ARTIFICIAL INTELLIGENCE
Unit-5

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UNIT-5

Natural language processing:

Introduction, sentence analysis phases, types of parsers, semantic analysis

Expert system:

Introduction, Phases in building Expert systems, Expert systems architecture, Expert systems vs Traditional systems, Rule based expert systems, Applications of expert systems, List of shells and tools

INTRODUCTION

- NLP is a component of Artificial Intelligence
- NLP focuses on the communication between humans and computers
- The goal of NLP is to enable computers to understand and interpret human language in a way that is similar to how humans process language
- It is a driving force behind things like virtual assistants, speech recognition, sentiment analysis, automatic text summarization, machine translation and much more
- Just as humans have different sensors, such as ears to hear and eyes to see computers have programs to read and microphones to collect audio

PHASES OF NLP

1. DATA PREPROCESSING
2. ALGORITHM DEVELOPMENT

1. DATA PREPROCESSING

Data Preprocessing : Data preprocessing involves preparing and "cleaning" text data for machines to be able to analyze it.. There are several ways this can be done, including:

- **Lower case**: Making all the text lower case is one of the simplest and most effective forms of text preprocessing

Raw	Lowercased
Canada CanadA CANADA	canada
TOMCAT Tomcat toMcat	tomcat

1. DATA PREPROCESSING (Cont..)

- **Tokenization:** Text is broken down into smaller units

sentence:

a touching movie it is full of emotions and wonderful acting

['a', 'touching', 'movie', 'it', 'is', 'full', 'of', 'emotions', 'and', 'wonderful', 'acting']

- **Stop word:** Common words are removed from text. Words like ‘the’, ‘is’, ‘a’ have less value and add noise to the text data.

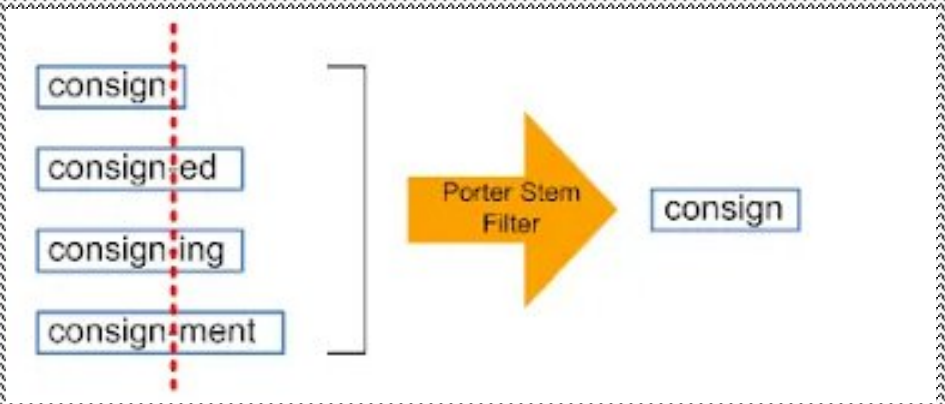
statement:

" a touching movie it is full of emotions and wonderful acting i could have sat through it a second time."

['touching', 'movie', 'full', 'emotions', 'wonderful', 'acting', 'could', 'sat', 'second', 'time']

1. DATA PREPROCESSING (Cont..)

- **Stemming:** Stemming is the process of reducing a word to its stem/root word

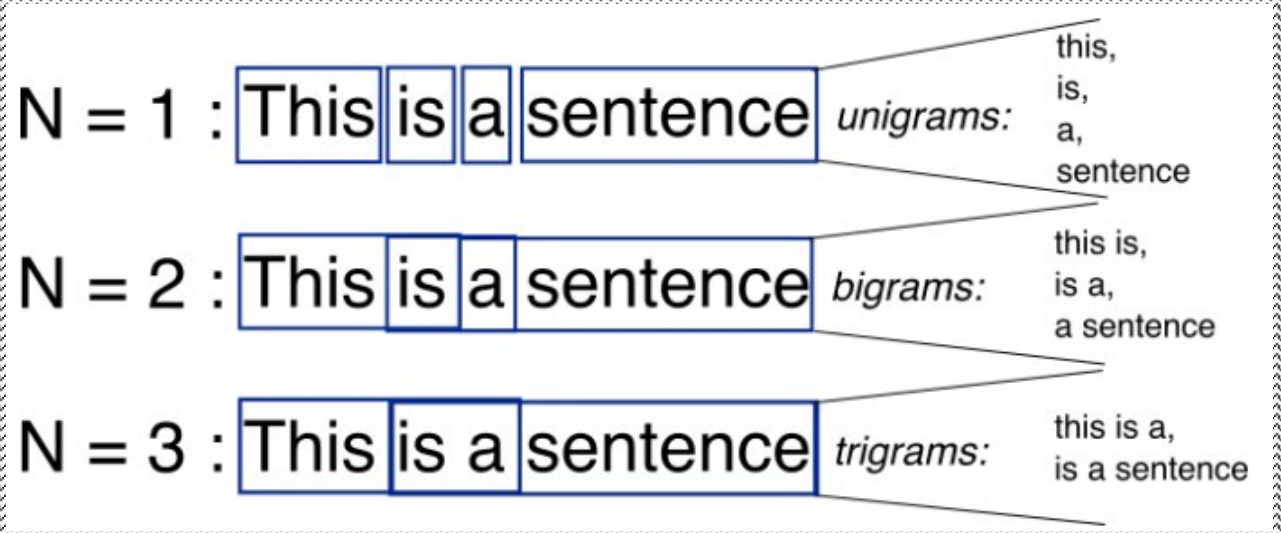


" a touching movie it is full of emotions and wonderful acting i could have sat through it a second time."

