Chapter 09
Knowledge Representation

Instructor

LE Thanh Sach, Ph.D.

Instructor's Information

LE Thanh Sach, Ph.D.

Office:

Department of Computer Science,

Faculty of Computer Science and Engineering,

HoChiMinh City University of Technology.

Office Address:

268 LyThuongKiet Str., Dist. 10, HoChiMinh City, Vietnam.

E-mail: LTSACH@cse.hcmut.edu.vn

E-home: http://cse.hcmut.edu.vn/~ltsach/

Tel: (+84) 83-864-7256 (Ext: 5839)

Acknowledgment

The slides in this PPT file are composed using the materials supplied by

- **Prof. Stuart Russell and Peter Norvig**: They are currently from University of California, Berkeley. They are also the author of the book "Artificial Intelligence: A Modern Approach", which is used as the textbook for the course

- **Prof. Tom Lenaerts**, from Université Libre de Bruxelles

Outline

- Knowledge:
  - What is it?
  - Why do we need?
  - How do we process?
- Knowledge Representation (KR)
- Approaches to KR
- Issues in KR

Knowledge: What is it?

- All of the learning about a field/fields.
- Include:
  - Concepts, terminologies
  - Objects
  - Relationships between objects
  - Rules to govern objects
  - …

Knowledge: Why do we need?

- For human:
  - Knowledge help people to communicate with and to understand others.
  - Perform works better.

- For computer program:
  - Knowledge + Reasoning
    →Do tasks more intelligently

Knowledge: How do we process?

- The first task in knowledge engineering:
  - Represent knowledge
  - = Acquire/Capture learning in the fields, and Store them in computer by a certain way.
- After that:
  - Retrieve knowledge (similar to SQL to retrieve data from database)
  - Infer non-mentioned facts, i.e., do reasoning – important task.

Knowledge: How do we process?

- So, important tasks for processing knowledge are
  - To represent knowledge
  - To do reasoning on knowledge base
- Example on knowledge and reasoning:
  - How a computer answer the following question? Mean that: user enter the following question to a web-page look like Google and wait for the answer
  - Question:
    - ✓ Which country in ASEAN have the highest GDP in 2000?

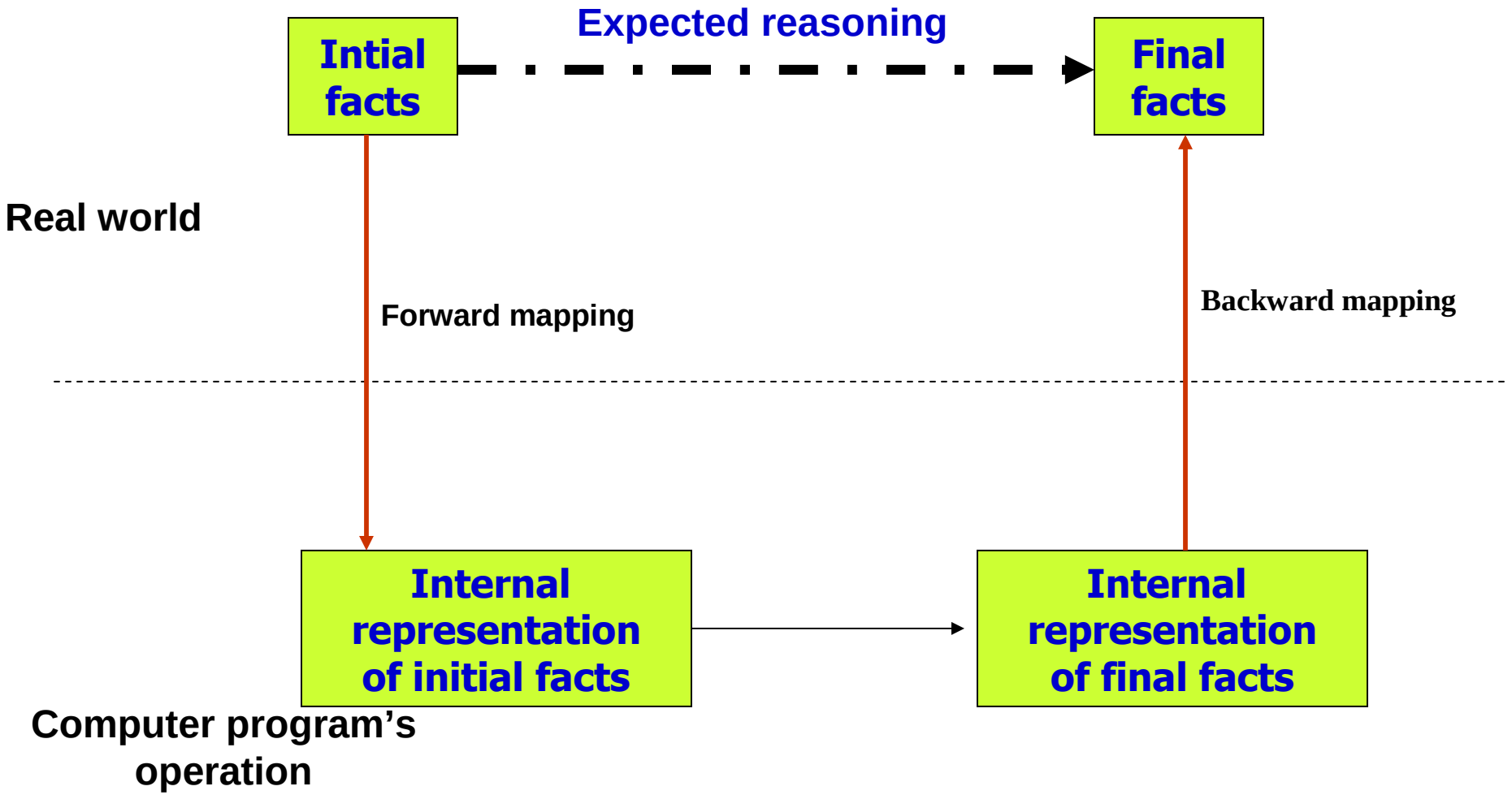
Knowledge: How do we process?

