Logic Programming

- Logic programming
  - Various facts are asserted to be true
  - On the basis of these facts, a logic program can infer or deduce other facts
  - A query can be posed to the program
    - The program applies logical deductions to answer the query
- Logic programming languages are sometimes called declarative languages

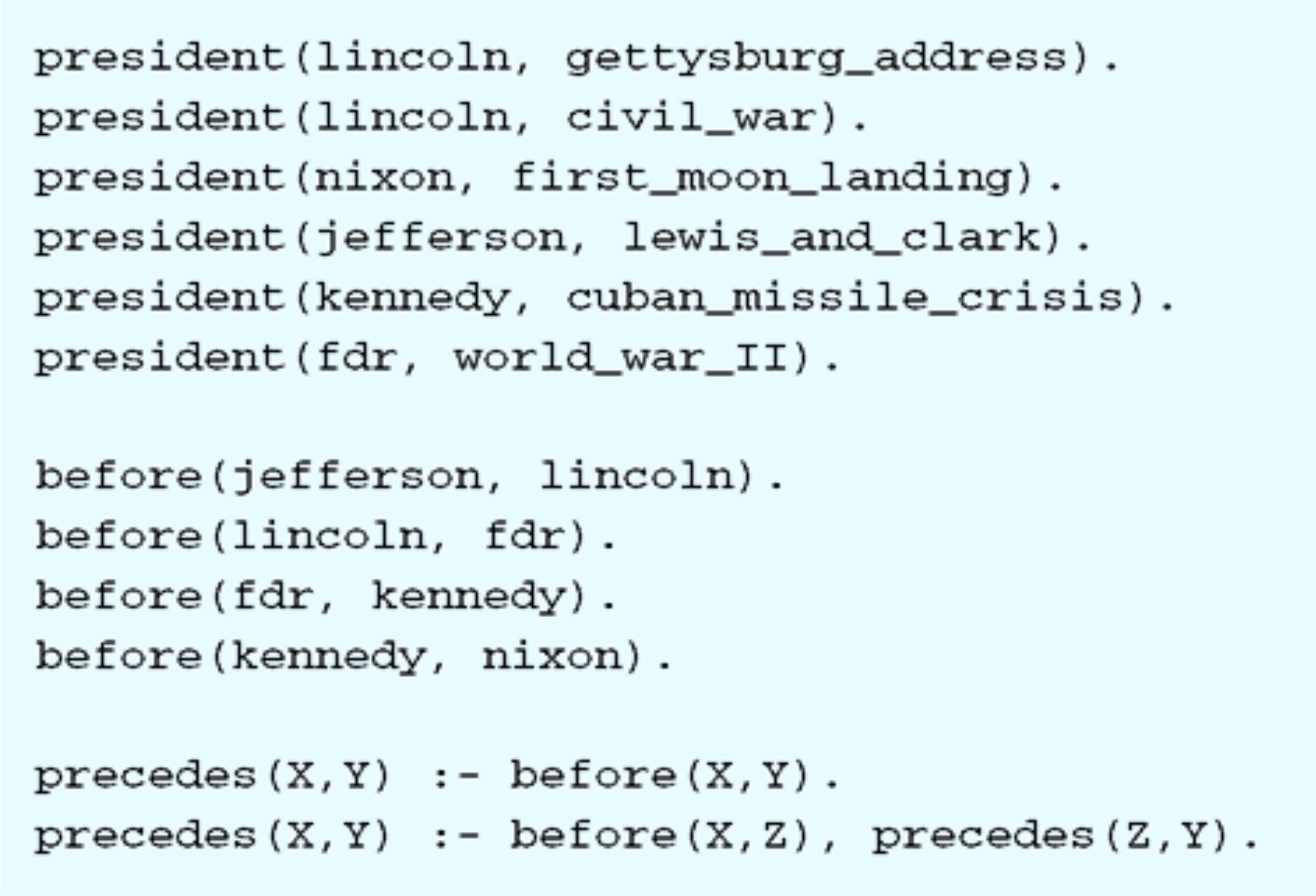
Logic Programming (continued)

