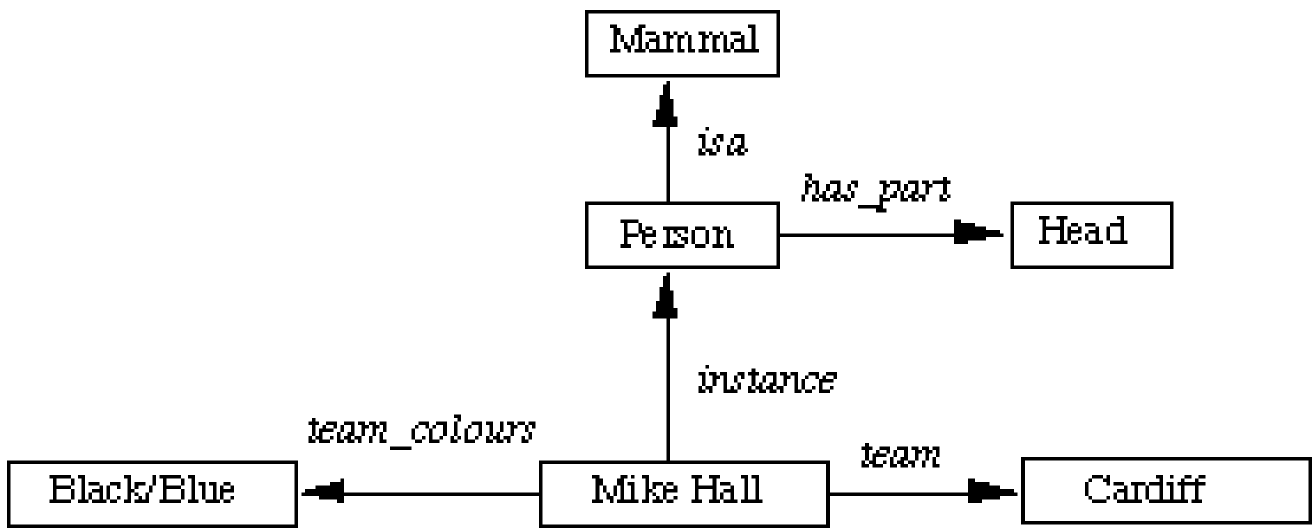
Semantic Nets

The major idea is that:

- The meaning of a concept comes from its relationship to other concepts, and that,
- The information is stored by interconnecting nodes with labeled arcs.

Representation in a Semantic Net

- The physical attributes of a person can be represented as in.

