Artificial Intelligence

Knowledge Representation III

Lecture 8

(20 October, 1999)

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Content: Knowledge Representation III

- Quick Review on Lecture 7
- First Order Logic BNF Grammer
- Class Workout 1: Express them in LFOPC and draw the diagrams (with solutions)
- Class Workout 2: Prove that Colonel West is a criminal
- Logic for Commonsense Reasoning
- Introduction to Non-monotonic Reasoning
- Representation using Semantic Nets
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- Semantic Nets Inference Mechanism
- Representation using Frames (Box on Table Example)
- Other kinds of Logic
- Students' Mini Research Presentation by Group C
- What's in Store for Lecture 9

Quick Review on Lecture 7

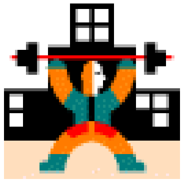
- Alt.Revision on L6
- Predicate Calculus
- Predicate Calculus Syntax
- First Order Predicate Calculus (FOPC)
- FOPC Equivalence
- Representation of English Language
- FOPC Inference Rules
- Some Useful Inference Rules
- Unification
- Substitution
- Most General Unifier

First Order Logic BNF Grammer

BNF Grammer for defining the well-formed formulae (WFF) in FOL

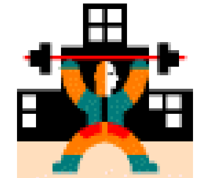
- **Sentence** → Atomic | Complex
- **Complex** → (Sentence) | !Sentence | Sentence Connective Sentence | Quantifier Var, ... Sentence
- **Atomic** → Predicate(Term, ...) | Term = Term
- **Term** → Function(Term, ...) | Constant | Variable
- **Connective** → $\wedge$ | $\vee$ | → | ~
- **Quantifier** → $\forall$ | $\exists$
- **Constant** → A | X1 | John | ...
- **Predicate** → Before | HasColor | Raining | ...
- **Function** → Mother | LeftLegOf | ...

Class Workout 1: Express them in LFOPC and draw the diagrams (with solutions)



- 1. All cats are mammals
- 2. Spot has a sister who is a cat
- 3. John loves everything
- 4. Everything loves everything
- 5. John loves all fuzzy things
- 6. All numbers are either odd or even
- 7. John loves something
- 8. Everybody loves somebody
- 9. There is someone who is loved by everyone
- 10. Spot has at least two sisters
- 11. There is exactly one King

Class Workout 2:
Prove that Colonel West is a criminal



- "The law says that it is a crime for an American to sell weapons to hostile nations. The country Nono, an enemy of America, has some missiles, and all of its missiles were sold to it by Colonel West, who is an American. Prove that Colonel West is a criminal."

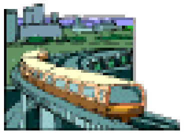
Logic for Commonsense Reasoning

- We need a **theory of reasoning** capable of dealing with **defaults**, **epistemic** statements, etc.

- Unlike mathematics, the **knowledge** used by a **"commonsense" reasoner** will be **incomplete** and **frequently updated**.

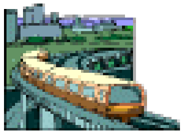
- Reasoning with such knowledge seems to be **nonmonotonic**, ie. new information may force us to **withdraw previous conclusions**.

Introduction to Non-monotonic Reasoning



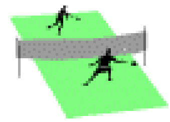
- Conventional Reasoning Systems are **monotonic.**
- **Closed World Assumption** (CWA) assumes a closed world of information.
- Information need to be **complete**, **consistent** & **new facts** added to the system be consistent with the already existing information.
- **Non-monotonic reasoning** - possible to reason with **incomplete information**.

Introduction to Non-monotonic Reasoning (cont)



- A **statement** is either believed to be **true**, **false** or **neither**.
- **New facts added** could be **inconsistent** with the previous.
- **Knowledge base** needs to be **updated** properly.
- Allow **inferences** to be made on the **basis of lack of knowledge** as well as **presence** of it.
- **Resolve conflicts** when several inconsistent non-monotonic inferences are drawn.

