1. Reasoning with Rules

a. Rules
   i. Strong methods require the creation of a knowledge base and a reasoning (inferencing) system based on FOL to interpret the rules and derive new knowledge (conclusions/results)
   
   ii. Rule
       1. “If antecedent, then consequence” structure
           a. antecedent is facts in a conjunction
               i. facts have true or false value
               ii. could have Boolean conditions within facts
               iii. could have a sensor to gather real-time data
           b. consequence is result if antecedent is true
               i. can add new fact to database
               ii. can perform programmed action (effector)
               iii. could have certainty factors for rule

b. Examples
   a. If animal and nurses young, then mammal.
   b. If mammal, then live-birth with CF: 99%.
   c. If number of eyes = 2, then

2. Why use a rule?
   a. Easier for humans to read and understand
   b. Each rule is stand-alone in truth value
   c. Easier to create and maintain since incremental

iii. Components of rule-based systems
    1. Rule and fact database
    2. Working memory of derived facts
    3. Inference engine to process rules and facts

iv. Uses of rule-based systems
    1. Expert systems
       a. Domain-specific expertise
          i. Diagnosis: medicine, circuit faults
          ii. Marketing analysis

    2. Planning systems

v. Problems
    1. Difficult to maintain sizeable knowledge base
    2. Incremental rule allows possibility of contradiction
3. Non-monotonic often required: uses truth maintenance system

b. Forward Chaining
   i. Data-driven
      1. Production system
         a. Earliest AI systems
         b. produces new facts from rules and initial facts
   ii. Specialized Programming Languages
      1. Very fast system
      2. Example: OPS5
   iii. Algorithm
      1. Load rulebase into inference engine & load facts into working memory
      2. Add any initial data into working memory
      3. Match rules against data in working memory and determine which
         rules could be triggered (i.e. antecedents are true). Gives conflict set.
      4. Use conflict resolution procedure to select a single rule to be
         processed.
         a. If only one, then use it.
         b. Select rule with most specific antecedent clauses.
         c. Select rule that refers to data that has changed most recently.
         d. If a tie, choose randomly.
      5. Fire the selected rule by evaluating the consequence.
      6. Repeat steps 3, 4 and 5 until conflict set is empty.

c. Backward Chaining
   i. Goal-directed
   ii. Reactive – responds (in a timely manner) to changes in its environment
   iii. Proactive – persistently pursues goals
   iv. Social – interacts with other agents
   v. Other Attributes
      1. Robust by being flexible
      2. Rational (as in human rationality) – problem solving, inferencing, planning
      3. Capable of learning

d. Fuzzy Rule Systems
   i. “Intelligent agent adds reactive, proactive and social to agent.” (Wooldridge, 2002)
   ii. Reactive – responds (in a timely manner) to changes in its environment
iii. **Proactive** – persistently pursues goals

iv. **Social** – interacts with other agents

v. **Other Attributes**
   1. Robust by being flexible
   2. Rational (as in human rationality) – problem solving, inferencing, planning
   3. Capable of learning

e. **Planning**
   i. “Intelligent agent adds reactive, proactive and social to agent.” (Wooldridge, 2002)

   ii. **Reactive** – responds (in a timely manner) to changes in its environment

   iii. **Proactive** – persistently pursues goals

iv. **Social** – interacts with other agents

v. **Other Attributes**
   1. Robust by being flexible
   2. Rational (as in human rationality) – problem solving, inferencing, planning
   3. Capable of learning

2. **Other types of reasoning**

a. **Predicate Logic**
   i. “An agent is a computer system that is situated in some environment and that is capable of autonomous action in this environment in order to meet its design objectives” (Wooldridge, 2002)

   ii. **Situated** – exists in an environment

   iii. **Autonomous** – independent, not controlled externally

b. **Intelligent Agent**
   i. “Intelligent agent adds reactive, proactive and social to agent.” (Wooldridge, 2002)

   ii. **Reactive** – responds (in a timely manner) to changes in its environment

   iii. **Proactive** – persistently pursues goals

   iv. **Social** – interacts with other agents
v. **Other Attributes**

1. Robust by being flexible
2. Rational (as in human rationality) – problem solving, inferencing, planning
3. Capable of learning

**FIGURES**

*Figure 8.1* Architecture of a typical expert system.

Rule 1: if

the engine is getting gas, and

the engine will turn over,

then

the problem is spark plugs.

Rule 2: if

the engine does not turn over, and

the lights do not come on

then

the problem is battery or cables.

Rule 3: if

the engine does not turn over, and

the lights do come on

then

the problem is the starter motor.

Rule 4: if

there is gas in the fuel tank, and

there is gas in the carburetor

then

the engine is getting gas.

*Figure: Examples of Rules*
Figure 8.9  And/or graph searched in the car diagnostic example.