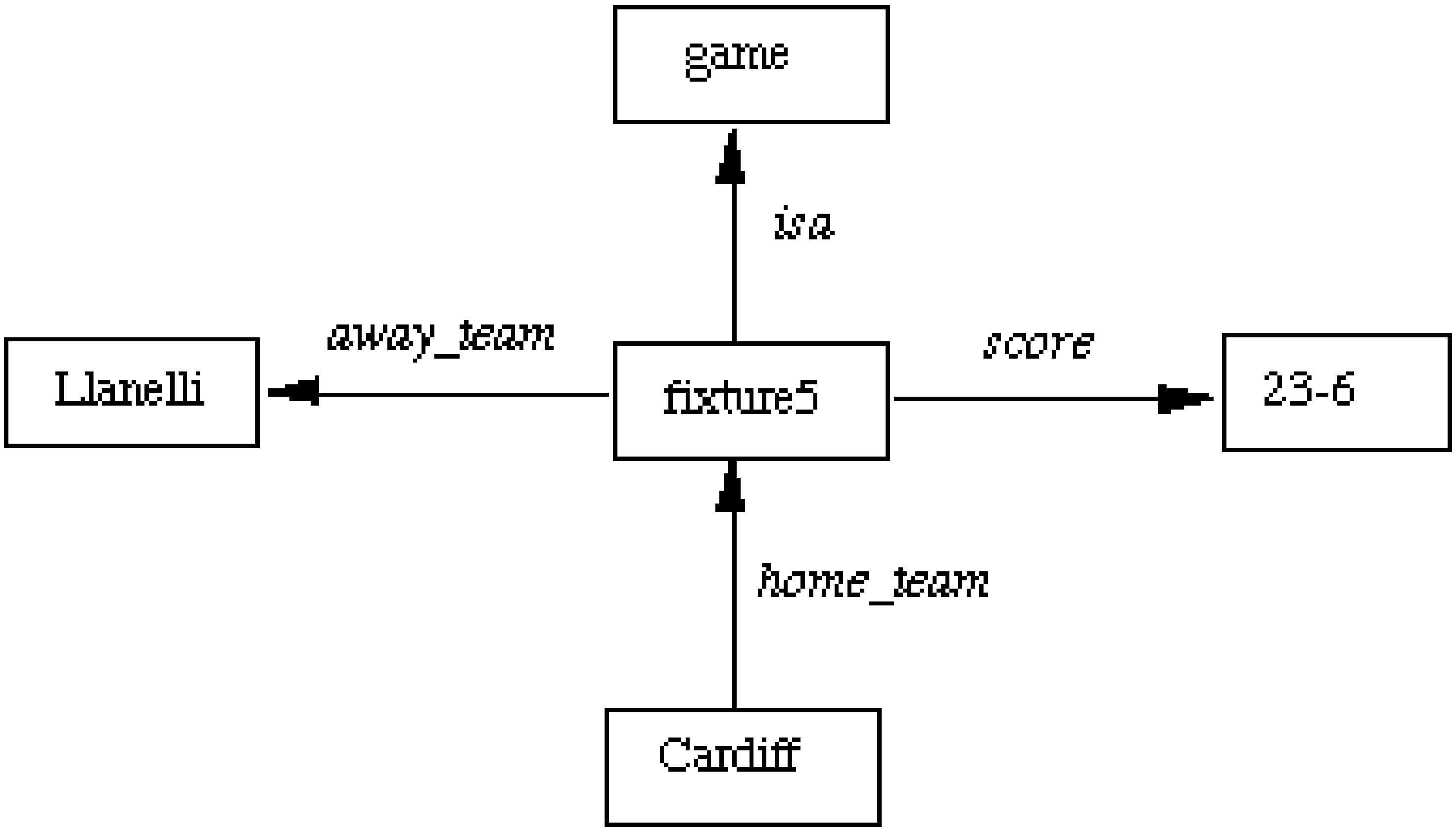


- Intersection search

- These values can also be represented in logic as:
  - *isa(person, mammal),*
  - *instance(Mike-Hall, person)*
  - *team(Mike-Hall, Cardiff)*

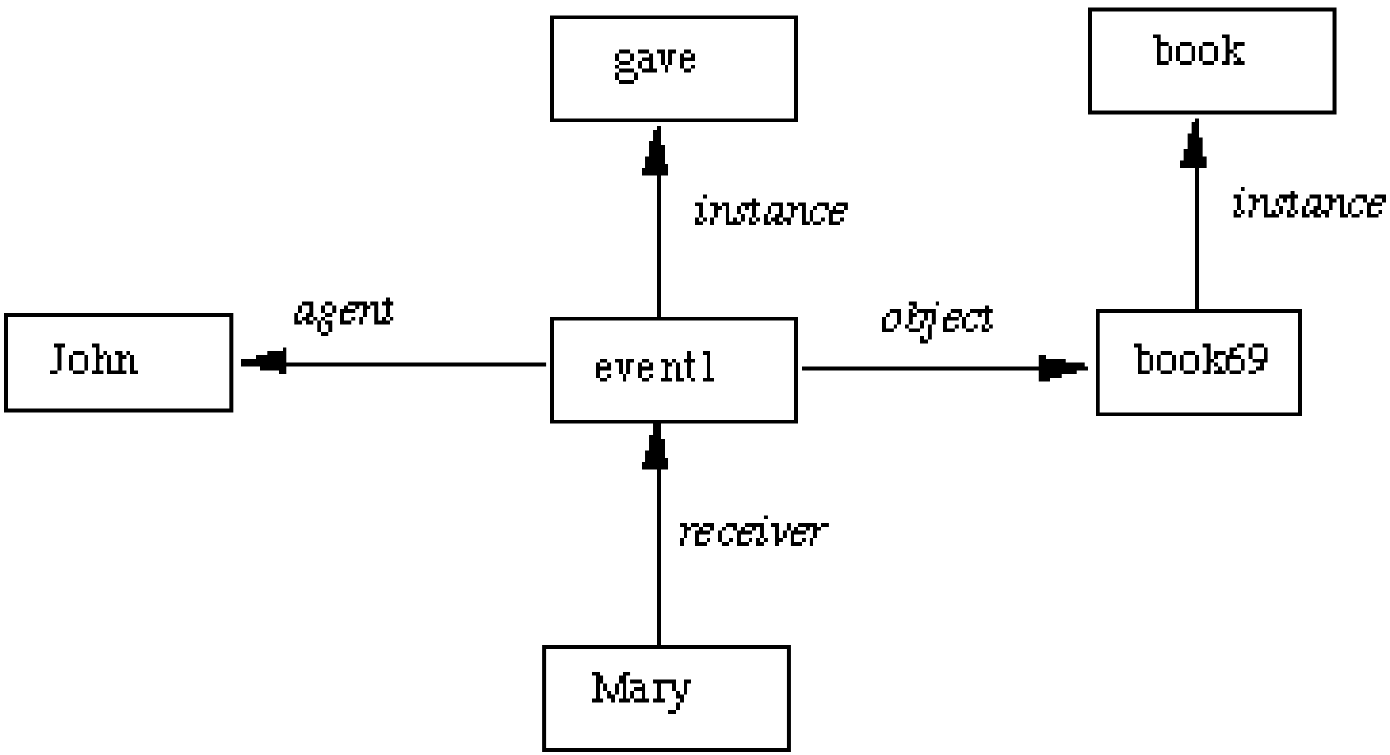
- We know that l*ecturer(dave)* can be written as *instance (dave, lecturer)*
- But we have a problem: *How we can have more than 2 place predicates in semantic nets? E.g. score(Cardiff, Linelli, 23-6)*

- Solution:
- Create new nodes to represent new objects either contained or referenced to in the knowledge, *game* and *fixture* in the current example.
- Relate information to nodes and fill up slots (Fig:



A Semantic Network for *n*-Place Predicate

- As a more complex example consider the sentence: *John gave Mary the book*. Here we have several aspects of an event.