Representation using Semantic Nets



The major idea of **Semantic Nets** is that:

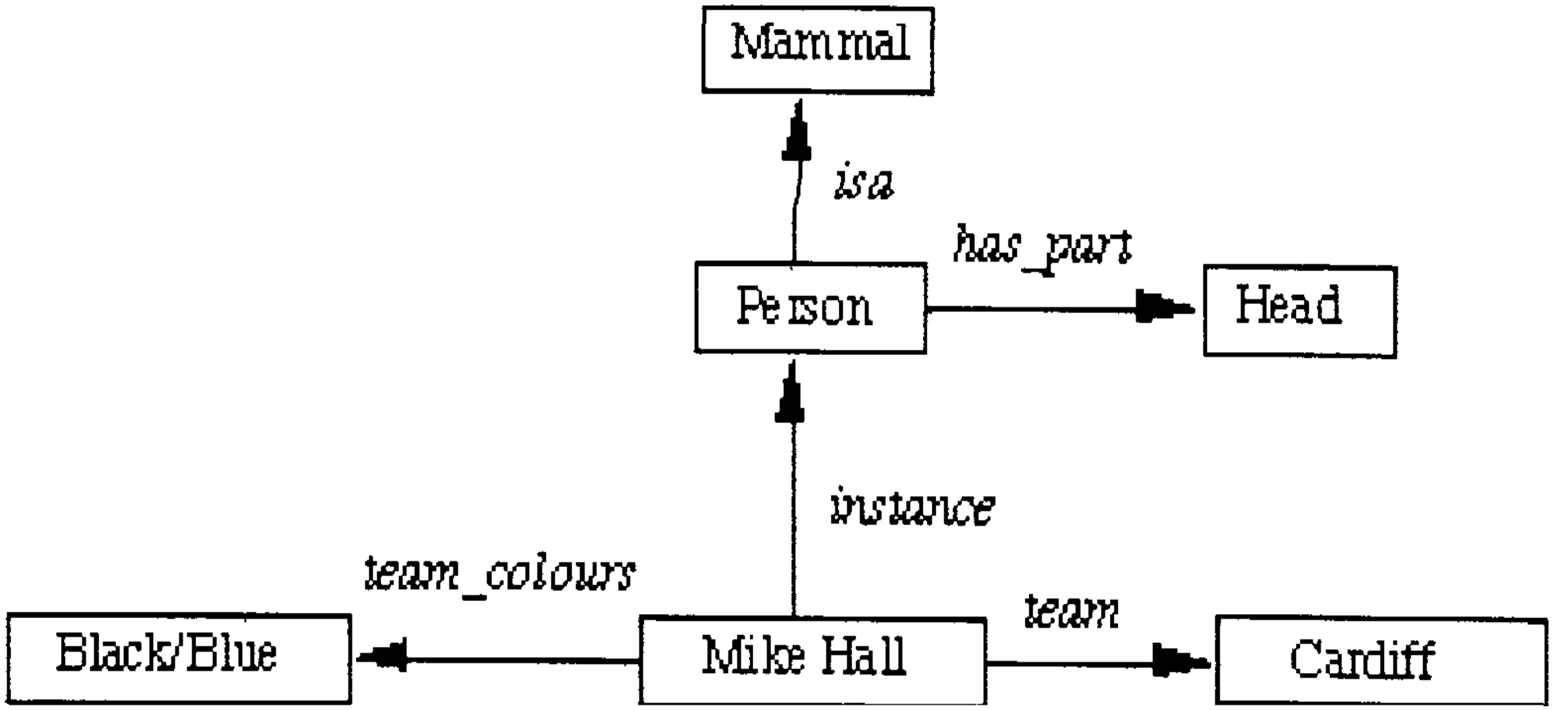
- 1. The meaning of a concept comes from its **relationship to other concepts** and
- 2. The information is stored by interconnecting **nodes with labelled arcs**.

The **physical attributes** of a person can be **represented** in logic as:

- isa(person, mammal)
- instance(Mike-Hall, person)
- team(Mike-Hall, Cardiff)

PS: isa and instance represent inheritance are popular in many knowledge representation schemes eg. lecturer(trex) can be written as instance(trex, lecturer)

Representation using Semantic Nets (cont)

