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CIT474: INTRODUCTION TO EXPERT SYSTEM

Definitions of expert system

- An expert system is software that attempts to provide an answer to a problem, or clarify uncertainties where normally one or more human experts would need to be consulted
- A type of artificially intelligent software system, which stores expertise concerning some subject matter in a knowledge base and attempts to answer questions or solve problems in a manner which simulates the thought processes of a human expert
- A type of application program that makes decisions or solves problems in a particular field by using knowledge and analytical rules defined by experts in the field.
- A computer program that mimics the judgment of experts by following sets of chemical specific knowledge rules derived from measured toxicity data and knowledge of how chemicals cause toxicity in animals and humans.
- A special program that resembles a collection of ``if ... then'' rules. The rules usually represent knowledge contained by a domain expert (such as a physician adept at diagnosis) and can be used to simulate how a human expert would perform a task.
- A computer program that uses knowledge and reasoning techniques to solve problems that normally require the abilities of human experts. Software that applies human-like reasoning involving rules and heuristics to solve a problem.
- A system designed for solving problems in a particular application area. One can draw an inference from a stored knowledge base that was developed by recording and structuring human expertise through an individual commonly called a knowledge engineer.
- A software system with two basic components: a knowledge base and an inference engine. The system mimics an expert's reasoning process.
- A domain specific knowledge base combined with an inference engine that processes knowledge encoded in the knowledge base to respond to a user's request for advice.
- A computerized compilation of knowledge that is used to make "intelligent" decisions about the management or status of a process or system
- An Expert System is a knowledge tool which uses rules and a process to guide the system user to specific information or knowledge which is indicated for the inquiry at hand.
- An artificial intelligence system that applies reasoning capabilities to reach a conclusion; a program that works with knowledge and relies on a database of if-then rules to draw inferences, in much the way a human expert does.
- An Expert System (XPS) is a software system, which finds solutions on the basis of expert knowledge or provides an evaluation of known problems. Examples are systems for the support of medical diagnosis or for the analysis of scientific data.
- Is a particular development of Artificial intelligence that helps to solve problems or make decisions through the use of a store of relevant Information (known as the Knowledge base, and derived from one or more human experts), and a set of reasoning techniques.
- Artificial intelligence based system that converts the knowledge of an expert in a specific subject into a software code. This code can be merged with other such codes (based on the knowledge of other experts) and used for answering questions (queries) submitted through a computer.
- Formally, an expert system is defined as a knowledge-based computer program that exhibits, within a specific domain, a degree of expertise in problem solving that is comparable to that of a human expert. This problem method uses a knowledge base, which is carefully formulated on the basis of expert judgment, intuition, and experience.

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Thus an expert system embodies the cognition and ability of an expert in a certain realm, thus emulating the decision-making ability of a human

what are the roles of Individuals who interact with the Expert system

 Domain expert : The individuals who currently are experts in solving the problems; the system is intended to solve

 Knowledge engineer : The individual who encodes the expert's knowledge in a declarative form that can be used by the expert system;

 User : The individual who will be consulting with the system to get advice which would have been provided by the expert.

 System engineer - the individual who builds the user interface, designs the declarative format of the knowledge base, and implements the inference engine.

What are the features of an expert system

■ **Goal Driven Reasoning or Backward Chaining**

An inference technique which uses IF-THEN rules to repetitively break a goal into smaller sub-goals which are easier to prove;

■ **Coping with Uncertainty**

The ability of the system to reason with rules and data which are not precisely known;

■ **Data Driven Reasoning or Forward Chaining**

An inference technique which uses IF-THEN rules to deduce a problem solution from initial data;

■ **Data Representation**

The way in which the problem specific data in the system is stored and accessed;

■ **User Interface**

That portion of the code which creates an easy to use system;

■ **Explanations**

The ability of the system to explain the reasoning process that it used to reach a recommendation.

■**Goal-Driven Reasoning**

Goal-driven reasoning, or backward chaining, is an efficient way to solve problems. The algorithm proceeds from the desired goal, adding new assertions found.

■ **Uncertainty Often the Knowledge is imperfect which causes uncertainty**. To work in the real world, Expert systems must be able to deal with uncertainty

■ **Data Driven Reasoning**

The data driven approach, or Forward chaining, uses rules similar to those used for backward chaining.

■ **Data Representation**

Expert system is built around a knowledge base module.

 knowledge acquisition is transferring knowledge from human expert to computer.

 Knowledge representation is faithful representation of what the expert Knows

What are the Benefits/advantages of Expert Systems

 Permanence: Expert systems do not forget.

 Reproducibility: Copies of an expert system can be made.

 Power: For applications where there is a maze of rules exhibited, it can be unraveled by the expert system.

 Efficiency: Expert systems can increase throughput and reduce personnel costs.

-Expert systems are inexpensive to operate.

-Development costs can be amortized over many years.

- Expert systems can eliminate routine costs and reduce major maintenance costs.

 Consistency: With expert systems, similar events are handled the same way. Expert systems will make comparable recommendations for 'like' situations and are not affected by recent or primary effects.

 Documentation: Expert systems provide permanent documentation of the decision process.

 Completeness: An expert system can review all the transactions or possibilities

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 Timeliness: Fraud and/or errors can be prevented. Information is available sooner for decision making and action. The expert system works 24 hours a day, all year long.
 Scope: The expert system can encompass the cumulative expertise of many human experts.
 Business success: Owners reduce the inherent risks of conducting their business due to:
- Consistency of decision making.
- Documentation (ISO requirements)
- Acquired expertise
 Positive impacts:
- Productivity gains and cost savings.
- Critical new tool for managers and a proactive answer to expertise attrition.
- Decisions and solutions are more consistent and less subject to biases or sensitivity to the environment
- Employment: shift to-wards more satisfying work.

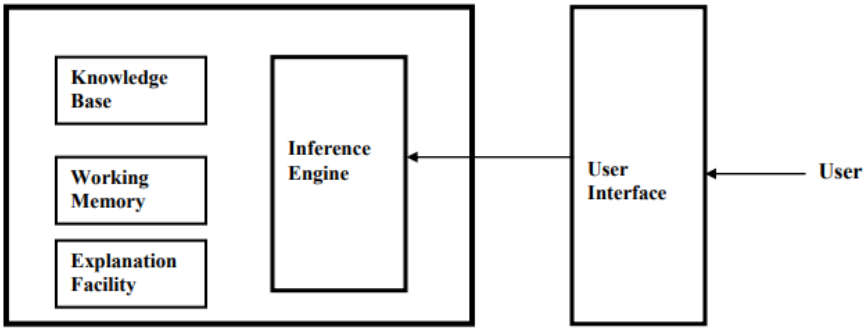
What are the disadvantages/limitation of expert system

common sense- - In addition to a great deal of technical knowledge, human experts have commonsense. It is not yet known how to give expert systems common sense
creativity-Human experts can respond creatively to unusual situations, expert systems cannot.
Learning- Human experts automatically adapt to changing environments; expert systems must explicitly updated. Case-based reasoning and neural networks are methods that can incorporate learning.
-sensory experience- Human experts have available to them a wide range of sensory experience; expert systems are currently dependent on symbolic input.
-degradation- Expert systems are not good at recognizing when no answer exists or when the problem is outside their area of expertise.

what are the Components of an Expert System

 User Interface.
is the part of the system which takes in the user's query in a readable form and passes it to the inference engine. then displays the results to the user.
 Inference Engine.
It is the brain of the expert systems that provides a methodology for reasoning about the information in the knowledge base, and for formulating conclusions.
 Knowledge base.
is the collection of facts and rules which describe all the knowledge about the problem domain.
 Working memory.
the working memory might be used to store intermediate conclusions and any other information inferred by the system from the data.
 Explanation facility
A part of the expert system that allows a user or decision maker to understand how the expert system arrived at certain conclusions or results

Diagram of the component of an expert system



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types of knowledge base

 shallow knowledge (experience) consists of all the peculiar heuristics and shortcuts
e.g.
IF it rains
THEN the vegetables will grow faster
 deep knowledge (theoretical) first principles, axioms, laws e.g.
IF it rains
THEN the vegetables will grow faster
BECAUSE the soil will become more moist

What are the two types of inferences

- **Forward Chaining**

 The forward chaining inference engine takes rule, and if its conditions are true, adds its conclusion to working memory, until no more rules can be applied;
 i.e.
if the conditions of the rule _if A and B
then C‘ are true,
then C is added to working memory

- **Backward Chaining**

 The backward chaining inference engines tries to prove a goal by establishing the truth of its conditions;
 i.e.
the rule _if A and B then C‘,
the backward chaining engine will try to prove C by first proving A and then proving B.

history of expert system

In the mid-1960s, Edward A. Feigenbaum was one of the people in artificial intelligence research who decided, that it was expedient to know how much a computer program can know and that the best way to find out would be to try to construct an artificial expert. In the course of looking for an appropriate field of expertise, Feigenbaum across Joshua Lederberg, the Nobel laureate biochemist, who suggested that organic chemists sorely needed assistance in determining the molecular structure of chemical compounds.
In 1965, Lederberg and Feigenbaum together with Bruce Buchanan, started work on Dendral, the first expert system, at Stanford University. Conventional computer-based systems had failed to provide organic chemists with a tool for forecasting molecular structure. Human chemists know that the possible structure of any chemical compound depends on a number of basic rules about how different atoms can bond to one another. They also know a lot of facts about different atoms in known compounds.
The only first major problem to be solved was Building the right kind of "if-then" program, with enough flexibility to use rules of thumb employed by human experts. After creating a program structure capable of manipulating expert knowledge, there is need to get some knowledge into the system. After feeding the computer program lots of data, the creators of Dendral interviewed as many expert chemists as they could to find out how they made their decisions. This "knowledge acquisition" phase has problems of its own
"Knowledge engineering" is the art, craft and science of observing human experts, building models of their expertise and refining the model until the human experts agree that it works. One of the first spinoffs from Dendral was Meta-Dendral, an expert system for those people whose expertise lies in building expert systems. By separating the inference engine from the body of factual knowledge, Buchanan was able to produce a tool for expert-systems builders.
In the mid-1970s MYCIN was developed by Edward H. Shortliffe, a physician and computer scientist at Stanford Medical School. The problems associated with diagnosing a certain class of brain infections was an appropriate area for expert system research and an area of particularly pressing human need because the first twenty-four to forty-eight hours are critical if the treatment of these illnesses is to succeed. With all its promise, and all its frightening ethical implications, medicine appears to be one of the most active areas of application for commercial

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knowledge engineering.
MYCIN's inference engine, known as E-MYCIN, was used by researchers at Stanford and Pacific Medical Center to produce Puff, an expert system that assists in diagnosing certain lung disorders. An even newer system, Caduceus, now has a knowledge base-larger than any doctor'sof raw data comprising about 80 percent of the world's medical literature. Prospector, developed by SRI International, looks at geological data instead of molecules or symptoms. Recently this program accurately predicted the location of a molybdenum deposit that may be worth tens of millions of dollars.