A Semantic Network for a Sentence

Inference in a Semantic Net

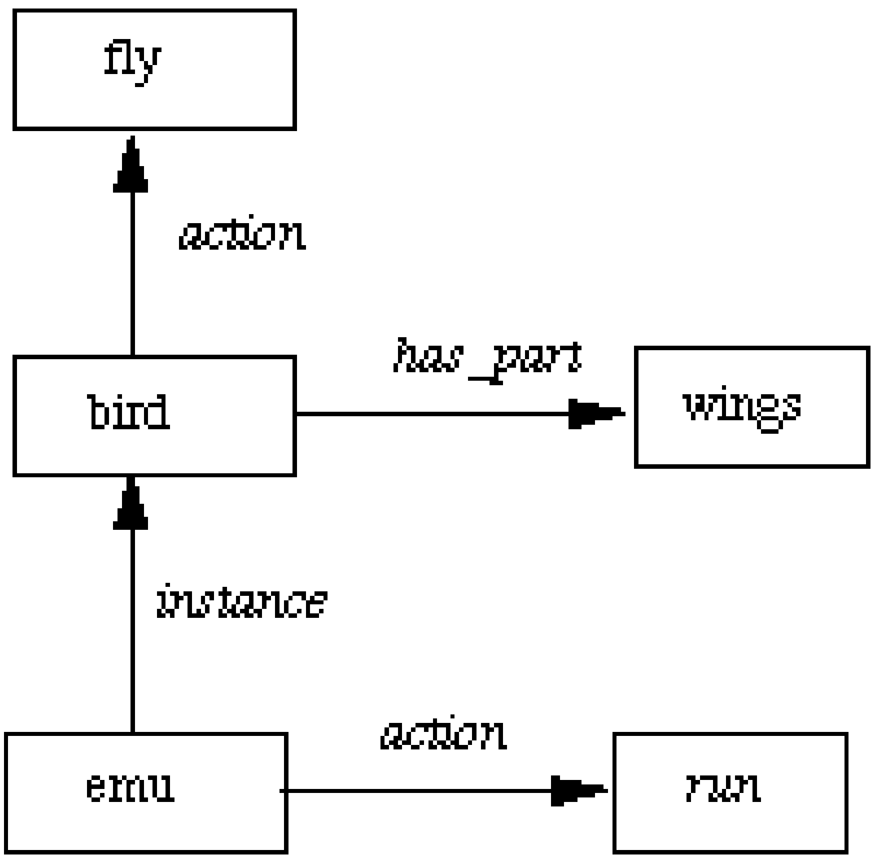
- Basic inference mechanism: *follow links between nodes*.
- Two methods to do this:
- **Intersection search** -- the notion that *spreading activation* out of two nodes and finding their intersection finds relationships among objects. This is achieved by assigning a special tag to each visited node. Many advantages including entity-based organisation and fast parallel implementation. However very structured questions need highly structured networks.

Inference in a Semantic Net

Inheritance -- the *isa* and *instance* representation provide a mechanism to implement this.

