CHAPTER 4 KNOWLEDGE BASED SYSTEMS IN AI

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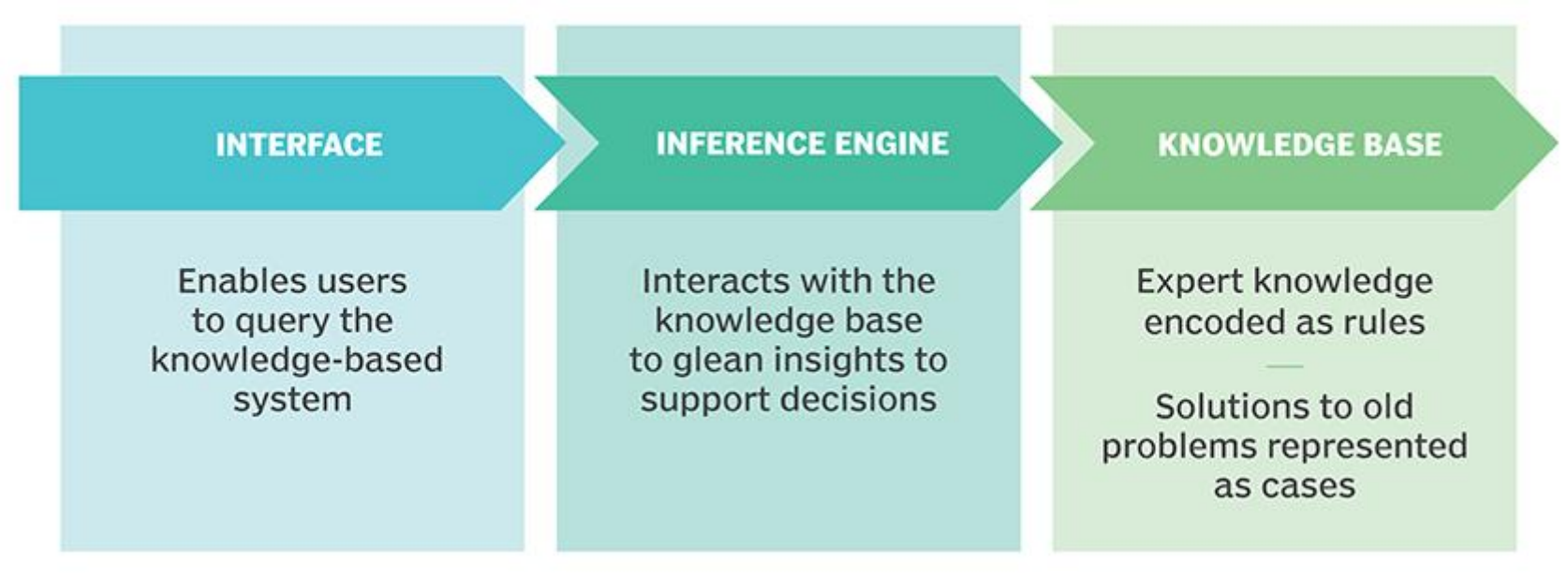
Overview

- A knowledge-based system (KBS) is a type of computer system that analyzes knowledge, data and other information from sources to generate new knowledge.
- The knowledge is typically represented in the form of rules or facts, which can be used to make decisions.
- knowledge-based system can help to automate decision-making processes. For example, a knowledge-based system could be used to diagnose a medical condition, by reasoning over a set of rules that describe the symptoms and possible causes

(KBS) Architecture

- Knowledge-based systems typically have three components, which include:
  - ***Knowledge base:*** *A collection of information and resources used to make decisions.*
  - ***Inference engine:*** *it processes data throughout the system. It is like the search engine in locating relevant information based on the requests.*
  - ***User interface:*** *it is how the knowledge-based system appears to users on the computer. This allows them to interact with the system and submit requests.*