What are the number of fields today in which expert system today

- KAS (Knowledge Acquisition System) and Teiresias help knowledge engineers build expert systems.
- ONCOCIN assists physicians in managing complex drug regimens for treating cancer patients.
- Molgen helps molecular biologists in planning DNA experiments.
- Guidon is an education expert that teaches students by correcting answers to technical questions.
- Genesis assists scientists in planning cloning experiments.
- TATR is used by the Air Force in planning attacks on enemy air base

What are the four major steps in the design and construction of expert system

- **Design a Rule Language**

The best way to ascertain that the expert system is well-received is to design a rule language that is easy for users to learn and easy to use. The language must meet the needs of the subject matter expert. Subject matter experts need a language that mimics the way they speak, think, and operate. Its lexical elements and syntax rules must make the resulting language appear as natural (i.e., similar to the spoken language) as possible. These goals must be balanced with the need to create a language that can be recognized by translators created with conventional translation writing tools

- **Generate Translator from Rule Grammar**

The rules composed by subject matter experts must be translated and stored in the Knowledgebase before they can be executed. Rules are transformed into machine-readable forms by the Rule Translator. The Rule Translator is generated automatically from lexical specifications and from the rule grammar. Lexical specifications define the lexical units (e.g., reserved words, numerical values, operators, etc) of the expert systems rule language. The rule grammar defines the syntax and semantics of the language.

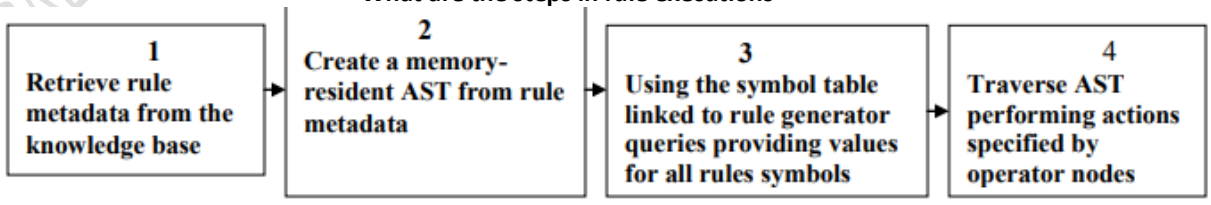
- **Design and Build a Rule Editor**

The Expert Systems Rule Editor provides the means for subject matter experts to compose rules. Some people prefer graphical editors. Graphical editors with the expressive power needed to precisely specify complex rules, however, are difficult to build, and might very well end up being too unwieldy for subject matter experts to use. Text editors are simple to use and are rather easy to build. The disadvantage of text editors is this: they are unforgiving of spelling and syntax errors. This fact forces subject matter experts to understand rule syntax, simple though it might be. To relieve the subject matter experts of this burden and to speed development of rules, the editor could be equipped with special aids. These might include a syntax-directed editing feature, drop-down, menus, checkboxes, radio buttons, and help facilities.

- **Design and Build a Rule Engine**

The Rule Engine executes (or more properly, interprets) Knowledge-base rules.

What are the steps in rule executions



- Retrieve rule metadata from the knowledge base

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- Create a memory resident AST from rule metadata
- Using the symbol table linked to rule generator queries providing values for all rules symbols
- Traverse AST performing actions specified by operator nodes

Diagram showing the steps in design and construction of expert system

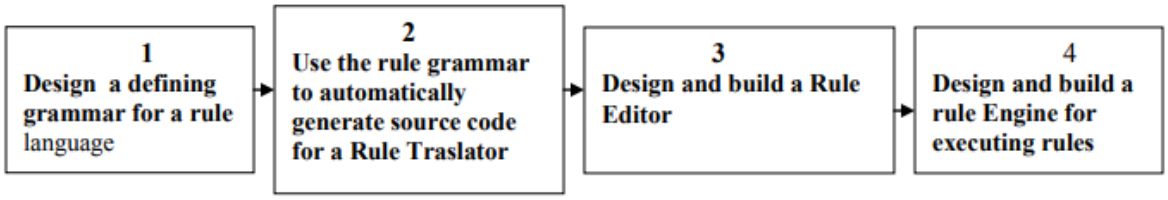
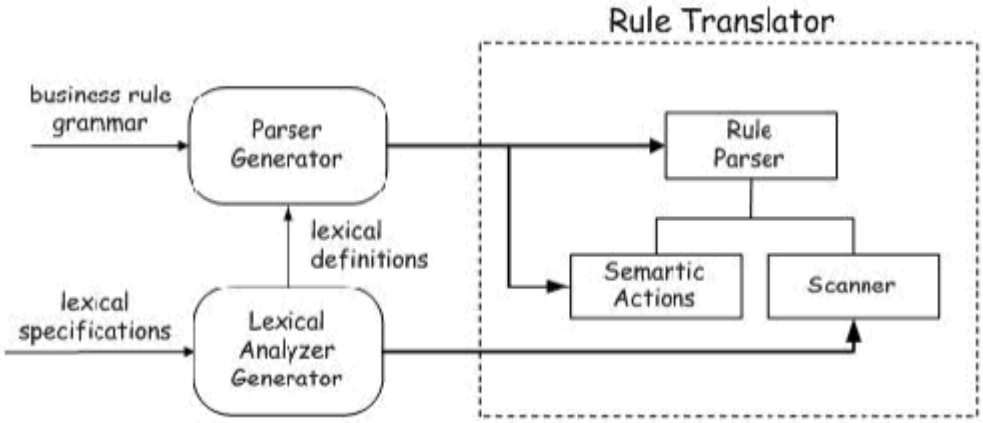


Diagram showing a rule translator



Describe how to Design and Build a Rule Editor

The Expert Systems Rule Editor provides the means for subject matter experts to compose rules. Some people prefer graphical editors. Graphical editors with the expressive power needed to precisely specify complex rules, however, are difficult to build, and might very well end up being too unwieldy for subject matter experts to use. Text editors are simple to use and are rather easy to build. The disadvantage of text editors is this: they are unforgiving of spelling and syntax errors. This fact forces subject matter experts to understand rule syntax, simple though it might be. To relieve the subject matter experts of this burden and to speed development of rules, the editor could be equipped with special aids. These might include a syntax-directed editing feature, drop-down, menus, checkboxes, radio buttons, and help facilities.

What are the steps on how to execute rules

1 Retrieve rule metadata from the knowledge base
2 Create a memoryresident AST from rule metadata
3 Using the symbol table linked to rule generator queries providing values for all rules symbols
4 Traverse AST performing actions specified by operator nodes

What are the characteristics of expert system

■ **Operates as an interactive system**

This means an expert system :

 Responds to questions
 Asks for clarifications

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 Makes recommendations
 Aids the decision-making process.
■ **Tools have ability to sift (filter) knowledge**
 Storage and retrieval of knowledge
 Mechanisms to expand and update knowledge base on a continuing basis.
■ **Make logical inferences based on knowledge stored**
 Simple reasoning mechanisms is used
 Knowledge base must have means of exploiting the knowledge stored, else it is useless; e.g., learning all the words in a language, without knowing how to combine those words to form a meaningful sentence.
■ **Ability to Explain Reasoning**
 Remembers logical chain of reasoning; therefore user may ask
1. for explanation of a recommendation
2. factors considered in recommendation
 Enhances user confidence in recommendation and acceptance of expert system
■ **Domain-Specific**
 A particular system caters a narrow area of specialization; e.g., a medical expert system cannot be used to find faults in an electrical circuit.
 Quality of advice offered by an expert system is dependent on the amount of knowledge stored.
■ **Capability to assign Confidence Values**
 Can deliver quantitative information
 Can interpret qualitatively derived values
 Can address imprecise and incomplete data through assignment of confidence values.
■ **Applications**
 Best suited for those dealing with expert heuristics for solving problems.
 Not a suitable choice for those problems that can be solved using purely numerical techniques.
■ **Cost-Effective alternative to Human Expert**
 Expert systems have become increasingly popular because of their specialization, albeit in a narrow field.
 Encoding and storing the domain-specific knowledge is economic process due to small size.
 Specialists in many areas are rare and the cost of consulting them is high; an exp