- Logic programming has been used to write expert systems

- Prolog (*PRO*gramming in *LOG*ic)
  - Developed in France at the University of Marseilles in 1972 by a group headed by A. Colmerauer

Logic Programming (continued)

- Prolog programs
  - Consist of “facts” and “rules”
    - A fact expresses a property about a single object or a relationship among several objects
    - A rule is a declaration of an “if A then B” form
  - We interact with the program by posing queries



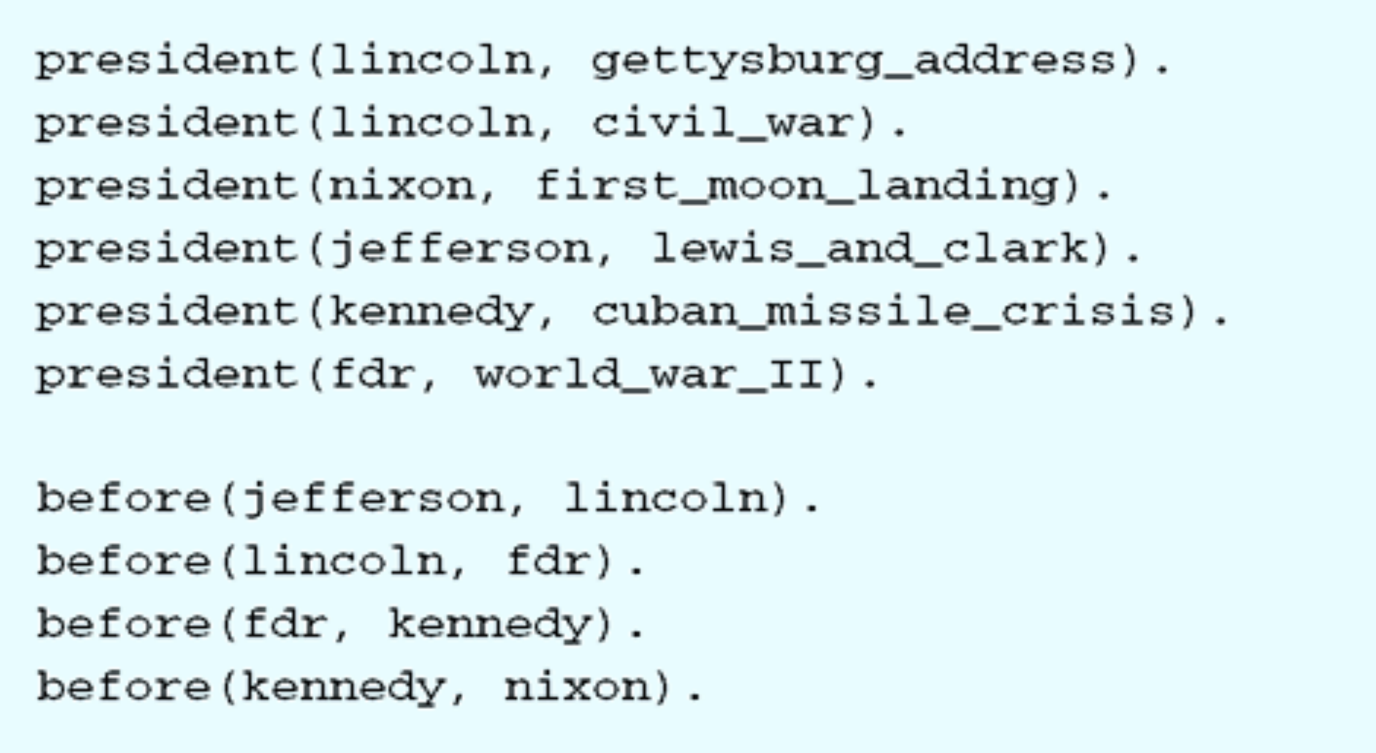
```
president(lincoln, gettysburg_address).
president(lincoln, civil_war).
president(nixon, first_moon_landing).
president(jefferson, lewis_and_clark).
president(kennedy, cuban_missile_crisis).
president(fdr, world_war_II).

before(jefferson, lincoln).
before(lincoln, fdr).
before(fdr, kennedy).
before(kennedy, nixon).

precedes(X,Y) :- before(X,Y).
precedes(X,Y) :- before(X,Z), precedes(Z,Y).
```

