Expert System

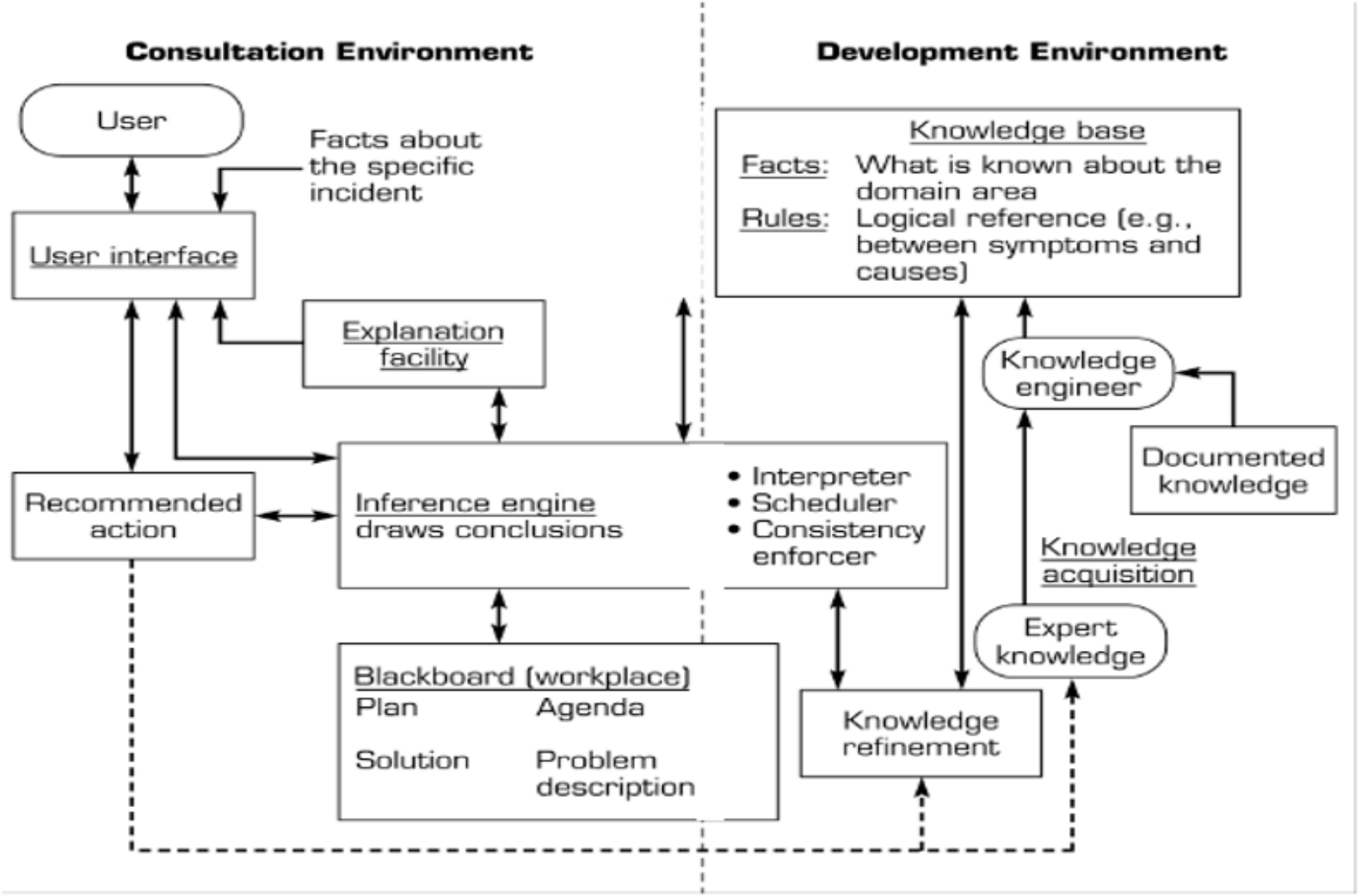
Expert System

- Attempt to model expert decision making in a limited domain
- Examples: medical diagnosis, computer configuration, machine fault diagnosis
- Requires a willing Expert
- Requires knowledge representable as rules
  - Doesn’t work for chess

Architecture

- Domain Knowledge as “if-then” rules
- Inference Engine
  - Backward chaining
  - Forward chaining
- Calculus for combining evidence
  - Construct all proofs, not just one
- Explanation Facility: can answer “why?”

Architecture of Expert System



Development environments

- Parts of expert systems that are used by builders to build the components and put knowledge into the knowledge base.
- It includes the knowledge base, the inference engine, knowledge acquisition, and improving reasoning capability.
- The knowledge engineer and the expert are considered part of these environments

Consultation environment

- The part of an expert system that is used by a non-expert to obtain expert knowledge and advice.
- It includes the workplace (backboard), inference engine, explanation facility, recommended action, and user interface

Components

- Three major components in ES are:
  - Knowledge base
  - Inference engine
  - User interface
- ES may also contain:
  - Knowledge acquisition subsystem
  - Blackboard (workplace)
  - Explanation subsystem (justifier)
  - Knowledge refining system

- **Knowledge acquisition (KA)**

  The extraction and formulation of knowledge derived from various sources, especially from human experts

  other sources: multimedia documents, textbooks, DB, research reports, and the Web.