What are the application areas of expert system

Accounting & Finance - Cost Code Selector, Stock & Commodity Trading, Portfolio Construction, Home Purchasing, Financial Planner Training and Selection, Personal Tax Advisor, Detecting Insider Trading, Organizational Services, Credit Analysis Advisor, Bank Loan Identification, Credit Control, Loan Documentation, Assessment of Risk and Fraud in Financial Institutions, Aid in Tax Form Completion, Commercial Loan Approval Predictor..
Agricultural - Irrigation and Pest Control, Crop Variety Selection and Management, Soil Characterization and Utilization for Specific Areas, Fertilizer, Climate and Soil Interaction and Analysis, Salmon Stocking Rates and Species Selection, Forest Inventory, Weed Identification, Soil Conservation, Tree Selection Based on Environmental Conditions, Planning and Design of Agro forestry Systems
Business - Alternatives for Fragmented Industry, Advertising Copy Development, Shipping Documentation and Routes, Market Advisor for Process Control Systems, Demographic and Market Assessment, Product Performance Trouble-shooting, Sales Personnel Assessment, Account Marketing, Invention Patent Ability, Salary & Benefit Planning, Client Profile Business Application Selection, Professional Service Selection, Career Goal Planning, Pension Fund Calculator, Unemployment Insurance Eligibility..
Chemical - Hazard Evaluation, Chemical Facilities Procedures, Correct Propellant Ingredient Mixture, Pollution Control Technology Permits, Common Metal and Alloy Identification, Real-time Process Controlled City Waste Water Management, Solvent Selection for Chemical Compounds, Pottery Glaze Recipe and Identification, Pulp Bleaching Advisor, Toxicity of Laboratory Chemicals, Lime Recognition System, Process Diagnosing and Troubleshooting
Computer - Software System Diagnostic Modeling, Application Sizing, Software Quality Assurance, Program Classification, Locating Component Failure & Analysis, New Technology Selection, Training Systems, Custom

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Construction - Pavement Rehabilitation & Design, Structural Damage Assessment, Equipment Evaluation & Selection, Material Costing & Selection, Project Scheduling, Cost Estimating, Evaluating Multifamily Housing Projects, Work Zone Safety Trainer/Advisor, Weld Procedure Selection and Cost Estimating, Soil Compacting, Fire Code Advisor, Alarm Management System

Education - Training - Library Reference Material Recommendation, Interpretation of Statistical Quality Control Data, Teaching Mineral, Rock and Fossil Identification, Student Financial Aid Eligibility, Analysis of Metal Cautions, Fire Department Emergency Management Advisor, Medical Student Diagnostic Systems, Dentistry Advisor, Telephone Customer Support Instruction, Gas Turbine Training, Industrial Training, Patient Care Advisor for Student Nurses

Engineering - Industrial - Engineering Change Control Demonstrating, Diesel Engine Lube Oil Wear Analysis, Superalloys Phase Analysis, Equipment Diagnostics, Electronic Semiconductor Failure Testing, Parts List Selection & Sizing, Power Generation System Scheduling, Component Failure Prediction, Machining Advisor, Numerically Controlled Machine Tool Selection, Petrochemical Plant Process Control, Control Panel Layout Design, Material and Process Design Advisor

Insurance - Rating for Substandard Life Insurance, Workers Comp Classification, Underwriting Assistance, Social Security Help Desk and Benefit Identification, Unemployment Insurance Eligibility

Medical - Admission Protocols, X-Ray Analysis, Hematological Diagnoses, Psychiatric Interviewing, Pediatric Auditory Brainstem Response Interpretation, Medical Decision Making, Respirator Selection for Preschool Children, Health Services Utilization and modeling, Diagnostic Systems, In-Vitro Fertilization, Symptom Analysis, Voice-Driven Lab Diagnosis, Rehabilitation Feasibility Strategies, Billing and Account Management, Disease Research

- Military, Government & Space Related - Submarine Approach Officer Training, Combat Methodology Selection, Radar Mode Workstation Designing, Federal Contract Management, Severe Weather Forecasting, Shuttle Payload On-Orbit Analysis, Metals Materials Selector, GB Satellite Abnormality Correction, Thermal Analyst, Selection of Non-materials in Aerospace Applications.

- Trouble-Shooting - Airplane Starting Systems, Data Communications, Test and Repair of a PCB, Gas Turbine Control System, Bearing System Failures, Telecommunications Difficulties, Real-Time Process Control, Meterman's Assistant System, Mechanical Equipment and Systems Diagnosis, Weld Flaw Detection, Web Break Diagnosis in Paper Milling, Power Plant Turbine Generator Bearing Maintenance System

- Many, Many Others - Telephone System Configurator, Training Material & Product Selection, Manufacturing Resource Planning, Production Scheduling, Service Networking, Airline Scheduling, Cost/Benefit Analysis, Planning Implementation, Career Development, Quick Proposal Estimating, Credit Control, Product Development, Telephone Call Screening, Real Estate Market & Mortgage Credit Analysis, Retirement Planning, Sales Analysis.

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What is natural language interface

A Natural language Interface(NLI) is defined as an interface that has the ability to interact with users using human language such as English, as opposed to computer language, a command line interface, or a graphical user interface. NLIs are usually only capable of understanding a restricted subset of a human language (usually restricted to a certain domain) and generate more or less pre-packaged responses. NLIs were first utilised for human-computer interaction through natural language in 1966 with a system, called ELIZA, created by Joseph Weizenbaum. ELIZA was a simple conversational agent that was capable of parsing simple sentences and utilising them to pick out keywords. These keywords were then utilised for substitutions to turned into questions. ELIZA was not capable of holding a long conversation with a user as most statements made by the user were merely turned into questions.

What is Conversational Speech Interfaces

A conversational speech interface is one that utilises speech as an interaction technique and is an example of a

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natural language interface. This interface operates utilising the following functions: speech recognition (input) and speech synthesis (output). A major benefit of incorporating speech in applications is that it comes naturally to humans. Most people find speaking and listening easy.

What is Speech Recognition

Speech recognition can be seen as the process by which a computer can identify the parts of human speech. The process starts with the user uttering something into a microphone and ends with the computer accomplishing a task. The solution that has not been successfully implemented by humans for computers is to accurately identify all possible words spoken by any person in any environment

Explain pattern matching

The goal of pattern matching is to take an unknown pattern and compare it to a set of known and stored patterns (also known as templates). These are established through training data. Templates are utilised to compare the pattern and compute a similarity score. The template with the highest score is then chosen as it will have the highest acoustic similarity to the users input

Explain knowledge based approaches

This approach makes use of a rule-based expert system which utilises a base classification of rules in order to function. However to utilise this model, a large set of rules would be needed in order to capture a great variability in speech Rules are formed from knowledge about speech signals. This approach could be useful, however, it does not perform effectively if there is insufficient knowledge.

Explain Speech Synthesis

Speech synthesis enables computers and other electronic devices to output simulated human speech. A computer system that is utilised for the purpose of producing human speech is known as a speech synthesiser. A text-to-speech (TTS) system is an example of a speech synthesiser that converts normal text into speech

What are the characteristics of Speech Synthesis

 Base-level achievement of speech that is intelligible (the ease with which the output is understood) to humans;
 produce speech that is as natural as that of human beings in other words how natural the speech is;
 produce speech that is personalised to a particular user, in other words it has the same intonation as a person‟s speech; and
 the final level and highest level of achievement is to produce speech based on a person‟s own voice recordings so that the speech sounds as if it belongs to that person.

What is normalization

Normalization is the process that occurs first, where the conversion of raw text occurs. All abbreviations and symbols are expanded into their respective words. These are then passed down to the component that starts the text-to - phoneme conversion. Once the text is passed on this component makes sure that the sentence is syntactically correct.

What is Text-Based Natural Language Interfaces

Text-based NLIs utilise text instead of speech in order to function. Text may be in the form of a query, sentence or a list of keywords (as used by search engines). A user will type in a question in an appropriate field (usually a textbox) and the system will retrieve information in accordance to the users query. Text-based natural language interfaces have been utilised in many applications including: databases (query and report generation) conversational agents and search engines (matching user requests to keywords). Conversational agents are a communication technology that utilizes natural language and various linguistic methods to interact with human users through natural language

What are the two set of requirements that needs to be satisfied by Conversational agents for them to be

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effective

 they must have good language processing capabilities such that they have the ability to engage in productive conversations with the user. This involves understanding user input and employing effective dialogue management techniques; and

 they must be scalable and reliable and allow for smooth integration within business processes.

What are the two methods utilised by text-based interfaces to comprehend user input

-Pattern matching – conversations and their responses are stored in pairs. The pattern is the user input or stimulus which is matched to produce a template which is the output of the system. The pattern can be seen as a simple text string that has to match the input exactly. The template is the output that a user receives as a response (as it was entered by the person who created the conversational agent). The biggest flaw with pattern matching is that it is difficult to maintain context of a conversation

-Bayesian networks - is a graphical model that represents a set of variables and their• probabilistic dependencies. It is implemented in conversational agents to maintain context in a conversation. Context can be maintained through Bayesian networks as the probability of the next question can be calculated. This probability is calculated by analysing current and previous user input.

What are the Benefits of Natural Language Interfaces

 Offers natural communication;

 Allows for physical mobility when troubleshooting problems that are not near the interface; and

 Allows for flattening of deep menu structures found in some computer systems. This would be possible as users could state their queries in natural language and would eliminate the need for menus. This would be beneficial for systems such as IVR.