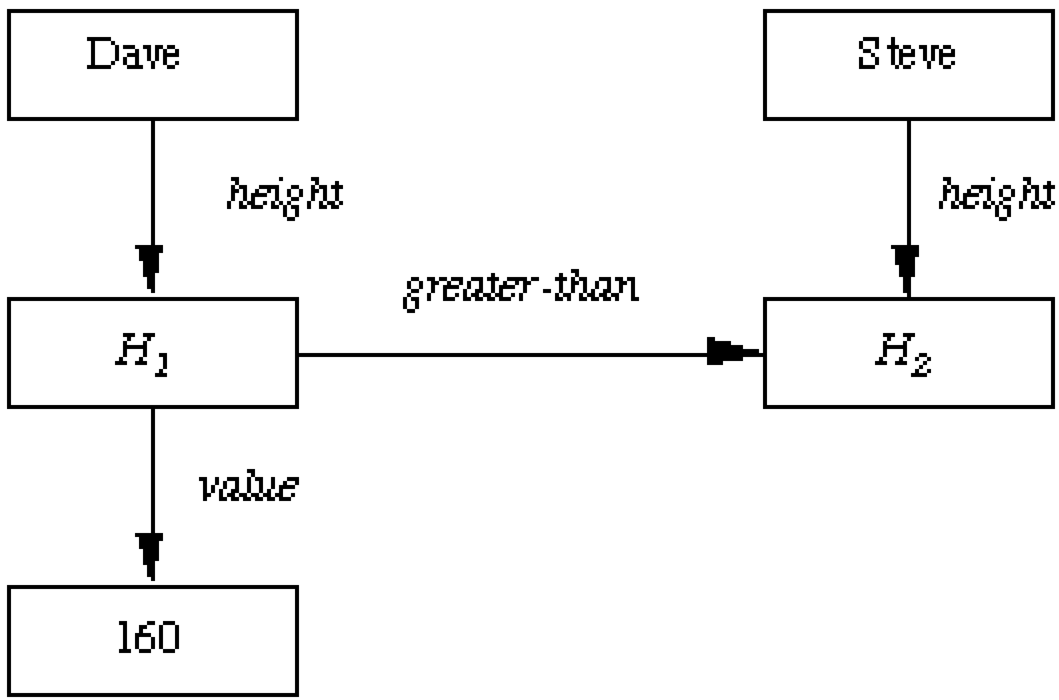
Inheritance also provides a means of dealing with *default reasoning*. *E.g.* we could represent:

- Emus are birds.
- Typically birds fly and have wings.
- Emus run.



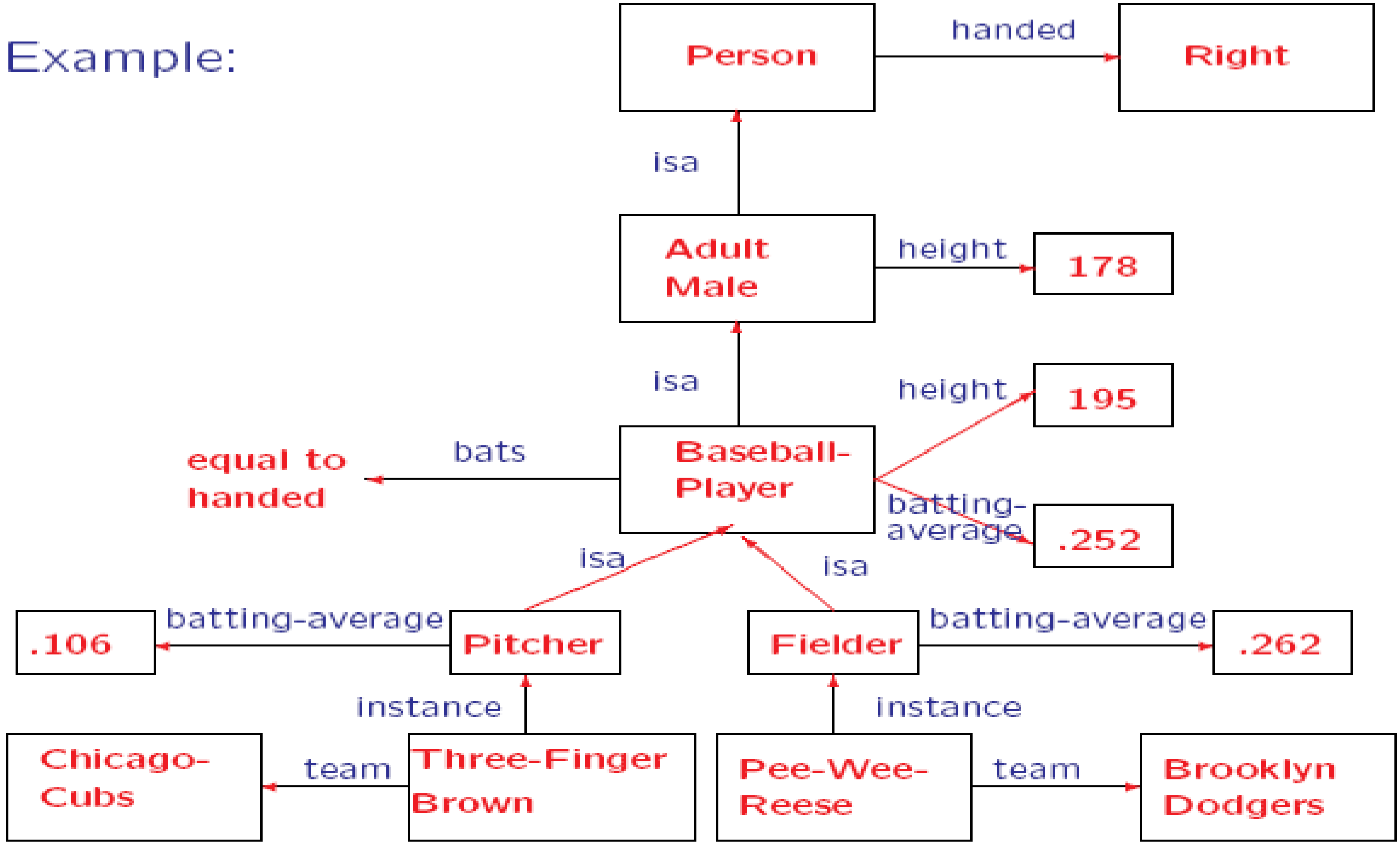
A Semantic Network for a Default Reasoning