- Knowledge base (KB):
  - ASIAN ---- include ---- countries
  - Countries ----hasGDP-2000----Number
- Process:
  - Parse the question
  - Do Reasoning:

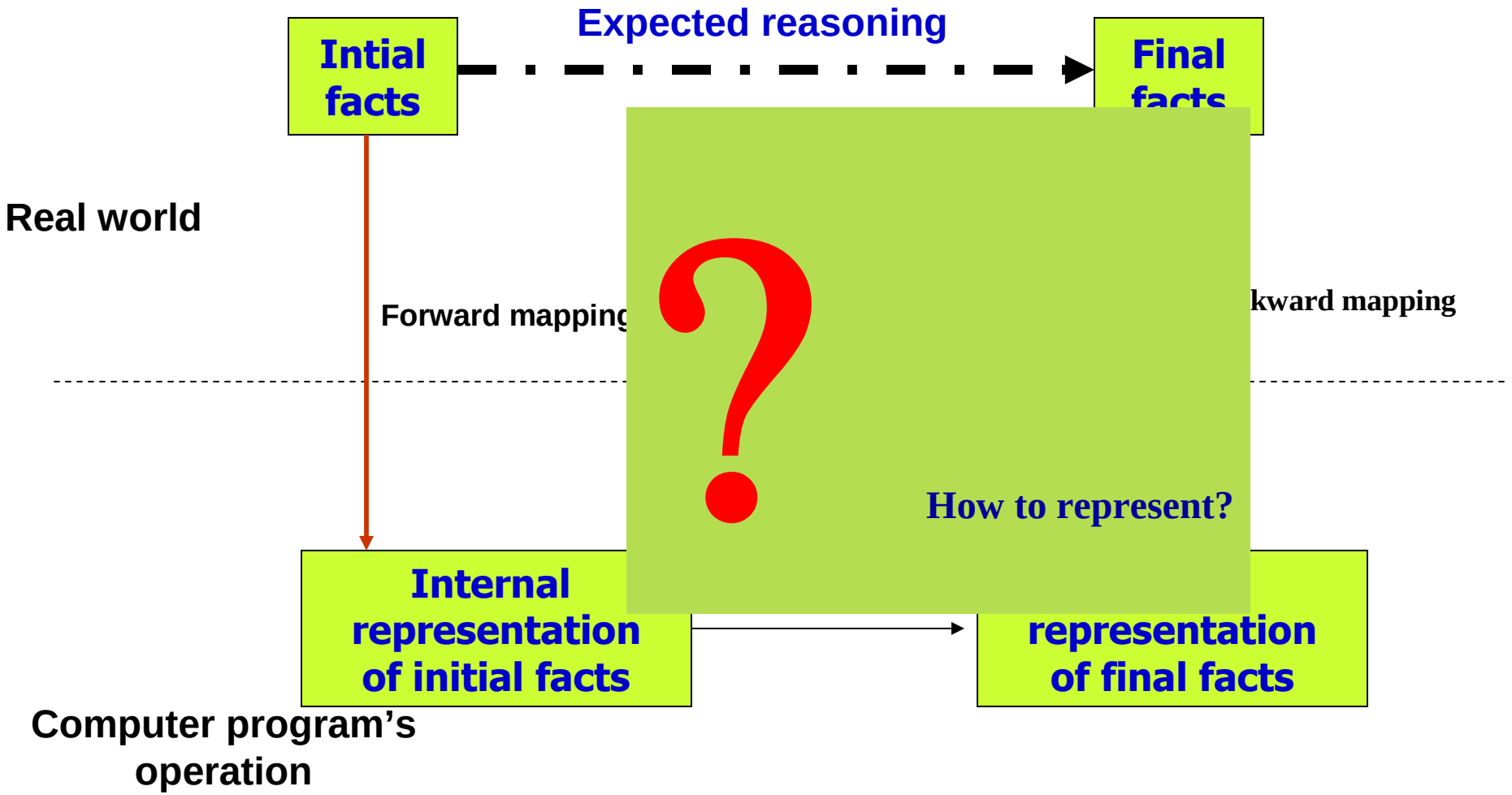
  (1) Divide the questions into:
    - ✓ What countries are in ASIAN?
    - ✓ In 2000, What is GDP of such the countries?