What are the two two issues that must be considered when building a natural interface for an expert system

- semantic processing of the user statements and
- the design of an interpreter for the expert system that efficiently utilizes the facts entered by the user

what is an Expert system shells

Most expert systems are developed via specialized software tools called shells. Shells provide framework to produce an expert system.so the knowledge base and rules are simply added to this frame work. These shells come equipped with an inference mechanism (backward chaining, forward chaining, or both), and require knowledge to be entered according to a specified format (all of which might lead some to categorize OPS5 as a shell). They typically come with a number of other features, such as tools for writing hypertext, for constructing friendly user interfaces, for manipulating lists, strings, and objects, and for interfacing with external programs and databases. These shells qualify as languages, although certainly with a narrower range of application than most programming languages

What are the two main classes of languages

Procedural
Declarative

What are the characteristics of the programming languages needed for expert systems work

• Efficient mix of integer and real variables
• Good memory-management procedures
• Extensive data-manipulation routines
• Incremental compilation
• Tagged memory architecture
• Optimization of the systems environment
• Efficient search procedures

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Differentiate between procedural and declarative programming

Procedural languages include C++ and Java. They are relatively general purpose languages that can be used in many different programming situations, e.g Expert System, Microsoft Windows program and company specific applications. They are organized as a set of procedures, very similar to the way that a chapter in a book is divided into a series of paragraphs. While they offer no specific support for the development of expert system, they do offer the ultimate in flexibility. As such languages such as these can be used to develop systems where other tools may be inadequate. Expert systems are typically written in special programming languages. The use of languages like LISP and PROLOG in the development of an expert system simplifies the coding process. The major advantage of these languages, as compared to conventional programming languages, is the simplicity of the ddition, elimination, or substitution of new rules and memory management capabilities

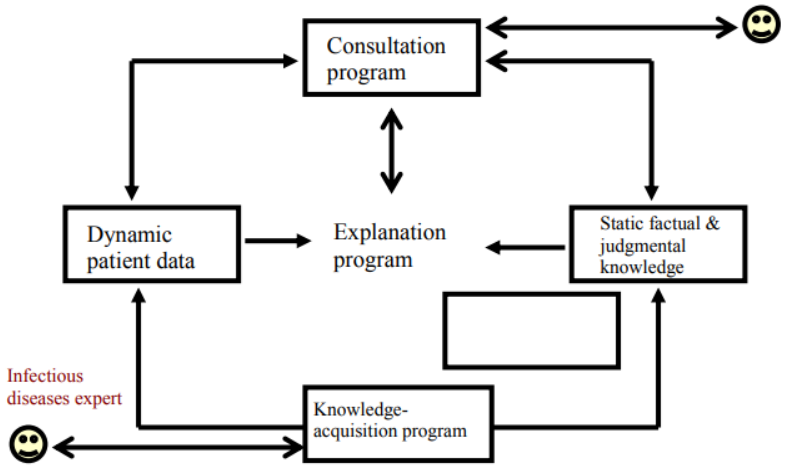
What is a rule-based expert system

A rule-based expert system is an expert system which works as a production system in which rules encode expert knowledge. Most expert systems are rule-based. It is an expert system based on a set of rules that a human expert would follow in diagnosing a problem. A classic example of a rule-based system is the domain-specific expert system that uses rules to make deductions or choices.

history of Mycin

Mycin was originally developed by Edward Shortliffe for Stanford Medical School in the earlyand mid-1970's. Written in Lisp, a language (a set of languages, actually) geared towards artificial intelligence, MYCIN was one of the pioneering expert systems, and was the first such system implemented for the medical field. The Goal of MYCIN was to compete in an experiment conducted at Stanford Medical similar to the Turing Test. The case histories of ten patients with different types of meningitis were submitted to MYCIN as well as to eight human physicians, including a resident, a research fellow, and five faculty specialists in infectious disease. Both MYCIN and the human physicians were given the same information. Both MYCIN's and the human physician's recommendations (as well as a record of the treatment actually received by the patients) were sent to eight non-Stanford specialists, completely unidentified as to which recommendation was MYCIN's and which were authored by the physicians. The outside specialists gave MYCIN the highest score as far as accuracy of diagnosis and effectiveness of treatment.

A diagram showing the components of Mycin



What are the two major component of mycin as an expert system

- **Mycin's knowledge base**

1. A knowledge base which stores the information the expert system "knows", much of which is derived from other information in the knowledge base. It is small relative to those used by most rules-based systems today; it is on the

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order of ~500 rules. The science of the generation of these rules is known as "knowledge engineering". MYCIN uses a modification of the method of reasoning called "backward chaning" to search it's knowledge base. The modification comes in when the system is in the beginning stages of diagnosis, when the system asks a series of broad questions in order to weed out any unnecessary searches later on, such as checking for pregnancy if the patient is male

- **inference engine**

2. An inference engine to derive knowledge from the presently known knowledge in the knowledge base. The core of MYCIN, its inference engine, is called EMYCIN ("Essential MYCIN"). EMYCIN is the framework for MYCIN, a semi-separate system which could be used to create other rulesbased expert systems to face problems similar to what MYCIN faces. In some cases this can be affected merely by changing the knowledge base.

explain the problem with Mycin

 If MYCIN gives an incorrect diagnosis and/or prescription (or, rather, a physician follows MYCIN's orders in giving such diagnosis and/or prescription), who would you sue?
 People tend to give too much credence to the recommendation of a computer simply based on the fact that it comes from a computer. This would of course lead some physicians to trust MYCIN too much in certain situations where they would be better served by taking it's recommendation with a grain of salt, so to speak.
- The second list item here points to a broader range of problems governing expert systems, namely the ethics and philosophy of using them in environments where not only are they not used currently, but also where their decisions and recommendations have a substantial impact on human life.

explain the practical use of Mycin

- Mycin is a program that diagnoses infectious diseases. It reasons backward from its goal of determining the cause of a patient illness. It attempts to solve its goal of recommending a therapy for a particular patient by first finding the cause of the patient‘s illness. It uses its production rule4s to reason backward from goals to clinical observations. To solve the top-level diagnostic goal, it looks for rules whose right sides suggest diseases. It then uses the left sides of those rules (the preconditions) to set up sub goals whose success would enable the rules to be invoked . these sub goals are again matched against rules, and their preconditions are used to set up additional sub goals.
- Mycin is a well known rule based deduction system. Its expertise lies in the domain of bacterial Infections. Physicians usually must begin antibiotic treatment for patient who have bacterial infections without knowledge 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 from can either prescribe a broad – spectrum drug that covers all possibilities , or she can prescribed a better, disease – specific drug.
- Mycin helps the physician to prescribe disease – specific drugs. Mycin in-forms it self about particular cases by requesting information from the physician about a patient‘s symptoms, general condition. History, and laboratory – test results that can be obtained easily and quickly. At each point, the question mycin asks is determined by Mycin‘s current hypothesis and the answers to all previous questions.

What is a blackboard system

A blackboard system is a task independent architecture for integrating multiple problem solving modules (referred to as knowledge sources). By task independent we mean that these architectures can be used for a wide range of tasks such as classification, design, diagnosis, repair etc. Integrated problem solvers, such as systems based on blackboard systems, attempt to overcome the inherent limitations of a single heuristic expert system by employing two or more problem solving (or reasoning systems). The problems solvers may all use the same technology or they may reply on different technologies. For example, a system might integrate a heuristic rule based reasoning system with a case-based reasoning system and possibly a model based system

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What are the three Component of Blackboard

• Knowledge sources (KSs) are independent modules that contain the knowledge needed to solve the problem. KSs can be widely diverse in representation and inference techniques.
• The blackboard is a global database containing input data, partial solutions, and other data that are in various problem-solving states.
• A control component makes runtime decisions about the course of problem solving and the expenditure of problem-solving resources. The control component is separate from the individual KSs.

Diagram of the basic component of a blackboard model

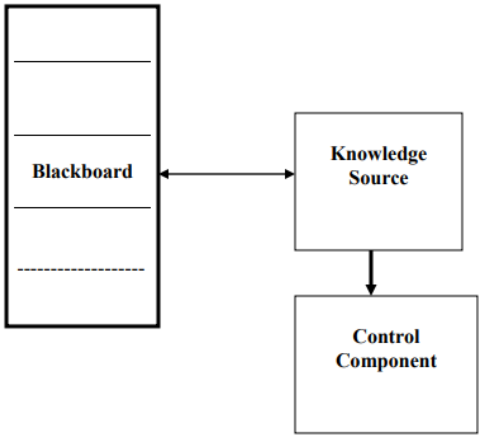
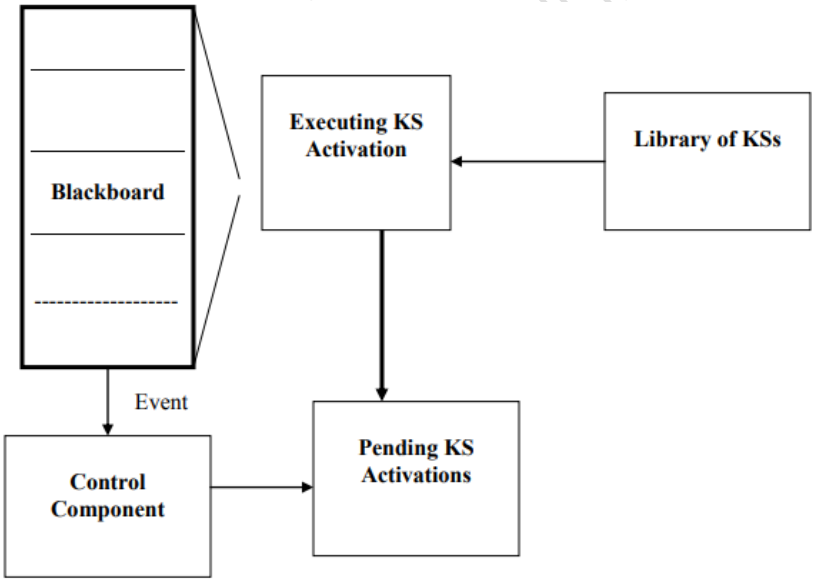


Diagram of a basic Blackborad System



Explain a Knowledge Source (KS)

Each KS is separate and independent of all other KSs. A KS needs no knowledge of the expertise, or even the existence, of the others; however, it must be able to understand the state of the problem-solving process and the representation of relevant information on the blackboard. Each KS knows the conditions under which it can contribute to the solution and, at appropriate times, attempts to contribute information toward solving the

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problem. This knowledge that each KS has about when to contribute to the problem-solving process is known as a triggering condition. KSs are much larger grained than the individual rules used by expert systems. While expert systems work by firing a rule in response to stimuli, a blackboard system works by firing an entire knowledge module, or KS, such as an expert system; a neural net or fuzzy logic routine; or a procedure

Explain the control component of a blackboard

An explicit control mechanism directs the problem-solving process by allowing KSs to respond opportunistically to changes on the blackboard database. On the basis of the state of the blackboard and the set of triggered KSs, the control mechanism chooses a course of action.
A blackboard system uses an incremental reasoning style: the solution to the problem is built one step at a time. At each step, the system can:
 execute any triggered KS
 choose a different focus of attention, on the basis of the state of the solution.

