Knowledge-Based Systems

Andrew Kusiak
Intelligent Systems Laboratory
2139 Seamans Center
The University of Iowa
Iowa City, Iowa 52242 - 1527

andrew-kusiak@uiowa.edu
http://www.icaen.uiowa.edu/~ankusiak
Tel: 319 - 335 5934 Fax: 319-335 5669

Expert System

Knowledge base

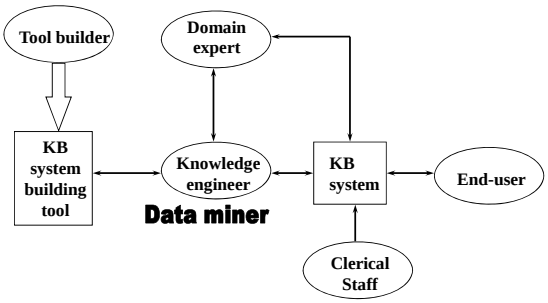
Inference Engine

Data

Expert system = Structured computer program

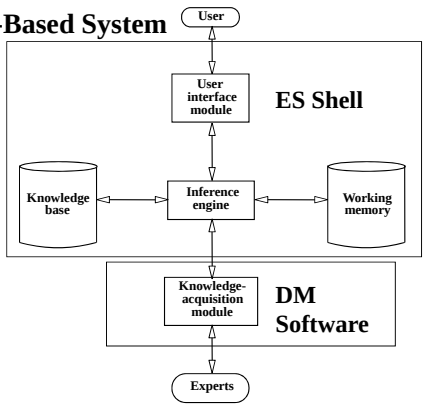
Development of KB Systems

Traditional Process



Knowledge-Based System

Components



Knowledge Representation Methods

- First-order logic
- Production rules
  (including structured production rules)
- Frames
- Semantic networks

Production Rules

IF (conditions)
THEN (conclusions)

EXAMPLE

IF part Pi is to be dispatched to machine Ma that is occupied by another part Pj

THEN check availability of an alternative machine Mb

Advantages of Production Rules

Simplicity

- The use of a rule can be easily explained to the system user
- Developers and users can modify some rules without breaking the entire system
- New knowledge can be incorporated into the system simply by adding new rules without concern of how they fit into the overall knowledge base

Basic Reasoning Strategies

- Forward reasoning
- Backward reasoning

Example

Rules Base:
R1: IF a AND b THEN Goal
R2: IF c AND d THEN a
R3: IF e THEN c

http://www.exsys.com/

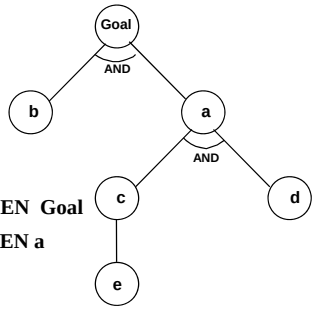
R1: IF a AND b THEN Goal

IF subassembly a AND subassembly b are available
THEN initiate the assembly process

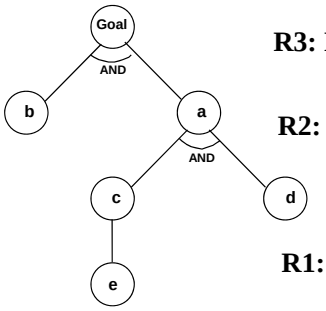
R2: IF c AND d THEN a

IF part c AND part d have been assembled
THEN subassembly a is available

Inference (And/OR) tree



Rules: R1: IF a AND b THEN Goal
R2: IF c AND d THEN a
R3: IF e THEN c

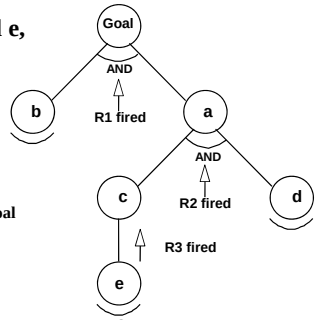


e
R3: IF sunny, THEN hot inside
c
R2: IF hot inside AND humid, THEN use AC
d a
a
R1: IF use AC AND many people, THEN switch
b on unit 2
Goal