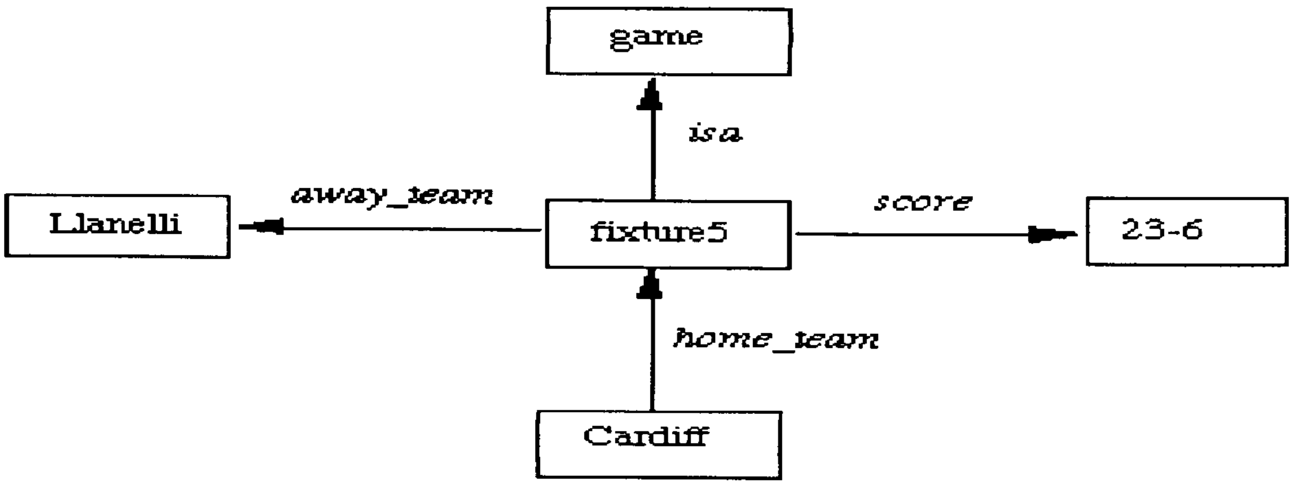


Semantic Nets Representation

How can we have more than **2 place predicate** in semantic nets?
eg. score(Cardiff, Llanelli, 23-6)

Solution:

- Create **new nodes** to represent new objects either contained or alluded to in the knowledge, game and fixture in the current example.
- Relate information to nodes and **fill up slot** (see diagram)



Semantic Nets Representation (cont)

- Consider the sentence "John gave Mary the book"

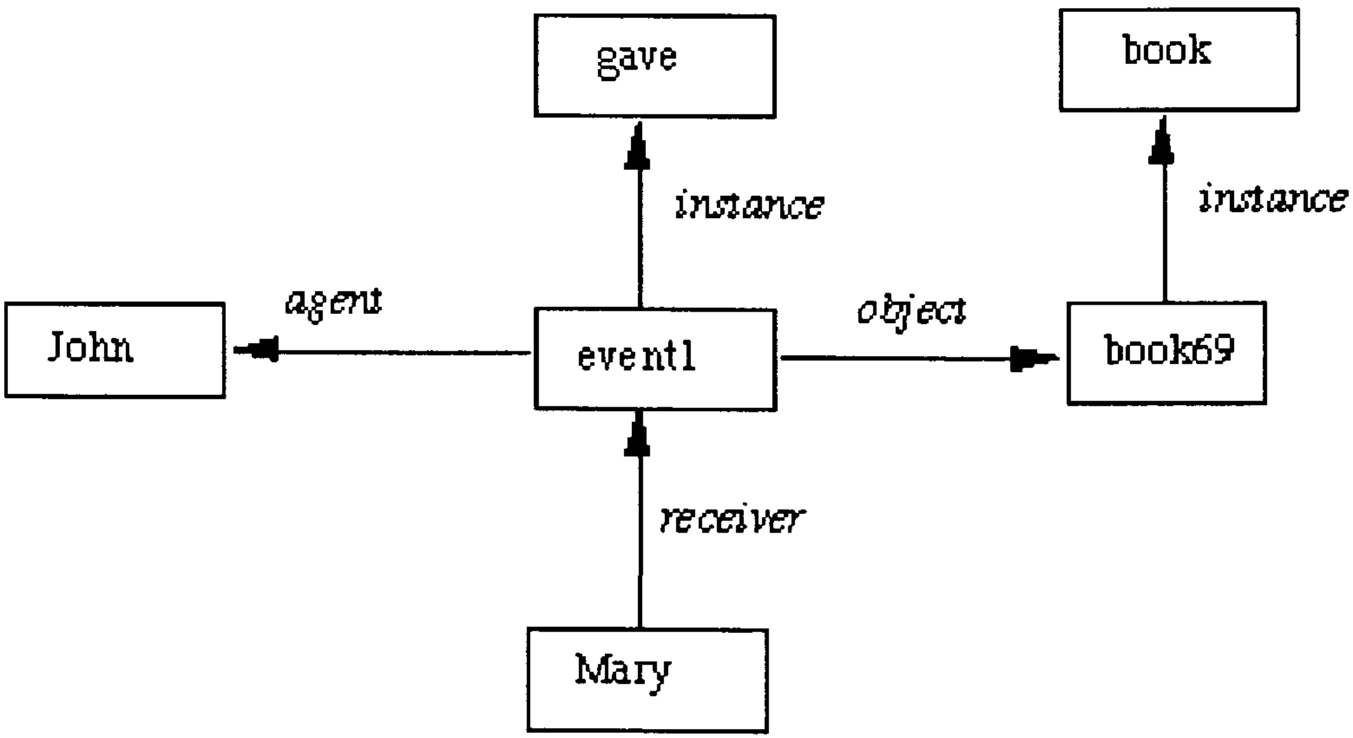
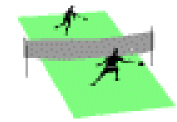