  (2) Return the countries which have the highest GDP

Knowledge Representation: The overall architecture



Knowledge Representation: The overall architecture



Knowledge Representation

First ideal: formalize and symbolize the knowledge

Real world	Symbolic world
- **Facts**: Inside a field	- **Representations**: Exist in form of a representation scheme
What we need to represent	What a computer can process

Knowledge Representation

First ideal: formalize and symbolize the knowledge

Real world	Symbolic world
- **Facts**: Inside a field	- **Representations**: Exist in form of a representation scheme

What we need to represent

What a computer can process

Representation scheme: What is it?

Knowledge Representation

- Representation Scheme:
  - Propositional logic
  - Predicate logic
  - Semantic-net
  - Conceptual Graph
  - Ontological Diagram
  - ....

Knowledge Representation

- Representation Scheme:
  - Propositional logic
  - Predicate logic
  - Semantic-net
  - Conceptual Graph
  - Ontological Diagram
  - ....
- We have many kinds of scheme, Why?
  - Answer: We have many kinds of knowledge, each of them need a special way of representation

Knowledge Representation

- Criteria on which a knowledge system/ scheme can be evaluated?
  - Representational adequacy
  - Inferential adequacy
  - Inferential efficiency
  - Acquisitional efficiency

Knowledge Representation

- Criteria on which a knowledge system/ scheme can be evaluated?
  - Representational adequacy
    - ✓ Representational Capability:
    - ✓ Can a scheme represent all the knowledge the given field?
  - Inferential adequacy
    - ✓ Inferential Capability:
    - ✓ Can a scheme support reasoning?

Knowledge Representation

- Criteria on which Representation Scheme can be evaluated?
  - Inferential efficiency
    - ✓ Concern more than the inferential capability:
    - ✓ Can work efficiently?
  - Acquisitional efficiency
    - ✓ Given a knowledge system: can it acquire the knowledge automatically?

Approaches to KR

- Kinds of Knowledge
  - Simple relational knowledge
  - Inheritable knowledge
  - Inferential knowledge
  - Procedural knowledge

Approaches to KR

- Simple relational knowledge
  - Exist in form of tables, like tables in database
  - Each relation (row in table) itself can provide very weak inferential capabilities.
  - Relations may serve as the input to powerful inference engines.

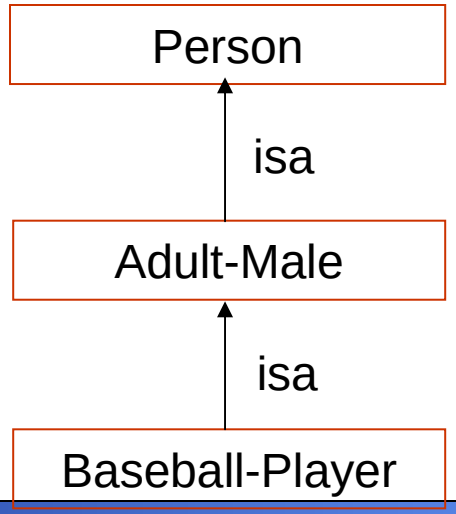
Approaches to KR

- Simple relational knowledge

Player	Height	Weight	Bats-Throws
Hank Aaron	6-0	180	Right-Right
Willie Mays	5-10	170	Right-Right
Babe Ruth	6-2	215	Left-Left
Ted Williams	6-3	205	Left-Right