Making important distinction



Semantic Nets

Example:



Semantic Nets

- *Isa* hierarchy is normally used in semantic nets/frames.
- Lines represent attributes. Boxed nodes represent objects and values of attributes of objects.
- Correct deduction from Figure 2could be:

  height of Three-Finger Brown is 195cm.
- An incorrect deduction could be:

  height of Three-Finger Brown is 178cm

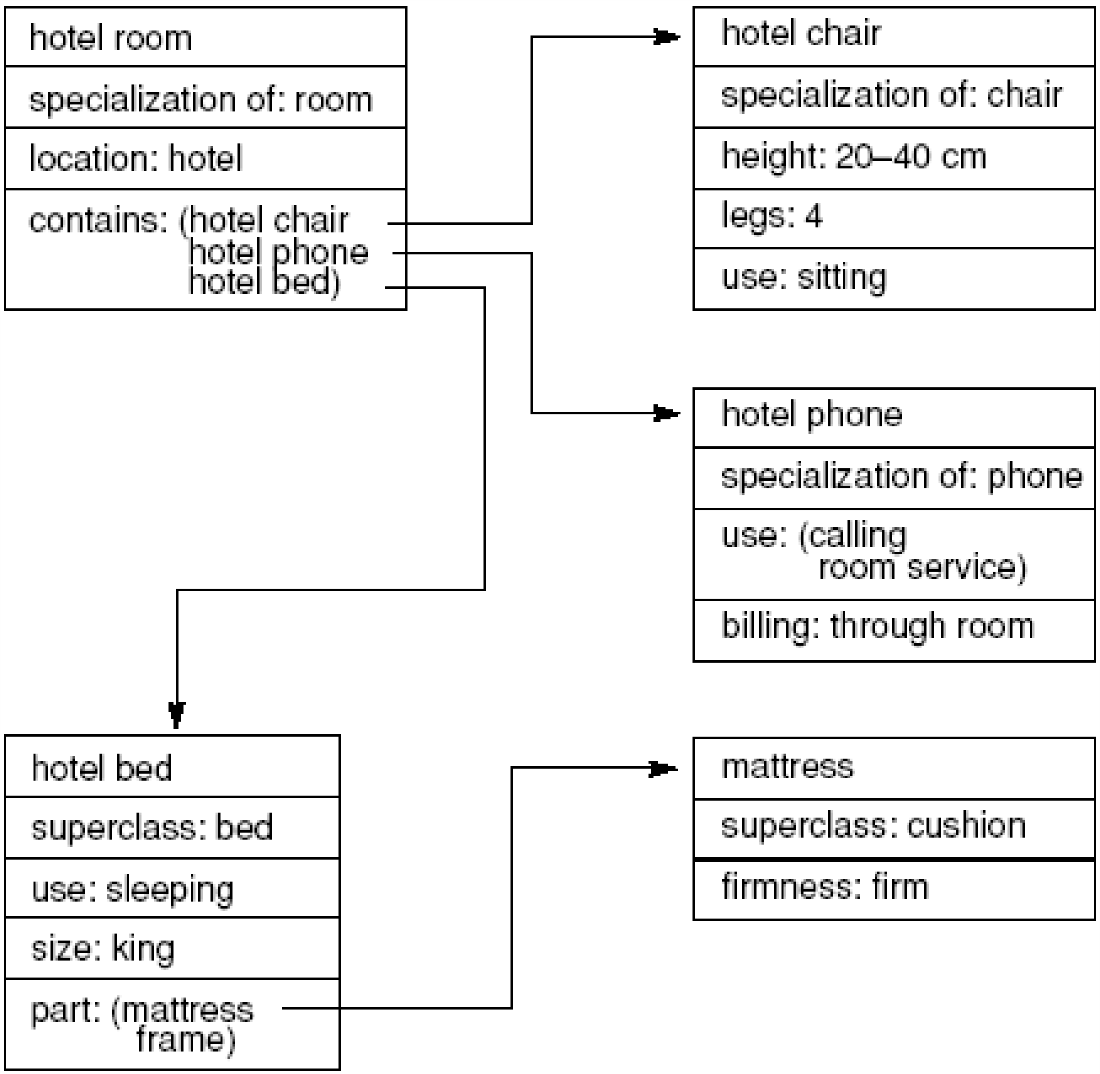
Semantic Nets

- The structure shown in the figure 2 is a *slot-and-filler* structure.
- It may be also called a *semantic network* or a collection of frames.
- It will be discussed more in the next session