Figure 9.10

A Prolog Program



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before(jefferson, lincoln).
before(lincoln, fdr).
before(fdr, kennedy).
before(kennedy, nixon).
```

- Some examples of simple Queries

  Q: ?-before (lincoln, fdr)

  A: Yes

  Q: ?-president (lincoln, civil_war).

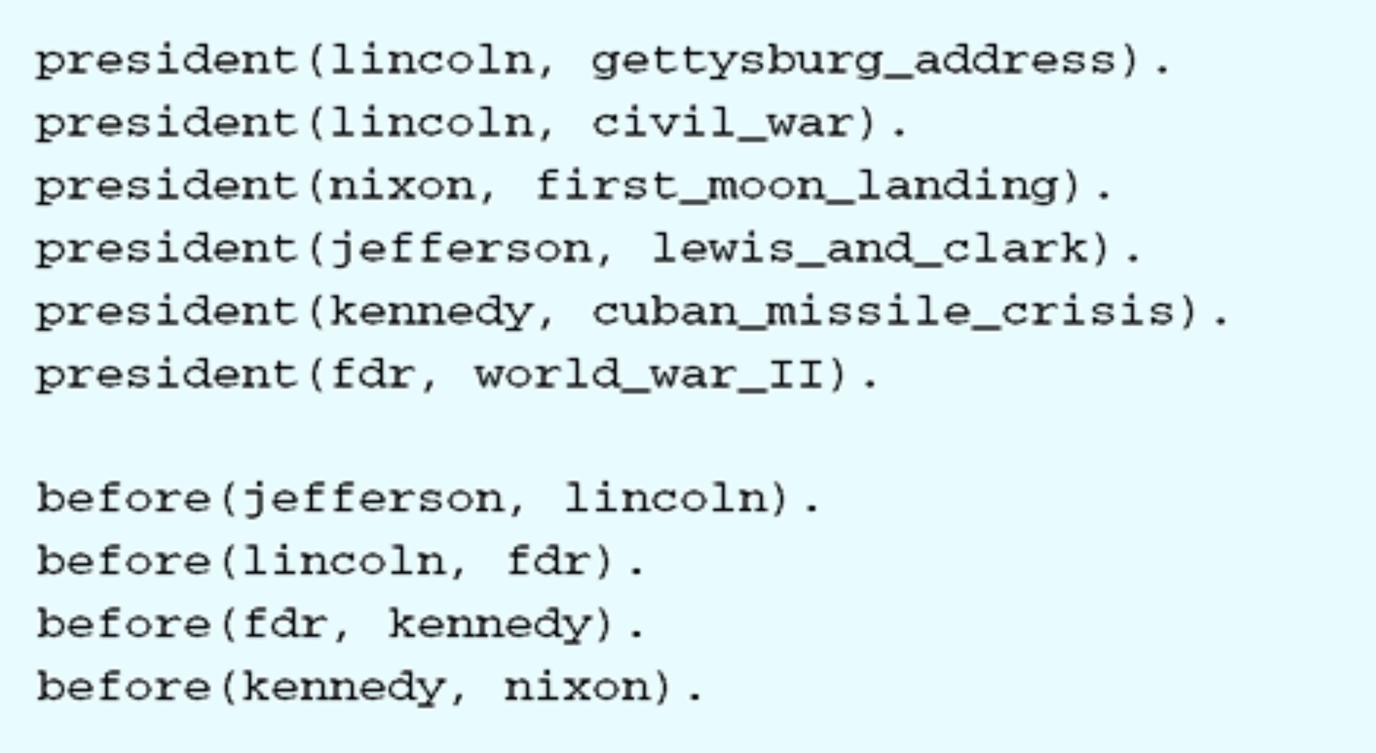
  A: Yes

  Q: ?-president (lincoln, civil_war), before(fdr, lincoln).

  A: No

HOW TO GET ANSWER?

Simple pattern matching with fact-base



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before(jefferson, lincoln).
before(lincoln, fdr).
before(fdr, kennedy).
before(kennedy, nixon).
```

- More Queries

  Q: ?-before (T, fdr).