What are the application areas of a blackboard system

- sensory interpretation
- design and layout
- process control
- planning and scheduling
- computer vision
- case-based reasoning
- knowledge-based simulation
- knowledge-based instruction
- command and control
- symbolic learning
- data fusion

Explain the Hearsay Expert System

Hearsay,1985, separates the different types of knowledge into coherent modules, called knowledge sources (KSs) in his speech signal processing system.The independent knowledge sources for phonetics, syntax, semantics were independent processes that looked at the speech signal and posted hypotheses about likely syllables, words, phrases, and so forth on the blackboard – a global data-structure accessed by all of the KSs through an established protocol. Hypotheses generated by the lower level knowledge sources (about syllables and words) would be examined for feasibility by the syntactic and semantic KSs; these, in turn, could make suggestions about what words might be expected and post them on the blackboard. The advantages of this organization are those generally associated with modularization of knowledge. The blackboard organization for representing multiple types of knowledge has been used in several domains besides speech understanding
In the Hearsay-II blackboard system, the flow of control occurs between the knowledge sources. These knowledge sources attempt to work in an opportunistic manner, influenced by the scheduler. By opportunistic we mean that cooperation occurs dynamically determined during the execution of the system based on the current information available.

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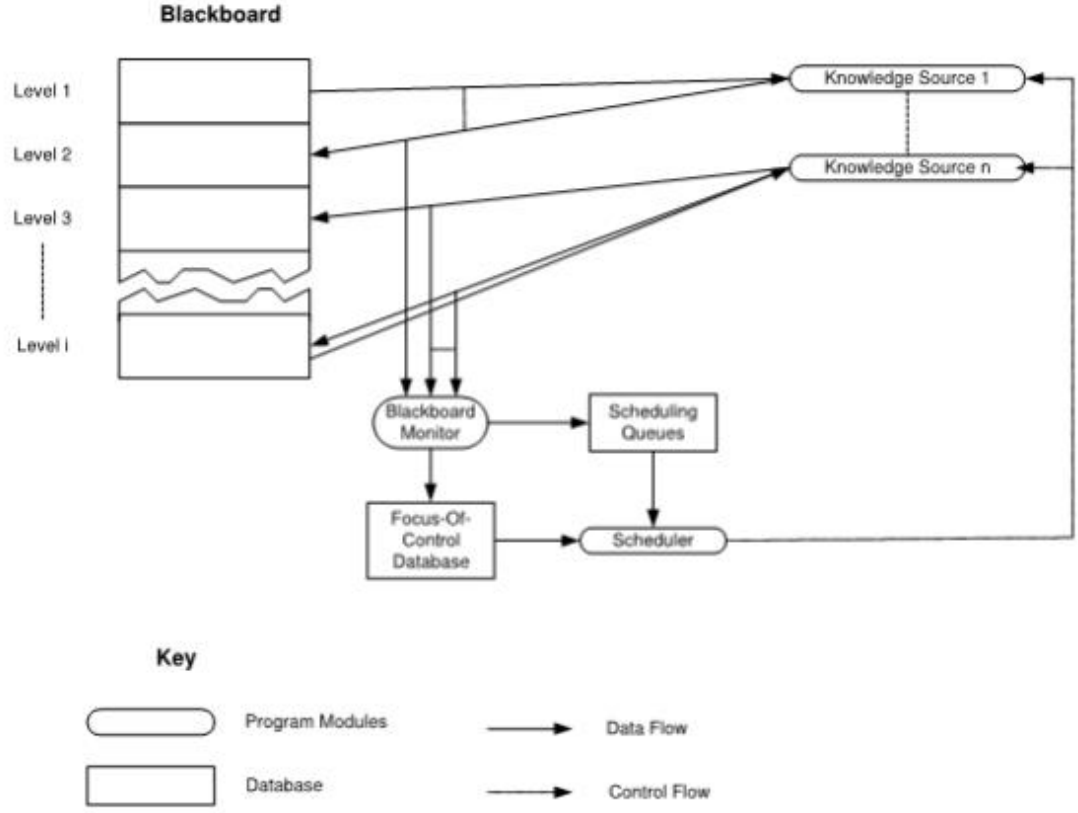
A diagram showing the Architecture of Hearsay-II



What are the Benefits/advantages of blackboard architectures

 Flexibility of configuration. The knowledge sources within a blackboard system are not tied together in a fixed or rigidly applied manner. Instead they communicate and cooperate via the common blackboard. This means that any knowledge sources can be added to the system without having to specify its existence in any other knowledge source.

 Flexible problem solving. A blackboard architecture is independent of any particular task and can therefore be used as the basis of very different applications, from route planning, to image processing, speech recognition and diagnosis. Cooperation is driven by the current state of the problem, rather then through any particular control strategy, and control of this cooperation is distributed between the knowledge sources themselves.

 Selection of knowledge sources. Because more than one knowledge source may be able to perform the same function, the scheduler can select that problem solver which will provide the most benefit to the emerging solution. This can improve both problem solving efficiency and the quality of the eventual solution.

 Multiple problem solvers. The blackboard architecture promotes the integration and multiple problem solving modules (knowledge sources). Each of these knowledge sources can potentially have its own representation and inference mechanism. This means that the twin advantages of multiple reasoning systems are maintained, namely: resilient behaviour and efficient behaviour.

 Management of multiple levels of abstraction. The blackboard architecture explicitly supports the management of multiple levels of abstraction. Not only can the blackboard be divided hierarchically, but the knowledge sources can reflect this hierarchy. Problems of moving between the levels of the hierarchy can be overcome by providing knowledge sources whose sole task is to move information between two particular abstraction levels.

 Opportunistic cooperation. Cooperation ins a blackboard system is explicitly opportunistic; knowledge sources can post partial solutions to the blackboard in the hoped that some other knowledge source will be able to take

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these partial solutions and progress further down the path to the final solution.

what are the drawbacks of blackboard architectures

 No communications language. The blackboard acts as a very general communications facility. However, the communications language is the language of the hypotheses. That is, if all communications have to go via the blackboard then not only does the blackboard access mediate each decision step, it also constrains the representation of the information to be exchanged.That is, the language for passing information between problem solvers is the language of the intermediate hypotheses on the blackboard

 Computational complexity of cooperation. The problem of determining which knowledge sources are appropriate in each situation and which of these appropriate knowledge sources should be activated has to be solved each time a decision has to be made. In the case of BB1 this can be computationally very expensive, even in Hearsay-II system this imposes a certain amount of computational overhead.

 No guidance for task. Blackboard architectures do not give any guidance to a system builder on how to solve a particular problem or perform a particular task within their framework. That is, blackboard architectures do not give any support for determining how specific problems should be addressed. Indeed they were never intended to do so, they are task independent architectures

More complex problem solving framework. The full facilities of a general problem solving system are rarely required for a specific task. Yet blackboard architectures provide such a generality whatever the task being performed. Therefore, systems built within the blackboard framework often possess a more complex problem solving framework than is necessary.

 No exploitation of task specific strategies. There is no explicit support for task specific and domain specific problem solving strategies (for example, the use of useful diagnostic short cuts). Such strategies would have to be implicitly added into the scheduling system of the architecture.

 Unbound nature of the control problem. BB1 faces the potential unbound problem of determining which problem solver to invoke. A great deal of control —problem solving‖ could occur before any real work is begun on solving the problem on the domain blackboard.

 Global database. The blackboard, through which all knowledge sources communicate, by which cooperation is achieved and on which the emerging solution is stored, is actually a global database. It is directly modified by the knowledge sources and assumes that knowledge sources will behave responsibly. If they do not, chaos could ensue. This assumption goes against all the principles of information hiding which have been developed by software engineers to promote well engineered systems.

 Knowledge of problem solving scope. Although individual knowledge sources are aware of the types of situations (problems) they can address, no knowledge of the scope of the system as a whole is maintained. Therefore blackboard systems are unable to easily detect problems on or beyond the periphery of the whole system‘s ability.

 Knowledge acquisition. Although the use of specialist knowledge sources should make it easier to develop problem solving systems, and to encode the appropriate knowledge in them, no support is given to help in the process of obtaining this knowledge in the first place. In addition, each knowledge source can potentially possess its own knowledge representation that may require its own particular techniques not only to obtain but also to codify.

 Implicit representation of management information. Within the scheduler of the Hearsay-II system, problem management information is implicitly represented. This information focuses on the generation of a solution, and determines which knowledge source, from those capable of processing a particular solution, should be invoked next

 Problem solvers defined at system build time. The knowledge sources need to be —connected‖ to the blackboard system at system build time

What is Frame based Expert System

A frame is a data structure with typical knowledge about a particular object or concept. A frame provides a means of organising knowledge in slots to describe various attributes and characteristics of the object.Frames are an application of object-oriented programming for expert systems. The concept of a frame is defined by a collection

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of slots. Each slot describes a particular attribute or operation of the frame. Slots are used to store values. Frame Based Expert System is associated with the objects of interest and reasoning consists of confirming expectations for slot values. Such systems often include rules too. In a framebased system, the inference engine also searches for the goal, or inother terms for the specified attribute, until its value is obtained.In a rule-based expert system, the goal is defined for the rule base. In a frame-based system, rules play an auxiliary role. Frames represent here a major source of knowledge, and both methods and demons are used to add actions to the frames

Explain The terms associated with frame based Expert System

Frame:A data structure with typical knowledge about a particular object
Slot: A component of a frame in a frame-based system that describes a particular attribute of the frame.
Attribute:A datum associated with an entity.