Frames

- The semantic network requires a graph representation which may not be a very efficient use of memory
- Another representation is the frame
  - the idea behind a frame was originally that it would represent a “frame of memory” – for instance, by capturing the objects and their attributes for a given situation or moment in time
  - a frame would contain slots where a slot could contain
    - identification information (including whether this frame is a subclass of another frame)
    - relationships to other frames
    - descriptors of this frame
    - procedural information on how to use this frame (code to be executed)
    - defaults for slots
    - instance information (or an identification of whether the frame represents a class or an instance)

Frame Example



Here is a partial frame representing a hotel room

The room contains a chair, bed, and phone where the be
contains a mattress and a be
frame (not shown)

Reasoning Mechanisms

- How do we use our semantic net/frame to reason over?
  - reasoning with defaults
    - the semantic network or frame will contain default values, we can infer that the default values are correct unless otherwise specified
    - what if default values are not given? what if default values are given but we have an exceptional case that is not explicitly noted?
  - reasoning with inheritance
    - we can inherit any properties from parent types unless overridden
    - what about multiple inheritance?
  - reasoning with attribute-specific values
    - Implement a process to reason over a “has” link
      - if A has B, we might assume A and B are physically connected and in close proximity
      - this doesn’t work if we are using “has” somewhat more loosely like “that man has three children” or “she has the chicken pox”

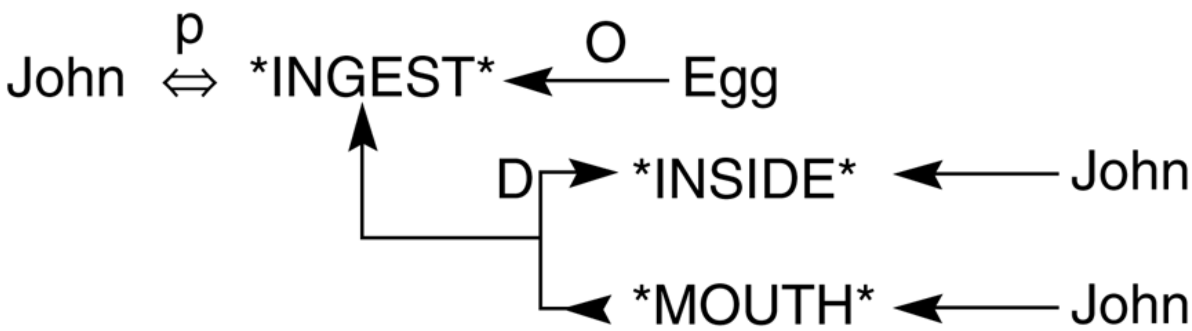
Problems

- The main problem with semantic networks and frames is that they lack formality
  - there is no specific guideline on how to use the representation
    - if I use the word “has” in a way other than “physical property”, your reasoning might break down
    - isa and instance attributes seem clearly defined, but the attributes may not be
    - unlike predicate calculus, there are no formal mechanisms for reasoning, inheritance itself can be considered controversial, at least when we allow multiple inheritance!
- The frame problem
  - when things change, we need to modify all frames that are relevant – this can be time consuming
    - consider having a frame the represents a hotel room and the table has a potted plant on it – when we move the table away from the window, do we also modify that the plant is no longer near the window and so may die because of a lack of sunlight?

Strong Slot-n-Filler Structures

- To avoid the difficulties with Frames and Nets, Schank and Rieger offered two network-like representations that would have implied uses and built-in semantics: conceptual dependencies and scripts
  - the conceptual dependency was derived as a form of semantic network that would have specific types of links to be used for representing specific pieces of information in English sentences
    - the action of the sentence
    - the objects affected by the action or that brought about the action
    - modifiers of both actions and objects
  - they defined 11 primitive actions, called ACTs
    - every possible action can be categorized as one of these 11
    - an ACT would form the center of the CD, with links attaching the objects and modifiers

Example CD



- The sentence is “John ate the egg”
- The INGEST act means to ingest an object (eat, drink, swallow)
  - the P above the double arrow indicates past test
  - the INGEST action must have an object (the O indicates it was the object Egg) and a direction (the object went from John’s mouth to John’s insides)
  - we might infer that it was “an egg” instead of “the egg” as there is nothing specific to indicate which egg was eaten
  - we might also infer that John swallowed the egg whole as there is nothing to indicate that John chewed the egg!