  A: T = lincoln

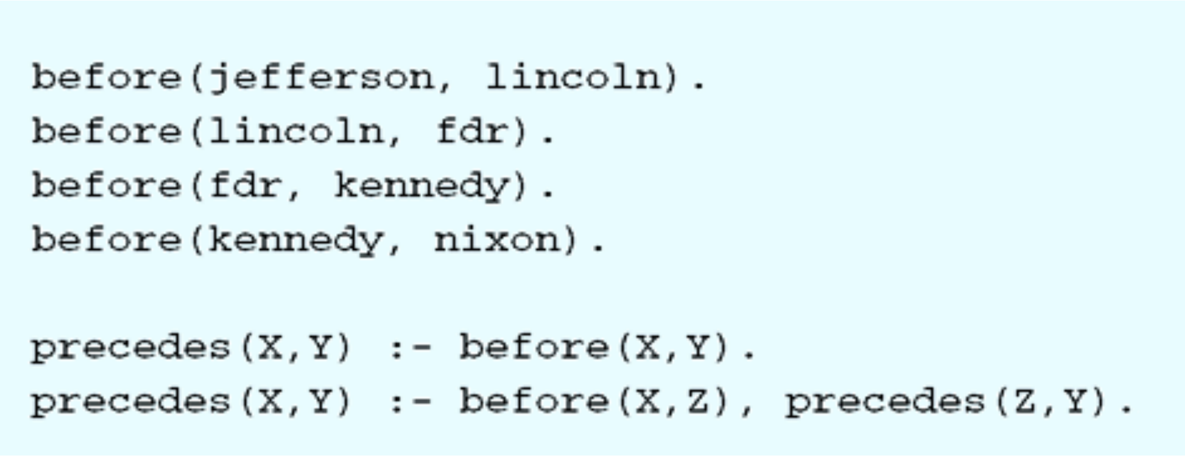
  Q: ?-president (lincoln, X).

  A: X = gettysburg_address

  X = civil_war

HOW TO GET ANSWER?

Pattern matching with fact-base, to get all possible values of variables T and X.



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before(lincoln, fdr).
before(fdr, kennedy).
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precedes(X,Y) :- before(X,Y).
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```

- **Queries** (with precedes)

  Q: ?-precedes (jefferson, lincoln).

  A: YES

  HOW?

  precedes (jefferson, lincoln)

  | R1 (use Rule R1 first)

  +→ before(jefferson, lincoln)

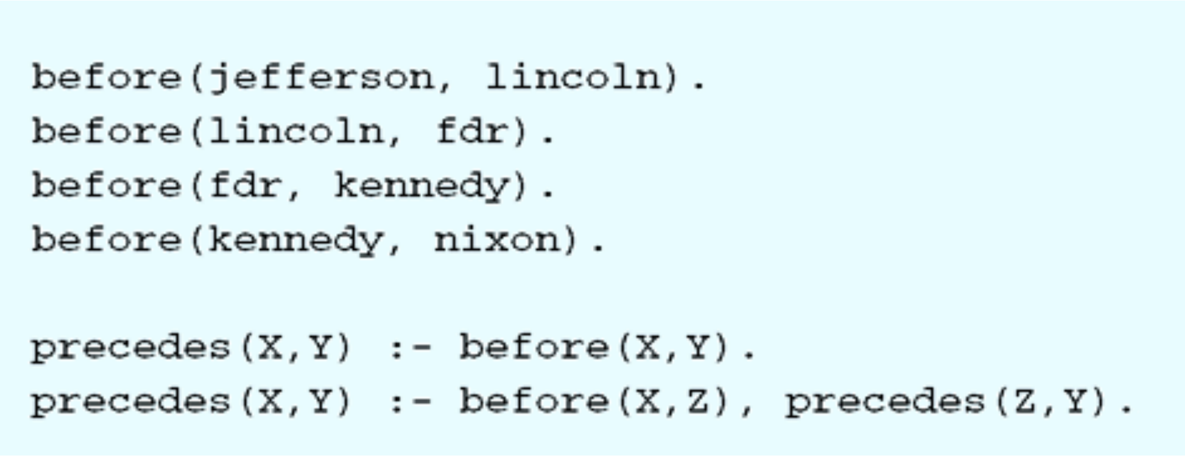
  TRUE

HOW TO GET ANSWER?