- **Knowledge base**

  A collection of facts, rules, and procedures organized into schemas. The assembly of all the relevant information and knowledge about a specific field of interest

- **Inference engine**

  The part of an expert system (program) that provides a methodology for reasoning about information in the KB and on the blackboard for formulating conclusions.

- **User interfaces**

  The parts of computer systems that interact with users, accepting commands from the computer keyboard and displaying the results generated by other parts of the systems

- **Blackboard *(workplace)***

  An area of working memory set aside for the description of a current problem and for recording intermediate results in an expert system
- **Explanation subsystem *(justifier)***

  The component of an expert system that can explain the system's reasoning and justify its conclusions

- **Knowledge-refining system**

  A system that has the ability to analyze its own performance, learn, and improve itself for future consultations

Inference Mechanisms

- Knowledge representation and organization
  - Expert knowledge must be represented in a computer-understandable format and organized properly in the knowledge base
  - Different ways of representing human knowledge include:
    - Production rules: easy to understand and adding new rules is easy
    - Semantic networks:
    - Logic statements

- The inference process

  Inference is the process of chaining multiple rules together based on available data to cover numerous conditions, since expert knowledge can not be represented in single rule.

- Popular approaches for inferencing:
  - **Forward chaining**

    A data-driven search in a rule-based system
  - **Backward chaining**

The good and the bad

- Forward chaining allows you to conclude anything
- Forward chaining is expensive
- Backward chaining requires known goals.
- Premises of backward chaining directs which facts (tests) are needed.
- Rule trace provides explanation.

The development of ES includes

1. Defining the nature and scope of the problem
   - Rule-based ES are appropriate when the nature of the problem is qualitative, knowledge is explicit, and experts are available to solve the problem effectively and provide their knowledge
2. Identifying proper experts
   - A proper expert should have a thorough understanding of:
     - Problem-solving knowledge
     - The role of ES and decision support technology
     - Good communication skills

3. Acquiring knowledge
   - **Knowledge engineer**

     An AI specialist responsible for the technical side of developing an expert system. The knowledge engineer works closely with the domain expert to capture the expert's knowledge in a knowledge base

4. Selecting the building tools
   - There are three different kinds of development tools:

   1) General-purpose development environment
   2) **Expert system shell**

      A computer program that facilitates relatively easy implementation of a specific expert system. Analogous to a DSS generator

5. Choosing an ES development tool
   - Consider the cost benefits
   - Consider the technical functionality and flexibility of the tool
   - Consider the tool's compatibility with the existing information infrastructure
   - Consider the reliability of and support from the vendor
6. Coding the system
   - The major concern at this stage is whether the coding process is efficient and properly managed to avoid errors
7. Evaluating the system
   - Two kinds of evaluation:
     - Verification: no error in the code and achieves results the same as that acquired by the expert
     - Validation: solve the problem correctly

Benefits of ES

- Increased output and productivity
- Decreased decision-making time
- Increased process and product quality
- Reduced downtime
- Capture of scarce expertise
- Flexibility
- Enhancement of problem solving and decision making
- Improved decision-making processes
- Improved decision quality
- Ability to solve complex problems
- Ability to work with incomplete or uncertain information

Problems with ES

- Knowledge is not always readily available
- It can be difficult to extract expertise from humans
- The approach of each expert to a situation assessment may be different yet correct
- It is difficult to abstract good situational assessments when under time pressure
- Users of ES have natural cognitive limits
- ES work well only within a narrow domain of knowledge
- Most experts have no independent means of checking whether their conclusions are reasonable
- ES may not be able to arrive at conclusions in some cases
- ES sometimes produce incorrect recommendations

MYCIN: 1972-1980

- 50-500 rules, acquired from expert by interviewing. Blood disease diagnosis.
- Example rule:

  if stain of organism is gramneg and morphology is rod and aerobicity is aerobic then strongly suggestive (.8) that organism is enterocabateriacease.
- Rules matched well knowledge in domain: medical papers often present a few rules
- Rule = nugget of independent knowledge

MYCIN: Shortliffe

- Begins with a few facts about patient
  - Required by physicians but irrelevant
- Backward chains from each possible goal (disease).
- Preconditions either match facts or set up new subgoals. Subgoals may involve tests.
- Finds all “proofs” and weighs them.
- Explains decisions and combines evidence
- Worked better than average physician.
- Never used in practice.
- Methodology used.

Examples and non-examples

- Soybean diagnosis
  - Expert codified knowledge in form of rules
  - System almost as good
  - When hundreds of rules, system seems reasonable.
- Autoclade placement
  - Expert but no codification
- Chess
  - Experts but no codification in terms of rules

Areas for ES applications

- Finance
- Data processing
- Marketing
- Human resources
- Manufacturing
- Homeland security
- Business process automation
- Health care management