- **Object Oriented Programming**

Class:A composite type which can contain both data and subprograms, and which can participate in inheritance.
object-oriented programming: A style of programming that defines data as objects with attributes and methods that are applied to those objects, and which can be inherited by other objects.
Attribute:A datum associated with an entity.

- **Database**

 Table:A set of data elements that has a horizontal dimension (rows) and a vertical dimension (columns) in a relational database system.
 Row:A group of fields or columns related by a common identifier

When can a demon be triggered?

A demon can be triggered when:
 A new value is added to a slot.
 A value is removed from a slot.
 The value in a slot is replaced by a new value.
 A value is requested from an empty slot (which does not contain a value).

Define the term FRAME

The term "frame" is used to refer both to class-frames, which are abstract templates, and to instance frames, which are concrete analogs of a particular entity.

Define inheritance in Frame-Based Experts

In the context of frames, inheritance refers to:
 The inheritance by a class-frame of the characteristics (slots) of all its superclasses.
 The inheritance by an instance-frame of the characteristics of its class-frame.

What is KEE (Knowledge Engineering Environment)

KEE (Knowledge Engineering Environment) is a frame-based development tool for Expert Systems[1]. KEE was developed and sold by IntelliCorp. It was first released in 1983 and ran on Lisp Machines. KEE was later ported to Lucid Common Lisp with CLX (X11 interface for Common Lisp)

Components of KEE

KEE Knowledge Engineering Environment. Frame-based expert system. Supports dynamic inheritance, multiple inheritance, polymorphism. Classes, meta-classes and objects are all treated alike. A class is an instance of a meta-class. Can control rules for merging of each field when multiple inheritance takes place. Methods are written in LISP. Actions may be triggered when fields are accessed or modified. Extensive GUI integrates with objects. Can easily make object updates to be reflected on display or display selections to update fields. This can in turn trigger other methods or inference rules which may then update other parts of the display. Intellicorp, for TI Explorer.
"The Role of Frame-Based Representation in Reasoning

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What is a shell

A shell (or inference engine) is a complete development environment for building and maintaining knowledge-based applications. It provides a step-by-step methodology, and ideally a user-friendly interface such as a graphical interface, for a knowledge engineer that allows the domain experts themselves to be directly involved in structuring and encoding the knowledge. Examples of shells include Drools, CLIPS, JESS, d3web, G2, eGanges, and OpenKBM (initially developed as a replacement for G2).

What are the generic components of a shell

the knowledge acquisition

A subsystem to help experts in build knowledge bases. However, collecting knowledge, needed to solve problems and build the knowledge base, is the biggest bottleneck in building expert systems.

the knowledge Base

It is a store of factual and heuristic knowledge. Expert system tool provides one or more knowledge representation schemes for expressing knowledge about the application domain. Some tools use both Frames (objects) and IF-THEN rules.

the reasoning engine

Inference mechanisms for manipulating the symbolic information and knowledge in the knowledge base form a line of reasoning in solving a problem

the explanation

Most expert systems have explanation facilities that allow the user to ask questions - why and how it reached some conclusion. The questions are answered by referring to the system goals, the rules being used, and existing problem solving. The rules typically reflect empirical or "compiled" knowledge. They are codes of an expert's rules of thumb, not the expert's deeper understanding.

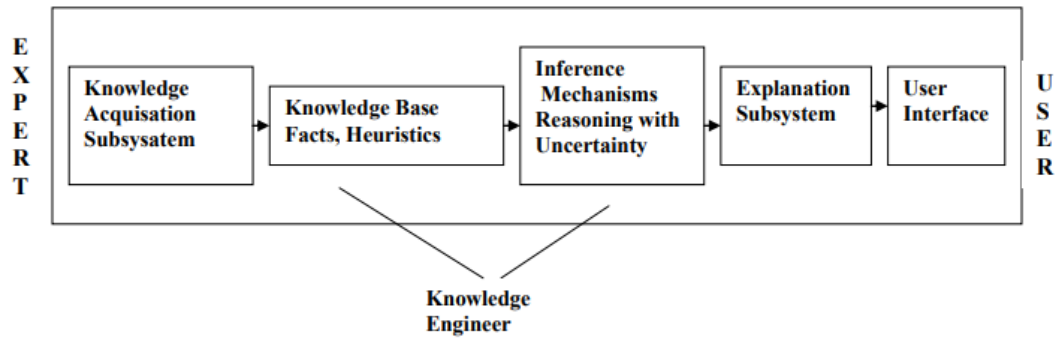
the explanation subsystem

A subsystem that explains the system's actions. The explanation can range from how the final or intermediate solutions were arrived at justifying the need for additional data.

the user interface

A means of communication with the user. The user interface is generally not a part of the expert system technology. It was not given much attention in the past. However, the user interface can make a critical difference in the perceived utility of an Expert system

A diagram of the components of a shell



What are The Components of the Proposed System

- The core system (knowledge base, data base, working memory, and stack mechanism infer- ence appropriate solutions),
- Input / output module,
- Explanatory module,
- Protocol

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 Other components of the system (knowledge base editor, editor of the database module learning outcomes generator module external sources.

What Are The Characteristics Of Fundamental Elements Of The Proposed Expert System

Knowledge Base

Knowledge Base focused on expert knowledge gained. It provides a space for the collection of all knowledge that can be used in the innovation process. Tidd (2007) points out that innovation is closely linked with knowledge. It states that —the issue is to create new opportunities by combining different sets of knowledge

Data Base

Data Base contains all the unique information relating to innovation. It consists of Bank of inventions, the Bank of innovative opportunities and the Bank of innovations. Bank of inventions is the search space, creation, evaluation and storage of inventions that may participate in the next phase in creating an innovation strategy. Invention is new knowledge that results in a change in the structure and level of knowledge and this is a new idea of possible change, respectively new approach

Working memory

Working memory provides space for the solution of the problem. It will include three components: a solution, plan and agenda. Solution provides to the space in working memory, which requires the solution to the problem created. It is about hypothesis, proposed structure and so on. The plan contains a sequence of actions to be taken to solve the problem. The plan may, for example a sequence of such steps: design the scheme-specifc variants of innovation strategy and then optimize.

Input-Output Module

The main task of I / O module is to create an interface between knowledge-based system and its surroundings, which is represented by end-users. These are the senior managers and staff involved in the process of creating an innovation strategy. Other end users are business marketers who use the knowledge gained in the evaluation of inventions and innovative opportunities in the implementation analysis to create an innovation strategy

Explanatory module

The basic module is a function of clarifying clarifcation, explanation and justifcation of the decision, which is the output of an expert system. Managers and marketers obtain the necessary justifcation for the fnal solution in the form of the chosen innovation strategy. Explana- tory module offers managers and marketers the opportunity to browse the knowledge base, view and modify working memory. They get invaluable help when debugging a knowledge base to guide the course of the solution.

Inference mechanism

It is allows fnding the required knowledge in knowledge base, data base and using them to develop innovative strategies. It can derive from these bases for further information and knowledge. Its work is based on a knowledge base and data base on which infuences the choice available to operators, limiting the number of tested solutions proposed generator and controls compliance testing solutions generated with the actual data. One of the important outcomes of inference mechanism is tray of appropriate solutions.

List the other important component of an expert system

 Editor of knowledge base
 Editor of data base,
 Module of learning,
 Generator of results
 Module of external sources

What Are The Conditions For Successful Work Of The Proposed Expert System

 Effcient data acquisition
 Implementation of quality input / output module
 A detailed and careful analysis of the enterprise environment.

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Within the context of expert systems, the precise roles of the following are:

- **Domain expert**
- **System engineer**
- **User**
- **Knowledge engineer**

 Domain expert : The individuals who currently are experts in solving the problems; the system is intended to solve

 Knowledge engineer : The individual who encodes the expert's knowledge in a declarative form that can be used by the expert system;

 User : The individual who will be consulting with the system to get advice which would have been provided by the expert.

 System engineer - the individual who builds the user interface, designs the declarative format of the knowledge base, and implements the inference engine.

Outline three (3) main ways in which expert systems can assign confidence values.

 Can deliver quantitative information

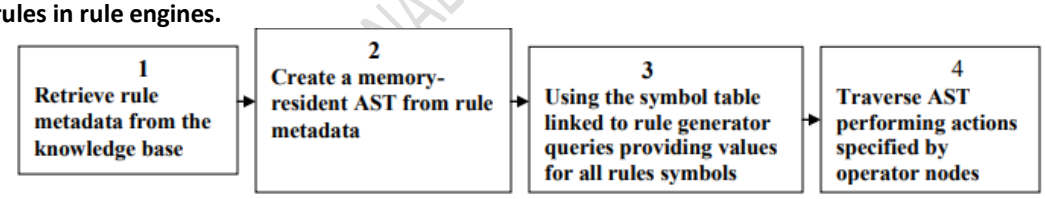
 Can interpret qualitatively derived values

 Can address imprecise and incomplete data through assignment of confidence values

Typically special programming languages are employed in the development of expert systems. Write down five (5) unique features of these programming languages.

• Efficient mix of integer and real variables
• Good memory-management procedures
• Extensive data-manipulation routines
• Incremental compilation
• Tagged memory architecture
• Optimization of the systems environment
• Efficient search procedures

With the aid of a well-labelled diagram, outline the key phases required to implement knowledge-base rules in rule engines.



List seven (7) classic application areas of expert systems in the agricultural sector.