R1: IF a AND b THEN Goal
R2: IF c AND d THEN a
R3: IF e THEN c

Forward Reasoning

Given the facts: b, d, and e, derive a goal

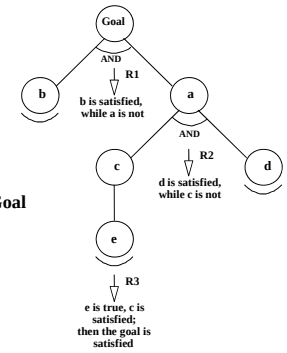


Rules: R1: IF a AND b THEN Goal
R2: IF c AND d THEN a
R3: IF e THEN c

Inference tree

Backward Reasoning

Given the goal,
derive facts that prove it



Rules: R1: IF a AND b THEN Goal

R2: IF c AND d THEN a

R3: IF e THEN c

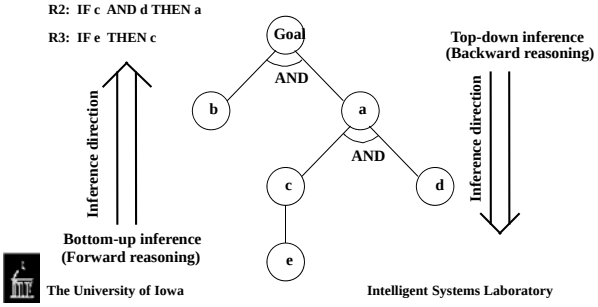
Reasoning Summary

- **Forward reasoning**
- **Backward reasoning**

Rules: R1: IF a AND b THEN Goal

R2: IF c AND d THEN a

R3: IF e THEN c



Uncertainty in Rule Bases

- **Rule R1: IF A1 AND B1 THEN D1**

Given certainty factors:

$$CF(A1) = CA1$$
$$CF(B1) = CB1$$

The certainty factor of rule R1

$$CF(D1) = CF(R1) = CF(A1 \text{ AND } B1) = \min\{CF(A1), CF(B1)\} = \min\{CA1, CB2\}$$

- **Rule R2: IF A2 OR B2 THEN D2**

The certainty factor of Rule R2

$$CF(D2) = CF(R2) = CF(A2 \text{ OR } B2) = \max\{CF(A2), CF(B2)\} = \max\{CA2, CB2\}$$

- **Rule R3: IF A1 AND B1 THEN D1** **CF = c**

Certainty factor of R3

$$CF(D1) = CF(R3) = \min\{C_{A1}, C_{B1}\}\ c$$

- **Rule R4: IF A2 OR B2 THEN D2 CF = c**

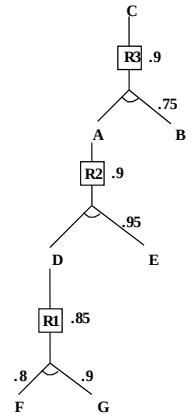
Certainty factor of R4

$$CF(D2) = CF(R4) = \max\{C_{A2}, C_{B2}\}\ c$$

Example

AND/OR tree with three rules

R1: IF F AND G THEN D
R2: IF D AND E THEN A
R3: IF A AND B THEN C



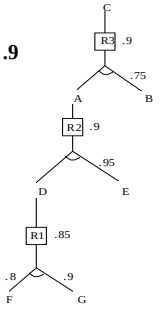
Given

CF(F) = .8, CF(G) = .9, CF(E) = .95, and CF(B) = .75
and
fcertainty factors of rules R1, R2, and R3
CF(R1) = .85, CF(R2) = .9, and CF(R3) = .9

Determine

Certainty factors of D, A, and C

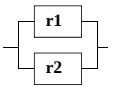
CF(D) = min{CF(F), CF(G)} . CF(R1) = .6800
CF(A) = min{CF(D), CF(E)} . CF(R2) = .6120
CF(C) = min{CF(A), CF(B)} . CF(R3) = .5508



Given two production rules and the corresponding certainty factors:

Rule R1: IF A1 AND B1 THEN D CF = c1
Rule R2: IF A2 OR B2 THEN D CF = c2

Reliability analogy



The combined evidence

$$CF(R1, R2) = c1 + c2 - c1 * c2$$
$$= c1 + c2(1 - c1)$$

EXAMPLE: Combined Evidence

Rule R1: **IF the inflation rate is less than 5%**
THEN stock market prices go up
CF = c1 = 0.7

Rule R2: **IF unemployment rate is less than 7%**
THEN stock market prices go up
CF = c2 = 0.6

The combined evidence is computed as follows:

CF(R1, R2) = c1 + c2 - c1 * c2 = 0.7 + 0.6 - 0.42 = 0.88

KNOWLEDGE ACQUISITION METHODS

- **KB system interfaces**
- **Protocol analysis**
- **Neural networks**
- **Data mining**