The CD Theory ACTs

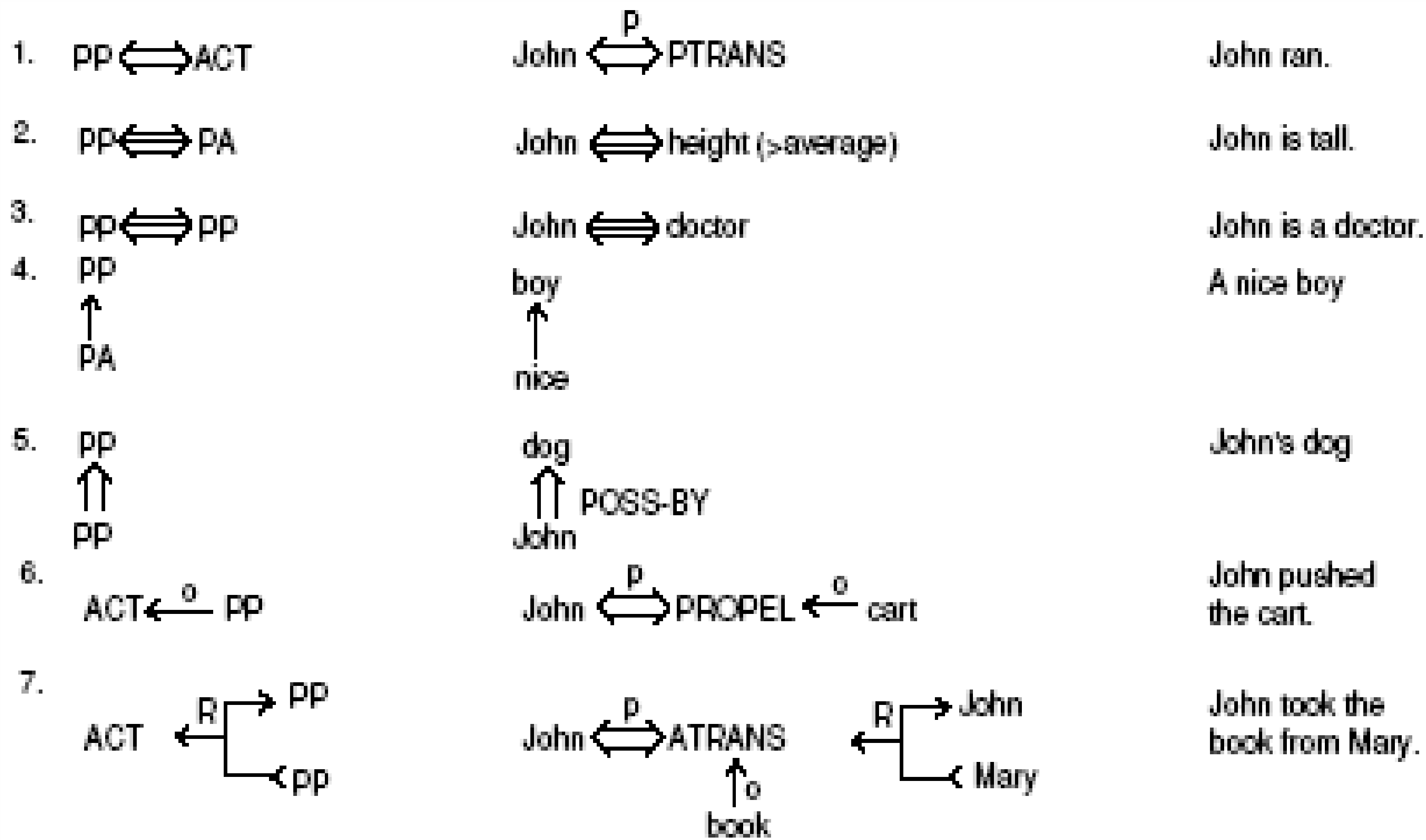
ATRANS	transfer a relationship (give)
PTRANS	transfer physical location of an object (go)
PROPEL	apply physical force to an object (push)
MOVE	move body part by owner (kick)
GRASP	grab an object by an actor (grasp)
INGEST	ingest an object by an animal (eat)
EXPEL	expel from an animal's body (cry)
MTRANS	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)

- Is this list complete?
  - what actions are missing?
- Could we reduce this list to make it more concise?
  - other researchers have developed other lists of primitive actions including just 3 – physical actions, mental actions and abstract actions