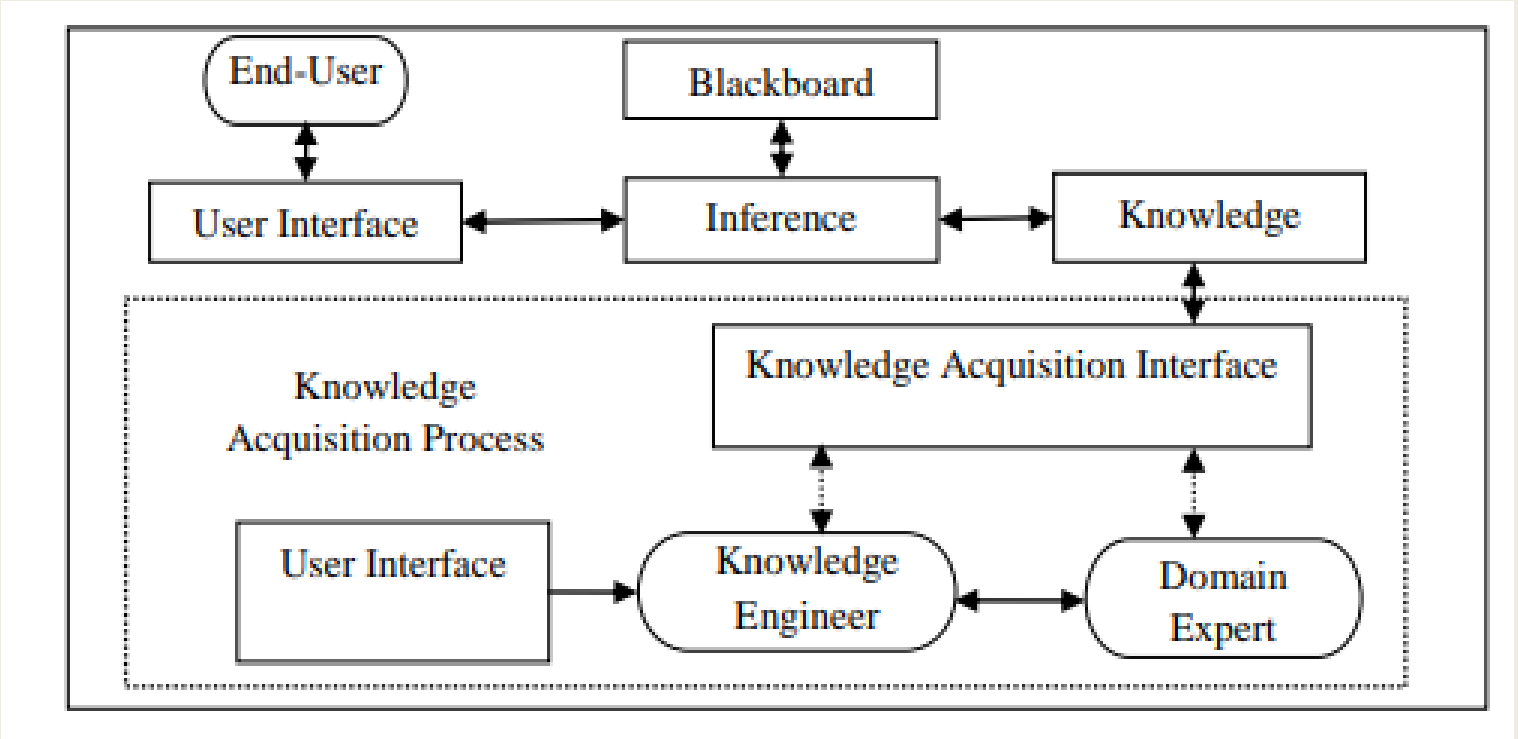
(KBS) Architecture



Source: https://www.techtarget.com/searchcio/definition/knowledge-based-systems-KBS

(KBS) Architecture

- More details appear below:



