18.6 EXAMPLE OF EXPERT SYSTEM

To illustrate how the components which we have illustrated fit together to form an expert system. Let us consider some early expert system, although these systems are not the most up-to-date, they were systems which were ground breaking when they were built and they have all been successful in their domains. As such they rank among the 'classics' of expert systems, and therefore merit a closer look. In each case we will summarize the features of the expert system in terms of the five key components we have identified. This will help us to see how different expert systems can be constructed for different problems. In each case, we shall consider the problem that the expert system was designed to solve, and why the particular components chosen are suited to that task.

MYCIN:

Historically, the MYCIN system played a major role in stimulating research interest in rule based expert systems.

"MYCIN is an expert system for diagnosing and recommending treatment of bacterial infections of the blood (such as meningitis and bacteremia)". It was developed at *Stanford University in California, USA, in the 1970s,* and has become a template for many similar rule based systems. It is intended to support clinicians in the early diagnosis and treatment of meningitis, which can be fatal if not treated in time. However, the laboratory tests for these conditions take several days to completed, so doctors (and therefore MYCIN) have to make decisions with incomplete information associated with medical knowledge. MYCIN incorporated a calculus of uncertainty called certainty factors which seemed (at that time) to fit well with how doctors assessed the impact of evidence on the diagnosis. This system was able to perform as well as some experts and considerably better than junior doctors. A consultation with MYCIN begins with requests for routine information such as age, medical history and so on, programming to more specific questions as required.

MYCIN's expertise knowledge lies in the domain of bacterial infections. MYCIN's pool of knowledge consists of approximately 500 antecedent-consequent rules, implemented in LISP which give MYCIN the ability to recognize about 100 causes of bacterial infections. Physicians usually begin antibiotic treatment for patients who have bacterial infections without knowing exactly which organism is the culprit. There is no time to wait for definitive laboratory culture evidence, which accumulates too slowly. For the desperately sick, therapy must begin at once, not 2 days after. This requirement leaves two choices: the physician can either prescribe a broad- spectrum drug which covers all possibilities, or he can prescribe a better, disease specific drug.

MYCIN helps the physician to prescribe disease specific drugs. MYCIN informs itself about particular cases by requesting information from the physician about a patient's symptoms, general condition, history, and laboratory test results. At each point, the question MYCIN asks is determined by MYCIN's current hypothesis and the answer to all previous questions. Thus, the questions start as though taken from a checklist, but the questions then vary as evidence builds. Here is an example from a sample session:

(1) *What is the patient's name?*

-K.Chandra

(2) *Male or Female?*

-Male

(3) *Age?*

-55

(4) *Have you obtained positive cultures indicating general type?*

-Yes

(5) *What type of infection is it ?*

-Primary bacteria.

(6) *When did symptoms first appear ?*

-May 5

(7) *Let's call the most recent positive culture U1. From what site was C1 taken?*

-From the blood.

(8) *When?*

-May 9, 2006

(9) *Let's call the first significant organism from this culture U1.Do you know the identity of U1 ?*

-No

(10) *Is U1 a rod or a coccus or something else?*

-Rod

(11) *What in the gram stain of U1 ?*

-Gram-negative

(12) *Have there been positive cultures from sites which are not associated with the infections about which you are seeking advice?*

-No

(13) *Did U1 grow aerobically?*

-Yes

When MYCIN is satisfied that it has a reasonably good grasp of the situation, MYCIN announces its diagnosis. My recommendation will be based on the opinion that the identity of *U1* may be :

1. *Pseudomonas-aeruginosa*
2. *Klebsiella-pneumonise.*
3. E.coli
4. *Bacteroides- fragilis.*
5. *Enterobacter*
6. *Proteus-nonmirabilis.*

After asking a few more questions about the patient, MYCIN announces its recommendation:

- On a scale of 0 to 4, where the higher number indicates greater severity, how would you rate the patient's degree of sickness?
- Does the patient have a clinically significant allergic reaction to any antimicrobial agent?
- How much does the patient weigh?
- My first recommendation is as follows: to cover for items 1,2, 3, 5,and 6, give gentamycin using a dose of 119 mg (1.7 mg/kg) q8$^{\text{th}}$ IV [or IM] for 10 days. Modify dose in renal failure. Also, to cover for item 4, give clindamycin using a dose of 595 mg (8.5 mg/kg) q6$^{\text{th}}$ IV [or IM] for 14 days. If diarrhea or other gastrointestinal symptoms develop, check for pseudomembranous colitis. It has the following organizational features:

(a) **Knowledge representation,** in the form of production rules implemented in LISP.

(b) **Reasoning,** backward chaining or goal-driven reasoning and uses certainty factors to reason with uncertain information.

(c) **Heuristics,** when the general category of infection has been established, MYCIN examines each candidate diagnosis in a depth-first manner. Heuristics are used to limit the search, including checking all premises of a possible rule to see if anyone of these is known to be false.

(d) **Dialogue/explanation.** The dialogue is computer controlled, with MYCIN driving the consultation through asking questions. Explanations are generated by tracing back through the rules which have been fired. Both "how?" and "why?" explanations are supported.

DENDRAL:

Dendral is one of the great classic application programs. To see what it does, let us suppose that an organic chemist wants to know the chemical nature of some substance newly created in the test tube. The first step is to determine the number of atoms of various kinds in one molecule of the stuff. This step determines the chemical formula, such as C8H160. The notation indicates that each molecule has eight atoms of carbon, 16 of hydrogen, and one of oxygen. Once a sample's chemical formula is known, the chemist may use the sample's mass spectrogram to work out the way the atoms are arranged in the chemical's structure, thus identifying the isomer of the chemical.

The spectrogram machine bombards a sample with high energy electrons, causing the molecules to break up into charged chunks of various sizes. Then, the machine sorts the chunks by passing them through a magnetic field which deflects the high-charge, low-weight ones more than the low-charge, high-weight ones. The deflected chunks are collected, forming a spectrogram.