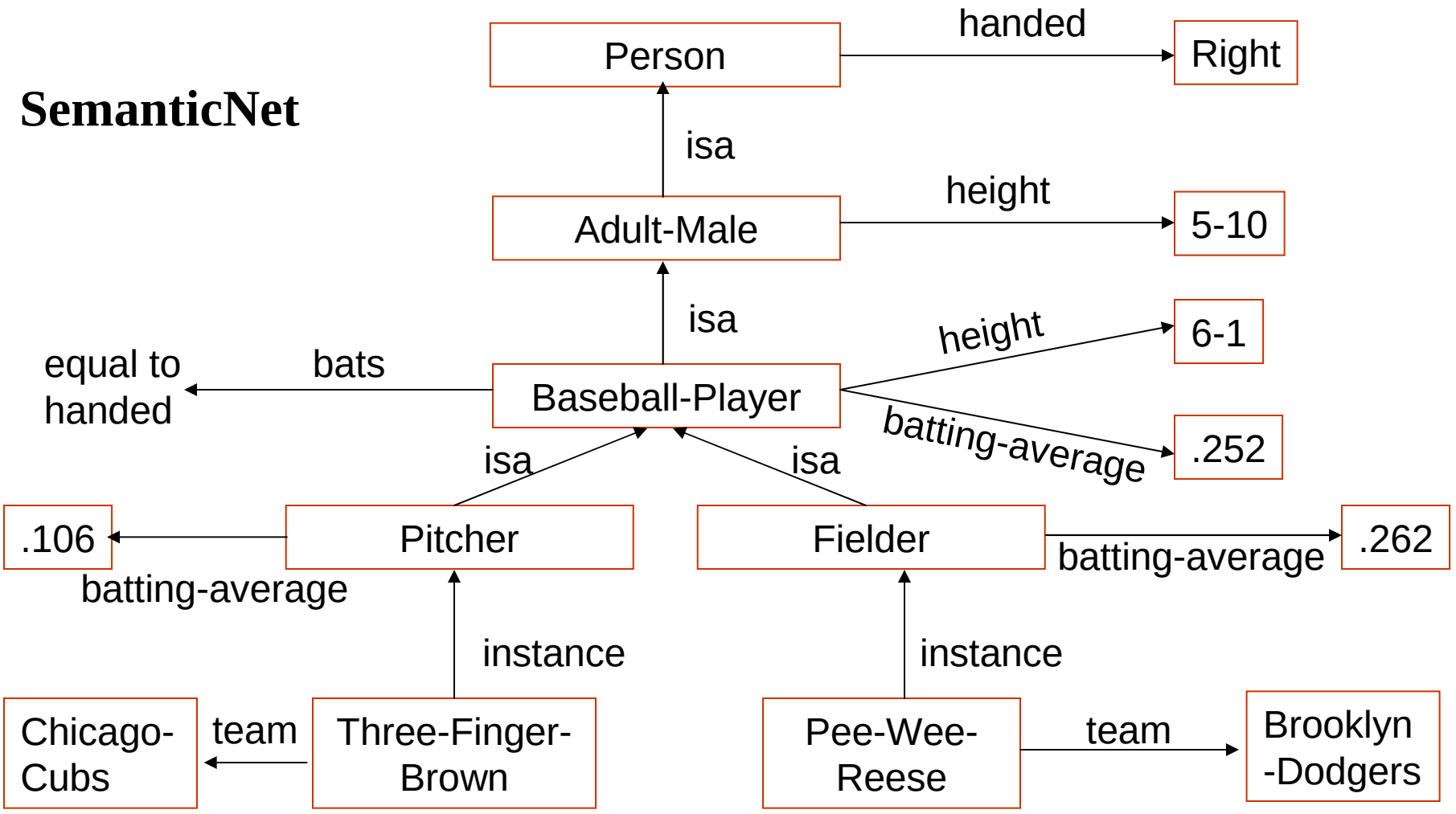
Approaches to KR

- Inheritable knowledge
  - Objects are organized into classes and classes are organized in a generalization hierarchy.
  - Inheritance is a powerful form of inference, but not adequate.