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Knowledge Base

- The knowledge base contains rules, facts and knowledge acquired from human experts
- Rules or production rules are the most common method of representing knowledge
- Definitional rule defines direct relationships among objects whereas heuristic rule requires experience to solve a certain problem.
- Production rules generally apply IF, AND, THEN and OR statements.
- A rule implies that if an action taken is true then it will result in some conclusions.
- Fact is a general statement which refers to either permanent or temporary knowledge applied by an expert

Inference Engine

- It is the brain of a KBS
- It performs the inferencing and decides how and when the facts and rules in the knowledge base are to be used in solving the problems
- It utilises reasoning techniques in making inferences by accessing the knowledge base
- There are two approaches that are used in controlling the inferencing process:
  - *Forward Chaining*
  - *Backward Chaining*

Inference Engine

- Forward chaining is the data driven approach where the reasoning starts from the known data and proceeds forward with that data until it reaches a conclusion or goal.
- KBS analyses and examines the input with the IF condition in the IF-THEN rule until the goal is satisfied
- Backward chaining or the goal driven reasoning starts with a goal and the inference engine attempts to seek the evidence to prove it.
- It works by searching rules that might have the desired solution and must have the goal in their THEN parts. If such a rule is found and its IF part matches the data in the database, then the rule is triggered and the goal is concluded.

Inference Engine

Initial Facts: A, B, C, D, E

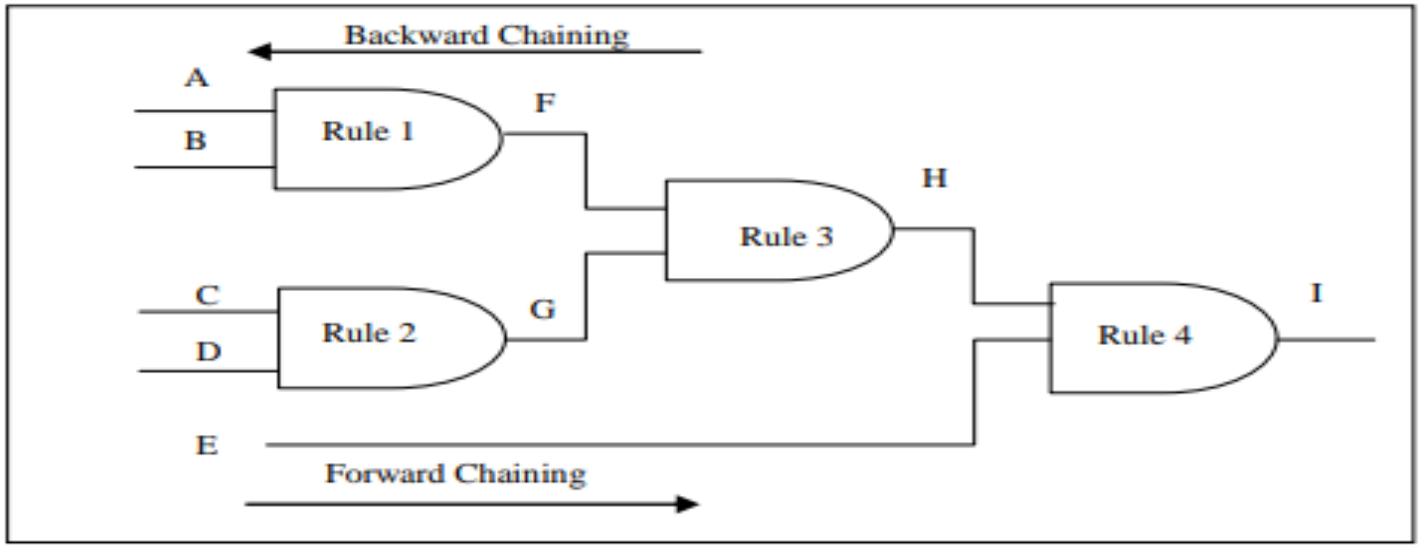
Rules

Rule 1. **IF A AND B THEN F**

Rule 2. **IF C AND D THEN G**

Rule 3. **IF F AND G THEN H**

Rule 4. **IF E AND H THEN I**



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User Interface

- The end user uses the system seeking for a solution to a particular problem
- The knowledge engineer is the person who seeks and then structures the knowledge from the experts of the particular area through interviews to find out how a particular problem is solved. He is thus responsible for development of a KBS from the initial stage to the final delivery of the system including the maintenance of the system.
- The domain expert is a knowledgeable and skilled person who possesses special knowledge, experience, skills and judgement in solving problems in a specific domain.

