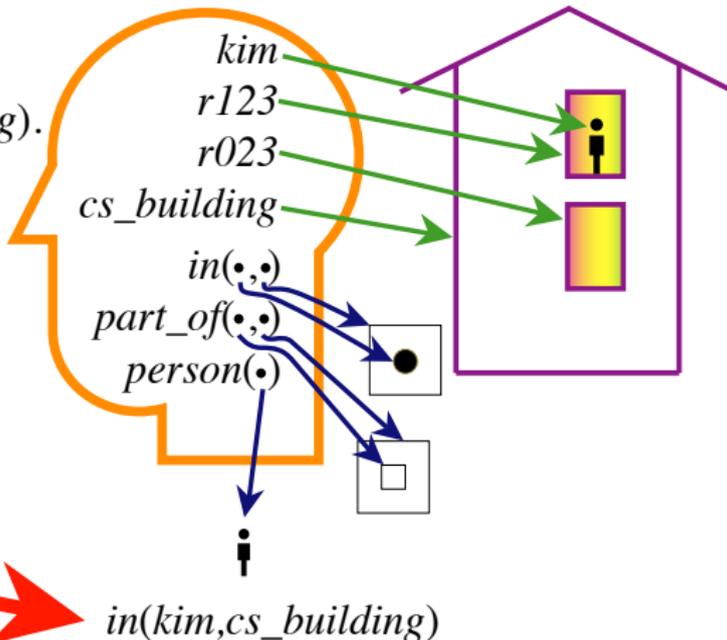
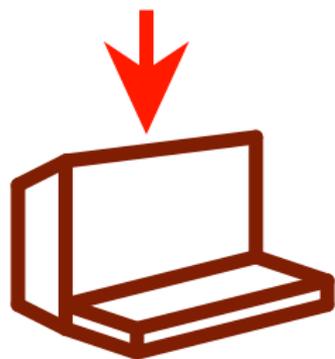


# Individuals and Relations

- It is useful to view the world as consisting of individuals (objects, things) and relations among individuals.
- Often features are made from relations among individuals and functions of individuals.
- Reasoning in terms of individuals and relationships can be simpler than reasoning in terms of features, if we can express general knowledge that covers all individuals.
- Sometimes we may know some individual exists, but not which one.
- Sometimes there are infinitely many individuals we want to refer to (e.g., set of all integers, or the set of all stacks of blocks).

# Role of Semantics in Automated Reasoning

$in(kim, r123).$   
 $part\_of(r123, cs\_building).$   
 $in(X, Y) \leftarrow$   
 $part\_of(Z, Y) \wedge$   
 $in(X, Z).$



# Features of Automated Reasoning

- Users can have meanings for symbols in their head.
- The computer doesn't need to know these meanings to derive logical consequence.
- Users can interpret any answers according to their meaning.

# Decision-theoretic Planning

- flat or modular or hierarchical
- explicit states or features or individuals and relations
- static or finite stage or indefinite stage or infinite stage
- fully observable or partially observable
- deterministic or stochastic dynamics
- goals or complex preferences
- single agent or multiple agents
- knowledge is given or knowledge is learned
- perfect rationality or bounded rationality

# Representational Assumptions of Datalog

- An agent's knowledge can be usefully described in terms of *individuals* and *relations* among individuals.
- An agent's knowledge base consists of *definite* and *positive* statements.
- The environment is *static*.
- There are only a finite number of individuals of interest in the domain. Each individual can be given a unique name.

⇒ Datalog

# Syntax of Datalog

- A **variable** starts with upper-case letter.
- A **constant** starts with lower-case letter or is a sequence of digits (numeral).
- A **predicate symbol** starts with lower-case letter.
- A **term** is either a variable or a constant.
- An **atomic symbol** (atom) is of the form  $p$  or  $p(t_1, \dots, t_n)$  where  $p$  is a predicate symbol and  $t_i$  are terms.

# Syntax of Datalog (cont)

- A **definite clause** is either an atomic symbol (a fact) or of the form:

$$\underbrace{a}_{\text{head}} \leftarrow \underbrace{b_1 \wedge \dots \wedge b_m}_{\text{body}}$$

where  $a$  and  $b_i$  are atomic symbols.

- **query** is of the form  $?b_1 \wedge \dots \wedge b_m$ .
- **knowledge base** is a set of definite clauses.

$in(kim, R) \leftarrow$   
     $teaches(kim, cs322) \wedge$   
     $in(cs322, R).$

$grandfather(william, X) \leftarrow$   
     $father(william, Y) \wedge$   
     $parent(Y, X).$

$slithy(foves) \leftarrow$   
     $mimsy \wedge borogroves \wedge$   
     $outgrabe(mome, Raths).$