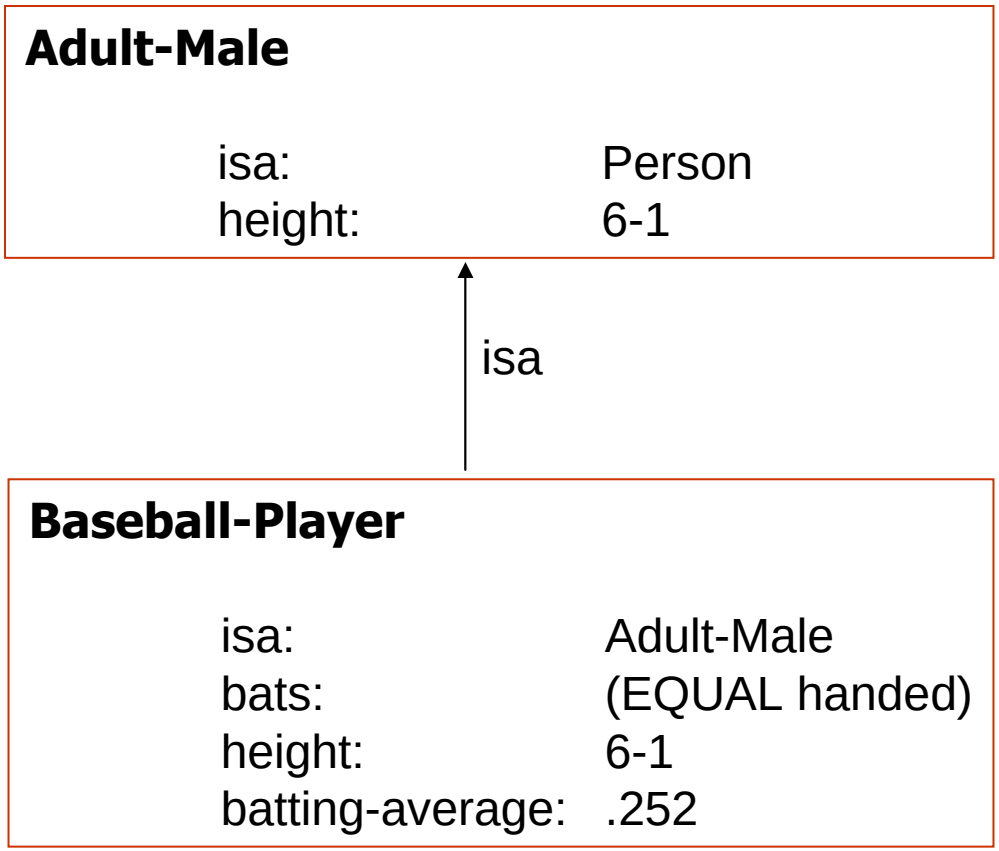


SemanticNet

Approaches to KR



Approaches to KR



Frame-based Scheme

Approaches to KR

- Inferential knowledge
  - Facts represented in a logical form, which facilitates reasoning.
  - An inference engine is required.

Approaches to KR

1. Marcus is a man.
2. All men are mortal.

Represent →

1. Men(Marcus)
2. $\forall$X(Men(X) $\Rightarrow$ Mortal(X))

A representation

Q: Is Marcus mortal?

Represent →

Q: Mortal(Marcus)

Approaches to KR

1. Marcus is a man.
2. All men are mortal.

Represent →

1. Men(Marcus)
2. ∀X(Men(X) ⇒ Mortal(X))

A representation

Do reasoning

1. Men(Marcus)
2. ∀X(Men(X) ⇒ Mortal(X))
3. Men(Marcus) ⇒ Mortal(Marcus), from 2, X = Marcus
4. Mortal(Marcus), from 1 and 3

A: Marcus is mortal.

Approaches to KR

- Procedural knowledge
  - Coding actions to be performed when a condition satisfied.
  - Example
    - ✓ IF

      Has fever more than 39°C
      Be lazy eating
      Skin has red dots

      THEN

      Suspect petechial fever

  - Implementation:
    - ✓ Writing actions in LISP Programming Language
    - ✓ Writing actions in Production System Framework, like CLISP, JESS

Issues in KR

- Are any attributes of objects so basic that they occur in almost every problem domain?
  - Isa
  - Instance
- Are there any important relationships that exits among object attributes?
  - Inverses: friend, sibling, ...
  - Isa hierarchy

Issues in KR

- At what level of detail should knowledge be represented?
  - Balance the trade-off
    - ✓ High-level facts may not be adequate for inference
    - ✓ Low-level primitives may require a lot of storage.
- How should sets of objects be represented?
  - By names.
  - By extensional definition.
  - By intensional definition
- Given a large amount of knowledge stored, how can relevant parts be accessed?
  - Selecting an initial structure.
  - Revising the choice.

Home Works

- Reading
  - Conceptual Graph
  - Ontology