Irrigation and Pest Control
Crop Variety Selection and Management
Soil Characterization and Utilization for Specific Areas
Fertilizer, Climate and Soil Interaction and Analysis
Salmon Stocking Rates and Species Selection
Forest Inventory
Weed Identification,

The quality and effectiveness of speech produced by text-to-speech systems is measured by utilising a number of characteristics. State any three (3) of these characteristics.

 Base-level achievement of speech that is intelligible (the ease with which the output is understood) to humans;

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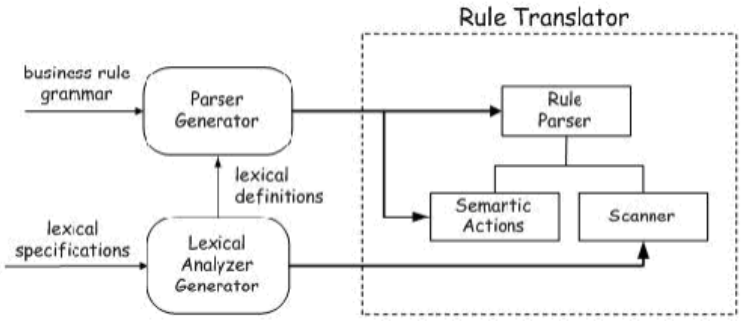
- produce speech that is as natural as that of human beings in other words how natural the speech is;
- produce speech that is personalised to a particular user, in other words it has the same intonation as a person‟s speech; and
- the final level and highest level of achievement is to produce speech based on a person‟s own voice recordings so that the speech sounds as if it belongs to that person

Outline the processes involved in automatically generating a rule translator from lexical specifications and the rule grammar.

The rules composed by subject matter experts must be translated and stored in the Knowledgebase before they can be executed. Rules are transformed into machine-readable forms by the Rule Translator. The Rule Translator is generated automatically from lexical specifications and from the rule grammar. Lexical specifications define the lexical units (e.g., reserved words, numerical values, operators, etc) of the expert systems rule language. The rule grammar defines the syntax and semantics of the language



Give a concise description of the natural language interface.

A Natural language Interface(NLI) is defined as an interface that has the ability to interact with users using human language such as English, as opposed to computer language, a command line interface, or a graphical user interface. The interface takes as input either written text or spoken speech. These types of input may be utilised individually or in a combination to produce a multimodal input interface. NLIs are usually only capable of understanding a restricted subset of a human language (usually restricted to a certain domain) and generate more or less pre-packaged responses

you were invited to an international conference to present a paper on expert systems, if at the end of your presentation, a co-presenter were to ask you to enlighten participants on the demerits of expert systems. Mention and briefly describe any four (4) demerits of expert systems you would focus on.

- **Common sense**- In addition to a great deal of technical knowledge, human experts have commonsense. It is not yet known how to give expert systems common sense
- **Creativity**- Human experts can respond creatively to unusual situations, expert systems cannot.
- **-learning**- Human experts automatically adapt to changing environments; expert systems must explicitly updated.
- -sensory experience- Human experts have available to them a wide range of sensory experience; expert systems are currently dependent on symbolic input

A common technique that could be employed in averting ambiguity while using the natural Language interface is to limit the syntax and vocabulary that exists in a natural language. An additional technique that could be used is to apply certain linguistic theories, which outline definite rules that should be adopted while conversing. Write down three (3) of such rules.

- **users should not give more information than necessary;**
- **users should not make unnecessary speech contributions than is necessary; and**

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□ users should not intentionally make ambiguous references but rather use references that they believe will unambiguously describe exactly what they what want to achieve.

Give a concise explanation of the following:

- **Class**
- **Frame**
- **Slot**
- **Member**

Class: A composite type which can contain both data and subprograms, and which can participate in inheritance.
Frame:A data structure with typical knowledge about a particular object.
Slot: A component of a frame in a frame-based system that describes a particular attribute of the frame
Member:A data value (attribute) or function (method) contained in a class or structure.

Write down seven (7) common application areas of expert systems in the accounting and financial sector.
Accounting & Finance
Agricultural
Business
Chemical
Construction
Education – Training
Engineering - Industrial -

A common trend in the field of commerce and research is the employment of expert systems. Briefly describe how expert systems can be employed in the following fields:

i. **Teaching**
ii. **Cloning**
iii. **Treating cancer patients**
iv. **Devising attack strategies**

- ONCOCIN assists physicians in managing complex drug regimens for treating cancer patients.
- Genesis assists scientists in planning cloning experiments
- Guidon is an education expert that teaches students by correcting answers to technical questions.
- TATR is used by the Air Force in planning attacks on enemy air bases.

What is the best way of ascertaining if an expert system is well-received?

The best way to ascertain that the expert system is well-received is to design a rule language that is easy for users to learn and easy to use. The language must meet the needs of the subject matter expert.

Give three reasons to supportthe best way of ascertaining if an expert system is well-received?
- language must meet the needs of the subject matter expert.
- Subject matter experts need a language that mimics the way they speak, think, and operate
- Its lexical elements and syntax rules must make the resulting language appear as natural (i.e., similar to the spoken language) as possible

Describe the concept of expert system within the context of a 'knowledge tool'.

An Expert System is a knowledge tool which uses rules and a process to guide the system user to specific information or knowledge which is indicated for the inquiry at hand.

A common expert system scheme that has found application in various spheres of life is the blackboard approach. Write down eight (7) specific areas where they have been applied.
Accounting & Finance
Agricultural

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Business
Chemical
Construction
Education – Training
Engineering - Industrial -

List and describe the generic components of a shell within the context of expert systems.

Knowledge Base
It is a store of factual and heuristic knowledge. Expert system tool provides one or more knowledge representation schemes for expressing knowledge about the application domain. Some tools use both Frames (objects) and IF-THEN rules.

Reasoning Engine
Inference mechanisms for manipulating the symbolic information and knowledge in the knowledge base form a line of reasoning in solving a problem.

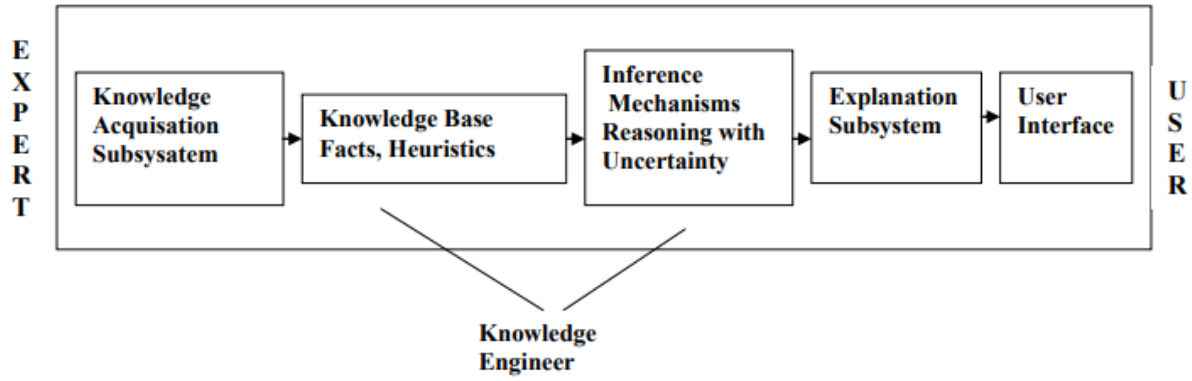
Knowledge Acquisition subsystem
A subsystem to help experts in build knowledge bases. However, collecting knowledge, needed to solve problems and build the knowledge base, is the biggest bottleneck in building expert systems.

Explanation subsystem
A subsystem that explains the system's actions. The explanation can range from how the final or intermediate solutions were arrived at justifying the need for additional data.

User Interface
A means of communication with the user. The user interface is generally not a part of the expert system technology. It was not given much attention in the past.

Explanation
Most expert systems have explanation facilities that allow the user to ask questions - why and how it reached some conclusion. The questions are answered by referring to the system goals, the rules being used, and existing problem solving.

Illustrate the generic components of a shell with the aid of a well-labelled diagram.



In spite of its numerous advantages, expert systems are said to have a number of drawbacks. State any three of these drawbacks.

Common sense-In addition to a great deal of technical knowledge, human experts have commonsense. It is not yet known how to give expert systems common sense.

Creativity-Human experts can respond creatively to unusual situations, expert systems cannot.

Learning-Human experts automatically adapt to changing environments; expert systems must explicitly updated. Case-based reasoning and neural networks are methods that can incorporate learning

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Explanation Facility is critical for identifying the roles of key words employed in expert systems. Based on this principle, state the main function of each of the following:

- **TRACE**
- **WHY**
- **HOW**
- **WHAT-IF-**

TRACE
displays all rules that are tried.
WHY
the program asks the user a particular question?
HOW
was a particular conclusion reached?
WHAT-IF-
explains what will happen if a certain value or rule is changed

Give a concise description of the following terms within the context of expert systems:

- **Grammar**
- **Shell**
- **Natural Language Interface**

Grammar
The grammar defines both the syntax and the semantics of the language. The grammar defines the structure of a rule.
Shell
A shell (or inference engine) is a complete development environment for building and maintaining knowledge-based applications. It provides a step-by-step methodology, and ideally a user-friendly interface such as a graphical interface, for a knowledge engineer that allows the domain experts themselves to be directly involved in structuring and encoding the knowledge.
Natural Language Interface
A Natural language Interface(NLI) is defined as an interface that has the ability to interact with users using human language such as English, as opposed to computer language, a command line interface, or a graphical user interface

The blackboard is often expressed as a global structure that is available to all Knowledge Sources. Give three reasons for this expression.

• a community memory of raw input data; partial solutions, alternatives, and final solutions; and control information
• a communication medium and buffer
• a KS trigger mechanism

State the distinction between the forward chaining and the backward chaining.