Blackboard

- The blackboard is a repository (working memory) that stores all partial solutions from the independent cooperating experts
- Using the blackboard, the experts have equal chance to propose a solution until the process reaches the final solution
- User enters description on a current problem into the blackboard, the system matches this description with the knowledge contained in the knowledge base to infer new facts

(KBS) Types

- **Blackboard systems.** These systems enable multiple sources to input new information into a system to help create solutions to potential problems.
- **Case-based systems.** These systems use case-based reasoning to review past data of similar situations and create solutions to a problem
- **Classification systems.** These systems analyze different data to understand its classification status.
- **Expert systems.** These are a common type of KBS that simulate human expert decision-making in a particular field, they provide solution with explanation
- **Intelligent tutoring systems.** These systems are designed to support human learning and education.
- **Medical diagnosis systems.** These systems help diagnose patients by inputting data or having a patient answer a series of questions. Based on the responses, the KBS identifies a diagnosis and makes recommendations medical professionals can use to determine a patient's treatment.

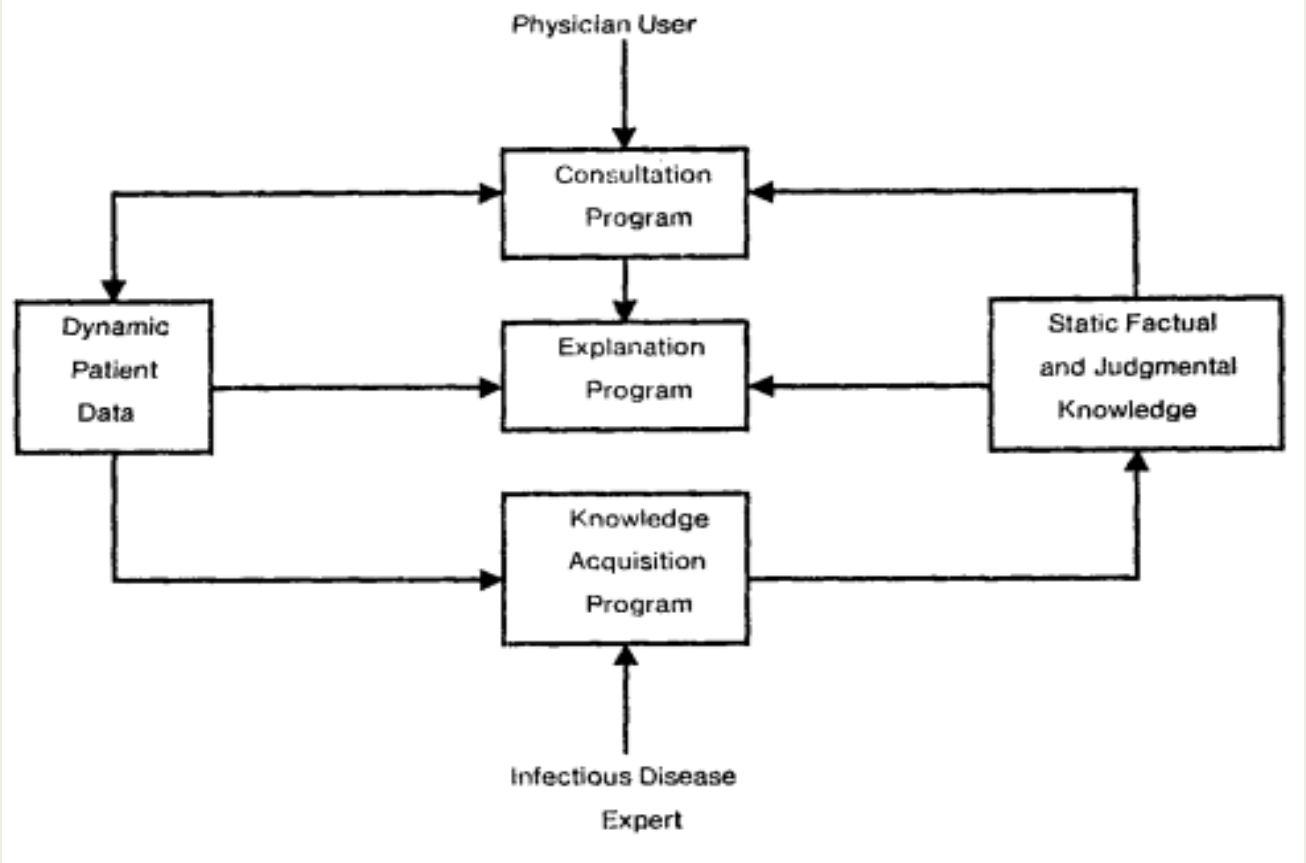
Case Study (MYCIN Expert System)