Need to also do

Rule-Expansion

(Simple case)



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before(fdr, kennedy).
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precedes(X,Y) :- before(X,Y).
precedes(X,Y) :- before(X,Z), precedes(Z,Y).
```

- **Queries** (with precedes)

  Q: ?-precedes (lincoln, kennedy).

  A: YES

HOW TO GET ANSWER?

More complicated

Rule-Expansion…

HOW?

precedes (lc, k)

| R1 (use Rule R1 first)

+→ before(lc, k)

FALSE

Use R2

Before(lc, Z), precedes (Z,k)

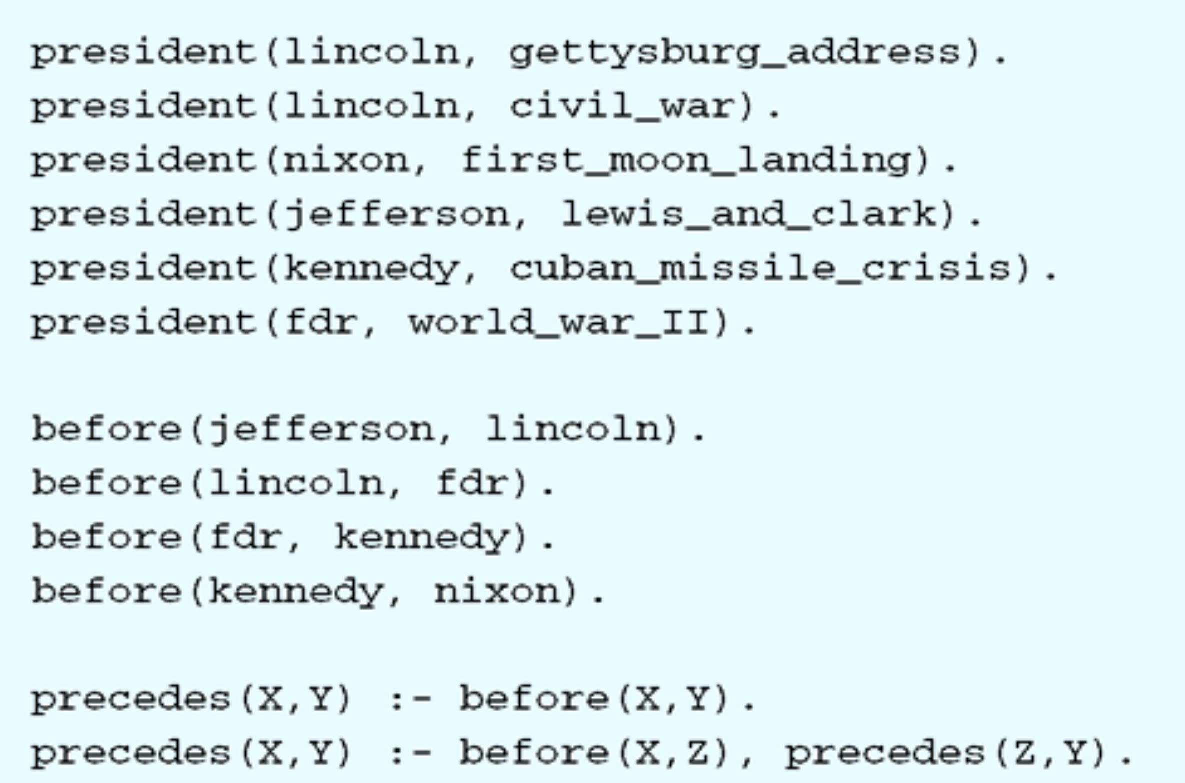
| matches with Z=fdr

Before(lc, fdr), precedes(fdr,k)

TRUE | use R1 first

+→ before(fdr,k)

TRUE



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precedes(X,Y) :- before(X,Y).