Fig. A Semantic Network for a Sentence

Semantic Nets Inference Mechanism



- Basic inference mechanism: **follow links between nodes**.

Two methods to do this:

- 1. **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.

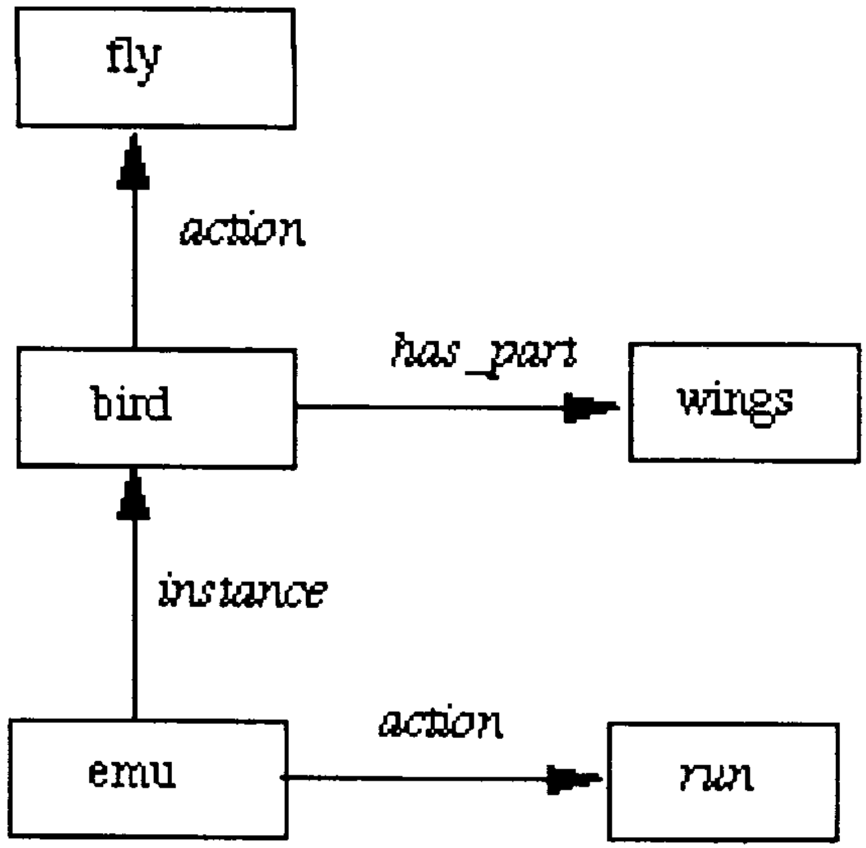
  Many advantages including entity-based organisation and fast parallel implementation. However, very structured questions need highly structured networks.

- 2. **Inheritance** - the **isa** and **instance** representation provide a mechanism to implement this. Inheritance also provides a means of **dealing with default reasoning**.