- Knowledge-based systems are commonly used to aid in solving complex problems and to support human learning
- An early knowledge-based system, **MYCIN**, was created to help doctors diagnose diseases.
- **MYCIN**, an early expert system, or artificial intelligence (AI) program, for treating blood infections.
- In 1972 work began on MYCIN at Stanford University in California.
- MYCIN diagnoses patients based on reported symptoms and medical test results.
- The program could request further information concerning the patient, as well as suggest additional laboratory tests, to arrive at a probable diagnosis,
- Using about 500 production rules (written in Lisp), MYCIN operated at roughly the same level of competence as human specialists in blood infections

MYCIN Components

- Consultation system
  - *Ask*
  - *Conclude*
  - *Advice*
- Explanation system
  - *Translate rule in English before display*
- Rule acquisition and modification system

MYCIN Components



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MYCIN Interface

1) Patient's name: (first-last)
** **FRED BRAUN**
2) Sex:
** **M**
3) Age:
** **55**
4) Are there any cultures for Fred Braun which may be related to the present illness, and from which organisms have been grown successfully in the microbiology laboratory?
** **Y**

(Questions 1-3 request background patient data.)

--------CULTURE-1--------
5) From what site was the specimen for CULTURE-1 taken?
** **BLOD**
=**BLOOD**
6) Please give the date and time when CULTURE-1 was obtained. (mo/da/yr time)
** **JUN 20, 1977**
The first organism isolated from the blood culture of 20-JUN-77 (CULTURE-1) will be referred to as:

(System corrects typing error.)

--------ORGANISM-1--------
7) Enter the laboratory-reported identity of ORGANISM-1:
**UNKNOWN
8) The stain (gram or Ziehl-Neelsen acid-fast) of ORGANISM-1:
** **NEG**
9) Is ORGANISM-1 rod or coccus (etc.):
** **ROD**
10) What is the form of the individual organisms (e.g. lancet-shaped for cocci, fusiform for rods, etc.)?
** **FUSIFORM**

(Typically identity is not yet known.)

(Preliminary lab results give some clues.)

(. . . more questions follow in order to gather sufficient information to infer the identity and significance of the infecting organisms . . .)

23) What is the suspected portal of entry of the gramneg rod from the blood culture of 20-JUN-77 (ORGANISM-1) into this sterile site?
** **GI (6)**
24) Is Fred Braun a burn patient?
** **N**
25) Is Fred Braun a compromised host (e.g. alcoholic, sickle-cell-disease, immunosuppressed)?
** **N**
26) Is Fred Braun febrile?
** **Y**

(User indicates the uncertainty of his response.)

(. . . after about 50–60 questions, MYCIN prints the diagnostic hypotheses on which therapy will be based . . .)