- **Forward Chaining**

 The forward chaining inference engine takes rule, and if its conditions are true, adds its conclusion to working memory, until no more rules can be applied;
 i.e.
if the conditions of the rule _if A and B
then C' are true,
then C is added to working memory.
 In forward chaining the system simply test the rules in the order that occurs, therefore rule order is important.

Backward Chaining
 The backward chaining inference engines tries to prove a goal by establishing the truth of its conditions;

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 i.e.
the rule _if A and B then C',
the backward chaining engine will try to prove C by first proving A and then proving B.

Write down the four (4) conditions that trigger daemons in expert systems.
 A new value is added to a slot.
 A value is removed from a slot.
 The value in a slot is replaced by a new value.
 A value is requested from an empty slot (which does not contain a value).

Distinguish between the shallow and the deep knowledge in expert systems
 shallow knowledge (experience) consists of all the peculiar heuristics and shortcuts e.g.
IF it rains
THEN the vegetables will grow faster
 deep knowledge (theoretical) first principles, axioms, laws e.g.
IF it rains
THEN the vegetables will grow faster
BECAUSE the soil will become more moist

Within the context of Expert Systems, discuss the natural language interface.
A Natural language Interface(NLI) is defined as an interface that has the ability to interact with users using human language such as English, as opposed to computer language, a command line interface, or a graphical user interface. The interface takes as input either written text or spoken speech. These types of input may be utilised individually or in a combination to produce a multimodal input interface. NLIs are usually only capable of understanding a restricted subset of a human language (usually restricted to a certain domain) and generate more or less pre-packaged responses

State three (3) classic 'Rule Actions' in expert systems.
 Assignment of values to an object (e.g., a row in a database table);
 Display of information (in reports or on screen) retrieved using ad-hoc queries specified in the rule; and
 Dispatch of built-in functions.

State the key role of the working memory in a proposed system.
Working memory provides space for the solution of the problem. It will include three components: a solution, plan and agenda. Solution provides to the space in working memory, which requires the solution to the problem created. It is about hypothesis, proposed structure and so on. The plan contains a sequence of actions to be taken to solve the problem

Typically, in expert systems, goals are often established in a frame based system either as method or daemon. State the main distinction between these two approaches of establishing frame based system.
 A demon has an IF-THEN structure. It is executed whenever an attribute in the demon's IF statement changes its value. In this sense, demons and methods are very similar, and the two terms are often used as synonyms.
 However, methods are more appropriate if we need to write complex procedures. Demons, on the other hand, are usually limited to IF-THEN statements.

Give a short description of the concept of slot with respect to a frame based system.
The concept of a frame is defined by a collection of slots. Each slot describes a particular attribute or operation of the frame. Slots are used to store values. A slot may contain a default value or a pointer to another frame, a set of rules or procedure by which the slot value is obtained.

Write down four (4) common incidences in which demons are triggered in expert systems.

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- A new value is added to a slot.
- A value is removed from a slot.
- The value in a slot is replaced by a new value.
- A value is requested from an empty slot (which does not contain a value).

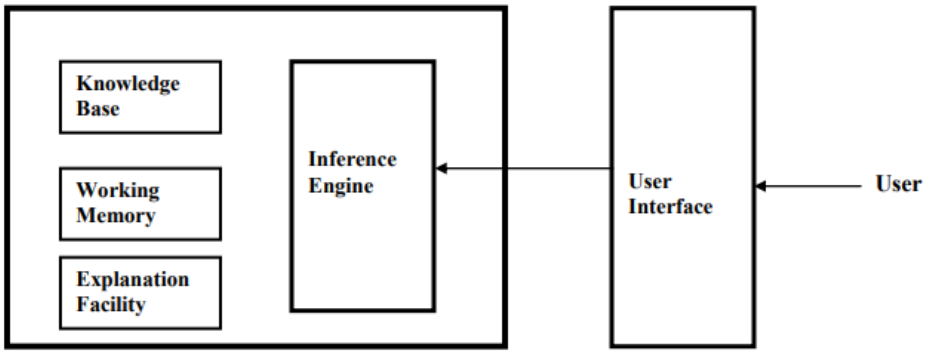
Name and state the key roles of individuals who interact with expert system.

- **Domain expert** : The individuals who currently are experts in solving the problems; the system is intended to solve
- **Knowledge engineer** : The individual who encodes the expert's knowledge in a declarative form that can be used by the expert system;
- **User** : The individual who will be consulting with the system to get advice which would have been provided by the expert.
- **System engineer** - the individual who builds the user interface, designs the declarative format of the knowledge base, and implements the inference engine.

Write a short note on the procedural language.

Procedural languages include C++ and Java. They are relatively general purpose languages that can be used in many different programming situations, e.g Expert System, Microsoft Windows program and company specific applications. They are organized as a set of procedures, very similar to the way that a chapter in a book is divided into a series of paragraphs. While they offer no specific support for the development of expert system, they do offer the ultimate in flexibility. As such languages such as these can be used to develop systems where other tools may be inadequate. Expert systems are typically written in special programming languages

With the aid of a well labeled diagram explains the components of an Expert System.



Identify and state five (5) drawbacks of the blackboard architecture.

- No communications language. The blackboard acts as a very general communications facility. However, the communications language is the language of the hypotheses. That is, if all communications have to go via the blackboard then not only does the blackboard access mediate each decision step, it also constrains the representation of the information to be exchanged

-- Computational complexity of cooperation. The problem of determining which knowledge sources are appropriate in each situation and which of these appropriate knowledge sources should be activated has to be solved each time a decision has to be made

- No guidance for task. Blackboard architectures do not give any guidance to a system builder on how to solve a particular problem or perform a particular task within their framework. That is, blackboard architectures do not give any support for determining how specific problems should be addressed

- Unbound nature of the control problem. BB1 faces the potential unbound problem of determining which problem solver to invoke. A great deal of control —problem solving‖ could occur before any real work is begun on solving the problem on the domain blackboard

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- Knowledge of problem solving scope. Although individual knowledge sources are aware of the types of situations (problems) they can address, no knowledge of the scope of the system as a whole is maintained. Therefore blackboard systems are unable to easily detect problems on or beyond the periphery of the whole system's ability.

Mention and analyse any five (5) characteristics of an expert system.

■ Operates as an interactive system

This means an expert system :

 Responds to questions

 Asks for clarifications

 Makes recommendations

 Aids the decision-making process.

■ Tools have ability to sift (filter) knowledge

 Storage and retrieval of knowledge

 Mechanisms to expand and update knowledge base on a continuing basis.

■ Make logical inferences based on knowledge stored

 Simple reasoning mechanisms is used

 Knowledge base must have means of exploiting the knowledge stored, else it is useless; e.g., learning all the words in a language, without knowing how to combine those words to form a meaningful sentence.

■ Ability to Explain Reasoning

 Remembers logical chain of reasoning; therefore user may ask

1. for explanation of a recommendation
2. factors considered in recommendation

Enhances user confidence in recommendation and acceptance of expert system

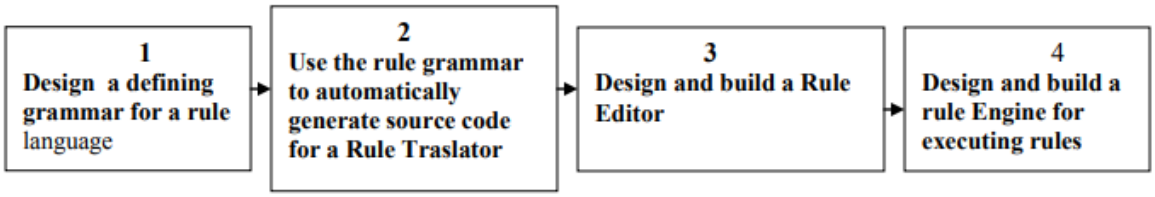
■ Capability to assign Confidence Values

 Can deliver quantitative information

 Can interpret qualitatively derived values

 Can address imprecise and incomplete data through assignment of confidence values.

With the aid of a well labeled diagram, illustrate the steps involved in developing an expert system.



Discuss five (5) merits of the blackboard architecture.

Flexibility of configuration. The knowledge sources within a blackboard system are not tied together in a fixed or rigidly applied manner. Instead they communicate and cooperate via the common blackboard. This means that any knowledge sources can be added to the system without having to specify its existence in any other knowledge source

Flexible problem solving. A blackboard architecture is independent of any particular task and can therefore be used as the basis of very different applications, from route planning, to image processing, speech recognition and diagnosis. Cooperation is driven by the current state of the problem, rather then through any particular control strategy, and control of this cooperation is distributed between the knowledge sources themselves.

- Selection of knowledge sources. Because more than one knowledge source may be able to perform the same function, the scheduler can select that problem solver which will provide the most benefit to the emerging solution. This can improve both problem solving efficiency and the quality of the eventual solution

- Multiple problem solvers. The blackboard architecture promotes the integration and multiple problem solving modules (knowledge sources). Each of these knowledge sources can potentially have its own representation and

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inference mechanism. This means that the twin advantages of multiple reasoning systems are maintained, namely: resilient behaviour and efficient behavior

- Management of multiple levels of abstraction. The blackboard architecture explicitly supports the management of multiple levels of abstraction. Not only can the blackboard be divided hierarchically, but the knowledge sources can reflect this hierarchy. Problems of moving between the levels of the hierarchy can be overcome by providing knowledge sources whose sole task is to move information between two particular abstraction levels.

Mycin is an expert system comprised of two major components. Identify and give a brief explanation of these components.

- **knowledge base**

1. A knowledge base which stores the information the expert system "knows", much of which is derived from other information in the knowledge base.

- **inference engine**

2. An inference engine to derive knowledge from the presently known knowledge in the knowledge base.

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