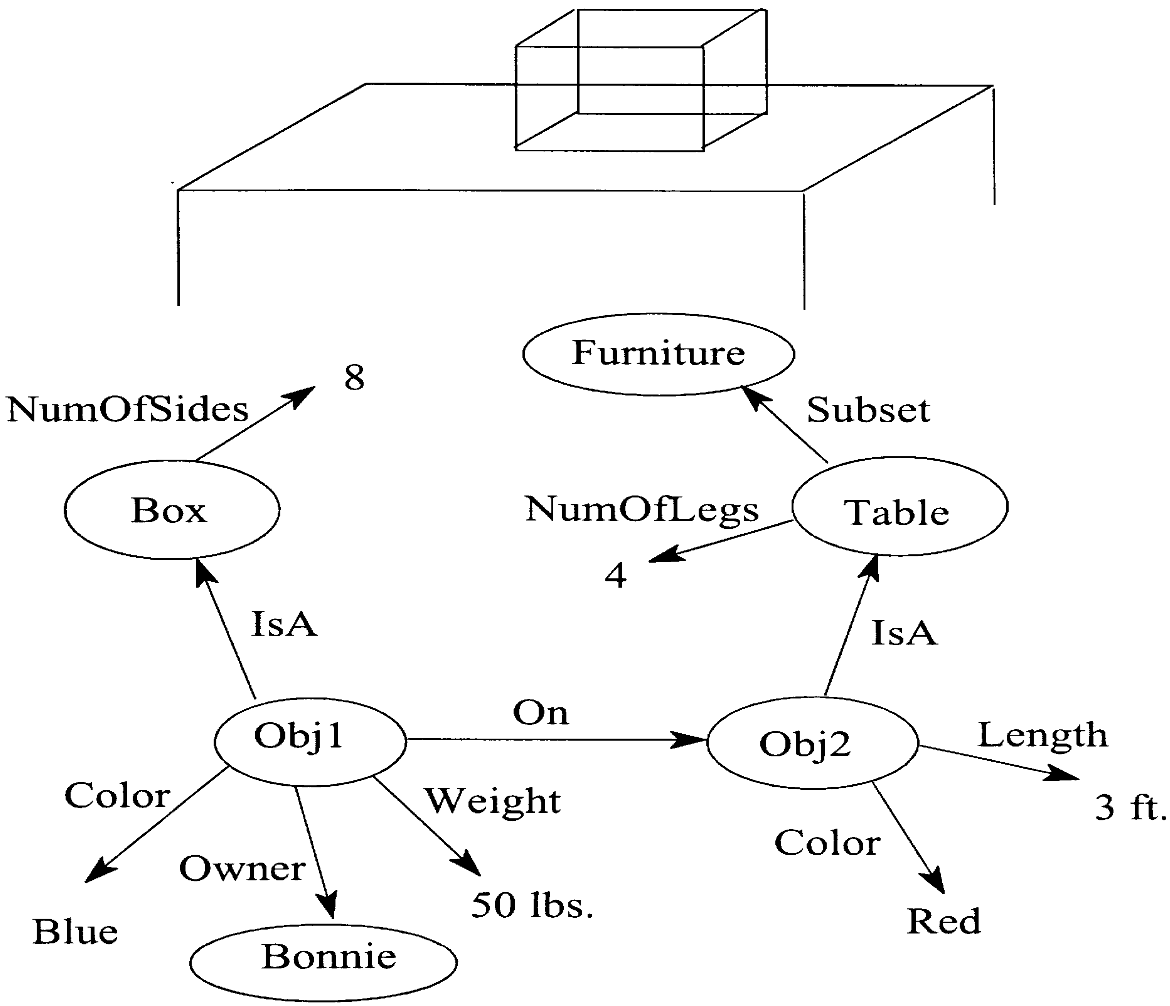
Semantic Nets Inference Mechanism (Bird example)

eg. we could represent:

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



Semantic Nets (Box on Table Example)



Representation using Frames (Box on Table Example)

(Box
SubsetOf: PhysicalObject
#Sides: 8)

(Box3
InstanceOf: Box
Color: Blue
Weight: 50 lbs
On: Table5)

(Table
SubsetOf: Furniture
#Legs: 4)

(Table5
InstanceOf: Table
#Legs: 3
Owner: Jocelyn)

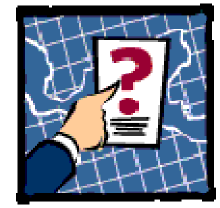
Other kinds of Logic

There are many other kinds of logic

- 1. **3 valued logic**: For expressing true, false, "don't know"
- 2. **Probabilistic logic**: For expressing confidence level of a statement
- 3. **2nd order logic**: For expressing quantification of objects as well as classes of objects
- 4. **Logic with states**: The truth/falsify of a statement depends on the state of the world
- 5. **Situation Calculus**: For expressing change in the environment. eg. At(Agent, location) becomes At(Agent, location, situation)

Students’ Mini Research Presentation by Group C

What’s in Store for Lecture 9



- Introduction to Planning
- Examples of Planning Systems
- Blocks World
- Assumptions of the "Standard" AI Planning Paradigm
- STRIPS - Linear Planner
- STRIPS Example
- State Space Searching
  - Progression Planners
  - Regression Planners
- Plan Space Searching
- Partial Ordered Planning
  - Introduction
  - An Example
  - Interpretation
- Partially ordered plans vs. Non-linear planning
- Shortcomings of AI Planning in General
- Students’ Mini Research Presentation by Group D
- Class Activity: Real-world Paper Reading

End of Lecture 8

Good Night.