My therapy recommendations will be designed to treat for organisms that are either very likely or, although less likely, would have a significant effect on therapy selection if they were present. It is important to cover for the following probable infection(s) and associated organism(s):

INFECTION-1 is BACTEREMIA

<ITEM-1> E.COLI [ORGANISM-1]
<ITEM-2> KLEBSIELLA [ORGANISM-1]
<ITEM-3> ENTEROBACTER [ORGANISM-1]
<ITEM-4> KLEBSIELLA-PNEUMONIAE [ORGANISM-1]

(. . . questions follow to evaluate possible therapy choices, and finally MYCIN prints its therapy recommendations . . .)

[REC-1] My preferred therapy recommendation is as follows:
In order to cover for items <1 2 3 4>:
Give: GENTAMICIN
Dose: 119 mg (6.0 ml) q8h IV for 10 days [calculated on basis of 1.7 mg/kg]
Comments: Modify dose in renal failure.

(One drug covers 4 possible identities.)

- Source:

Working Steps

- Decide if there is a desease (infection)
- Identify the causing organism by clinical and laboratory analysis
- Decide which antibiotic is suitable
- Prescribe the best combination of drugs in this case

A Sample Context Tree

- MYCIN's decisions must necessarily involve not only the patient but also the cultures that have been grown, organisms that have been isolated, and drugs that have been administered.
- Each of these is termed a context of the program's reasoning and MYCIN knows about ten different context-types:

A Working Steps

CURCULS	A current culture from which organisms were isolated
CURDRUGS	An antimicrobial agent currently being administered to a patient
CURORGS	An organism isolated from a current culture
OPDRGS	An antimicrobial agent administered to the patient during a recent operative procedure
OPERS	An operative procedure the patient has undergone
PERSON	The patient
POSSTHER	A therapy being considered for recommendation
PRIORCULS	A culture obtained in the past
PRIORDRGS	An antimicrobial agent administered to the patient in the past
PRIORORGS	An organism isolated from a prior culture

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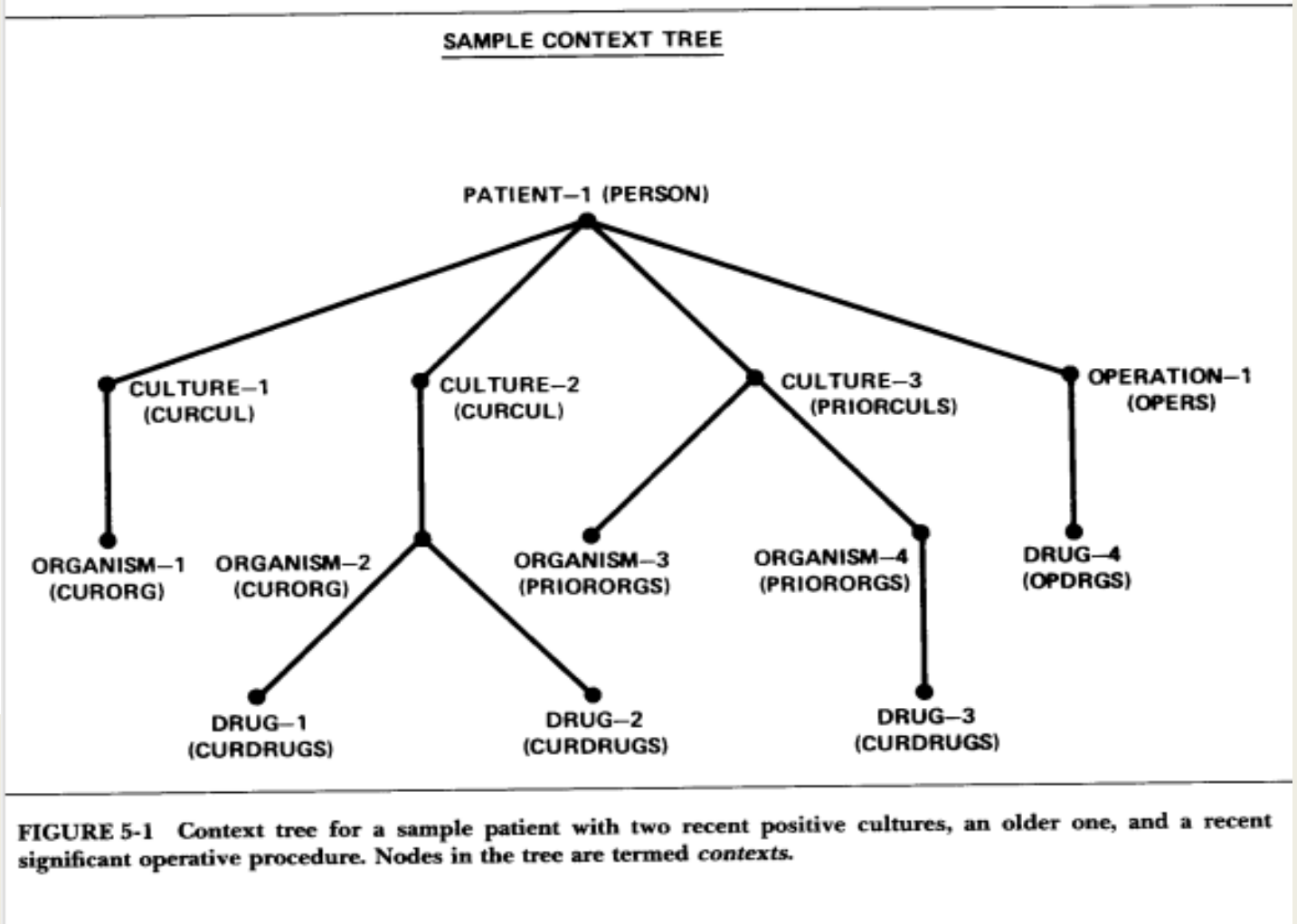