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```

- More Queries…

  Q: ?-precedes (jefferson, lincoln).

  A: YES

  Q: ?-precedes (lincoln, nixon).

  A: YES

  Q: ?-precedes (lincoln, bush).

  A: NO (*Why*?)

- More Queries

  Q: ?-precedes (lincoln, X).

  A: X = fdr
  X = kennedy
  X = nixon

  Q: ?-precedes (Y, bush).

  A: Y = nil or NULL or empty

Logic Programming (continued)

- Logic programming paradigm
  - The program is a knowledge base of facts and rules about a certain domain of interest
  - Interaction with the program: posing queries to an inference engine (also called a query interpreter)

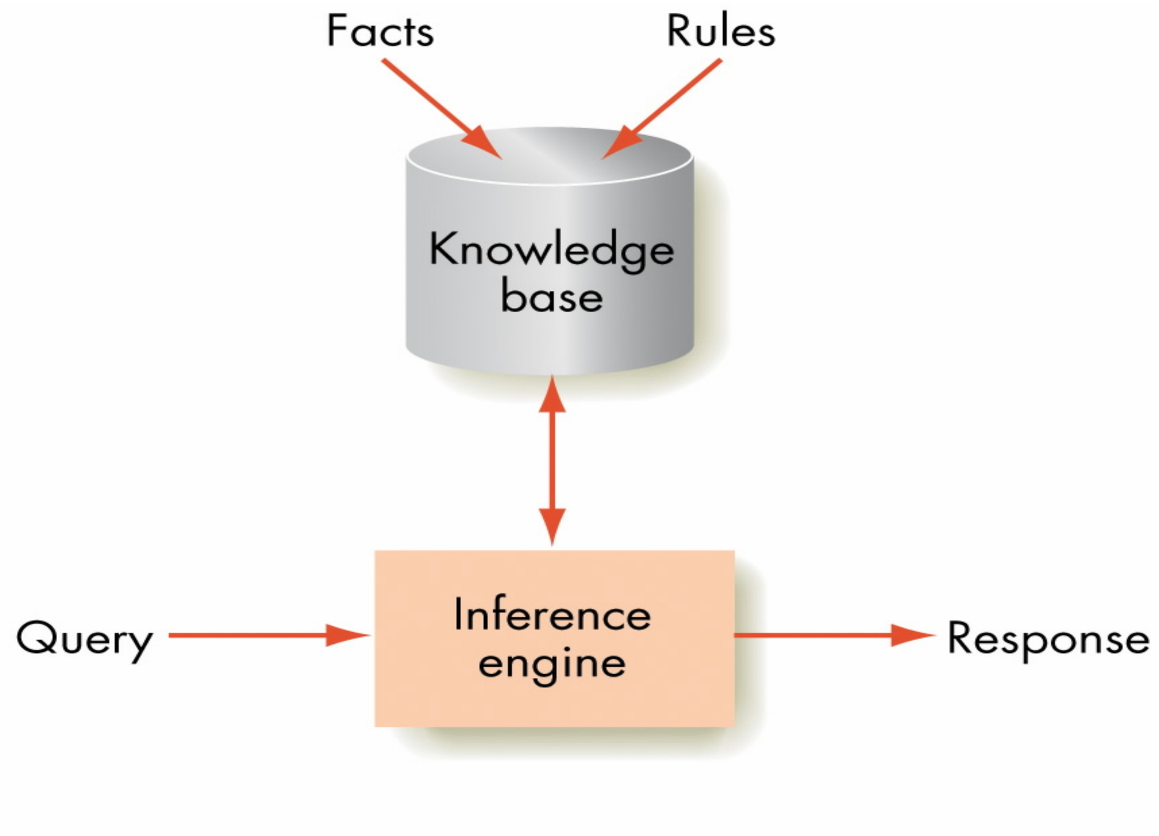

Figure 9.11

The Logic Programming Paradigm