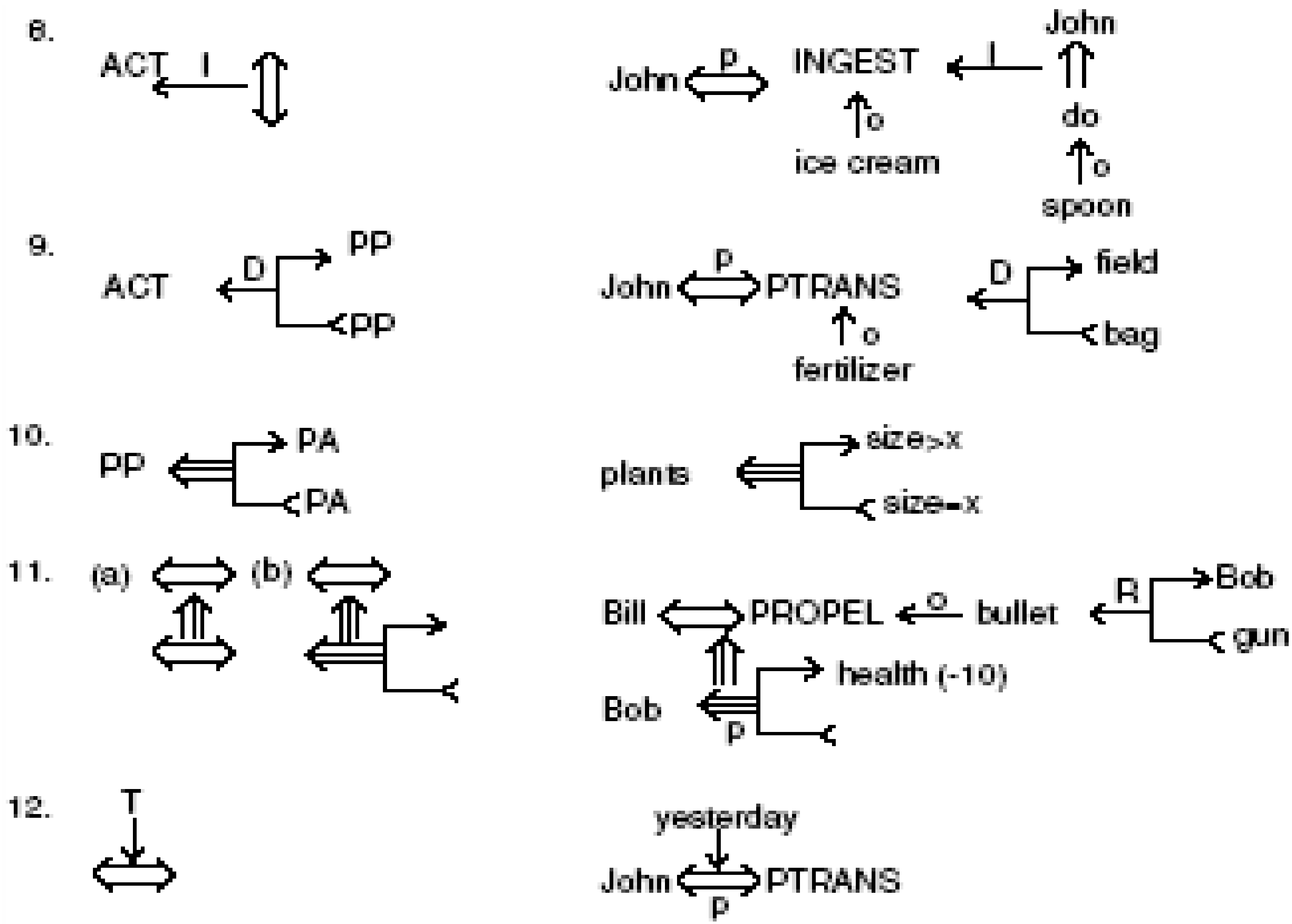
Example CD Links

$PP \Leftrightarrow ACT$	indicates that an actor acts.
$PP \Leftrightarrow PA$	indicates that an object has a certain attribute.
$ACT \overset{O}{\leftarrow} PP$	indicates the object of an action.
$ACT \leftarrow \overset{R}{} \begin{cases} \rightarrow PP \\ \leftarrow PP \end{cases}$	indicates the recipient and the donor of an object within an action.
$ACT \leftarrow \overset{D}{} \begin{cases} \rightarrow PP \\ \leftarrow PP \end{cases}$	indicates the direction of an object within an action.
$ACT \overset{1}{\leftarrow} \Updownarrow$	indicates the instrumental conceptualization for an action.
$\begin{matrix} X \\ \Uparrow \\ Y \end{matrix}$	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.

Example CDs


1.
PP
ACT
John
p
PTRANS
John ran.
2.
PP
PA
John
height (>average)
John is tall.
3.
PP
PP
John
doctor
John is a doctor.
4.
PP
PA
boy
nice
A nice boy
5.
PP
PP
dog
POSS-BY
John
John's dog
6.
ACT
o
PP
John
p
PROPEL
o
cart
John pushed
the cart.
7.
ACT
R
PP
PP
John
p
ATRANS
o
book
R
John
Mary
John took the
book from Mary.

More Examples



Scripts

- The other structured representation developed by Schank (along with Abelson) is the script
  - a description of the typical actions that are involved in a typical situation
    - they defined a script for going to a restaurant
  - scripts provide an ability for default reasoning when information is not available that directly states that an action occurred
  - so we may assume, unless otherwise stated, that a diner at a restaurant was served food, that the diner paid for the food, and that the diner was served by a waiter/waitress
- A script would contain
  - entry condition(s) and results (exit conditions)
  - actors (the people involved)
  - props (physical items at the location used by the actors)
  - scenes (individual events that take place)
- The script would use the 11 ACTs from CD theory

Restaurant Script

- The script does not contain atypical actions
  - although there are options such as whether the customer was pleased or not
- There are multiple paths through the scenes to make for a robust script
  - what would a “going to the movies” script look like? would it have similar props, actors, scenes? how about “going to class”?