FIGURE 5-1 Context tree for a sample patient with two recent positive cultures, an older one, and a recent significant operative procedure. Nodes in the tree are termed *contexts*.

English Rule Example

- The following examples are rules from MYCIN that have been translated into English from their internal LISP representation:
- **RULE037:**
- **IF** strain of org is gramneg and morphology of org is rod and aerobicity of org is aerobic
  - *إذا كانت سلالة العنصر جرامنيج وشكل العنصر طولي وكانت هوائية العنصر هوائية*
- **THEN** there is strongly suggestive evidence (0,8) that the class of org is *enterobacteriacae*
  - *فهناك دليل موحٍ بقوة (0،8) على أن فئة العنصر هي البكتيريا المعوية*

English Rule Example

- **RULE145:**
- **IF:**
  - *1) The therapy under consideration is one of: cephalothin clindamycin erythromycin lincomycin vancomycin,*
  - ***AND***
  - *2) Meningitis an infectious disease diagnosis for the patient*
- **THEN:**
  - *It is definite (1) the therapy under consideration is not a potential therapy for use against the organis*

Knowledge Base Components

- Inferential knowledge
  - *IF premise **THEN** action with certainty factor **(CF)***
- Static Knowledge
  - *MYCIN's dictionary, is used principally for natural language understanding*
  - *Data structures like simple lists and knowledge tables to store variables*
- Dynamic knowledge
  - *Include information entered by the user,*
  - *Inferences drawn using decision rules,*
  - *Record-keeping data structures that facilitate question answering by the Explanation System*
  - *Stored in the context tree*

The Evaluation Methods

- It is possible that two or more rules might draw conclusions about a parameter with different weights of evidence.
- For example, one rule may conclude that the organism in question is E. Coli with a certainty of 0.8 whilst another concludes that it is E. Coli with a certainty of 0.5 or even -0.8.
- In order to calculate the certainty factor MYCIN combined these weights using a specific formula to get a single certainty factor
- This formula can be applied more than once if more than two rules draw conclusions about the same parameter

MYCIN Limitations

- Requires more computing power and memory
- Exhaustive search in the knowledge base
- Used by physicians

References

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