['touch', 'movi', 'full', 'emot', 'wonder', 'act', 'could', 'sat', 'second', 'time']

1. DATA PREPROCESSING (Cont..)

- **Lemmatization**: It does the same thing as stemming, converting a word to its root form but with one difference. For example, the word "caring" would map to 'care' and not 'car' in case of stemming.
- **N-Grams**: These are the combination of multiple words used together.



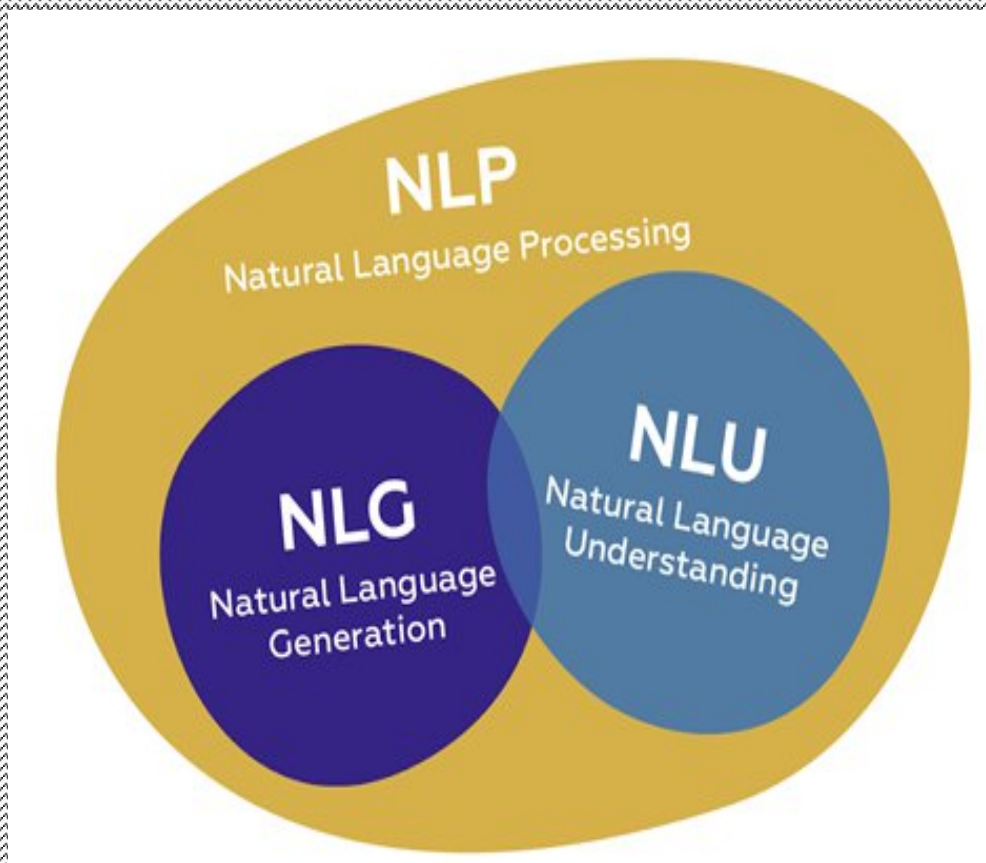
2. Algorithm Development:

- Rule Based System
- Machine learning based system

Components of NLP

NLP is divided into two components.

- Natural Language Understanding
- Natural Language Generation



Natural Language Understanding (NLU):-

- Natural Language Understanding (NLU) helps the machine to understand and analyze human language by extracting the text from large data such as keywords, emotions, relations, and semantics, etc.

Let’s see what challenges are faced by a machine-

For Example:-

- *He is looking for a match.*

What do you understand by the ‘match’ keyword? Does it partner or cricket or football or anything else?

This is **Lexical Ambiguity**. It happens when a word has different meanings. Lexical ambiguity can be resolved by using parts-of-speech (POS)tagging techniques.

- *The Fish is ready to eat.*

What do you understand by the above example? Is the fish ready to eat his/her food or fish is ready for someone to eat? Got confused!! Right? We will see it practically below.

This is ***Syntactical Ambiguity*** which means when we see more meanings in a sequence of words

Natural Language Generation (NLG):-

- It is the process of extracting meaningful insights as phrases and sentences in the form of natural language.

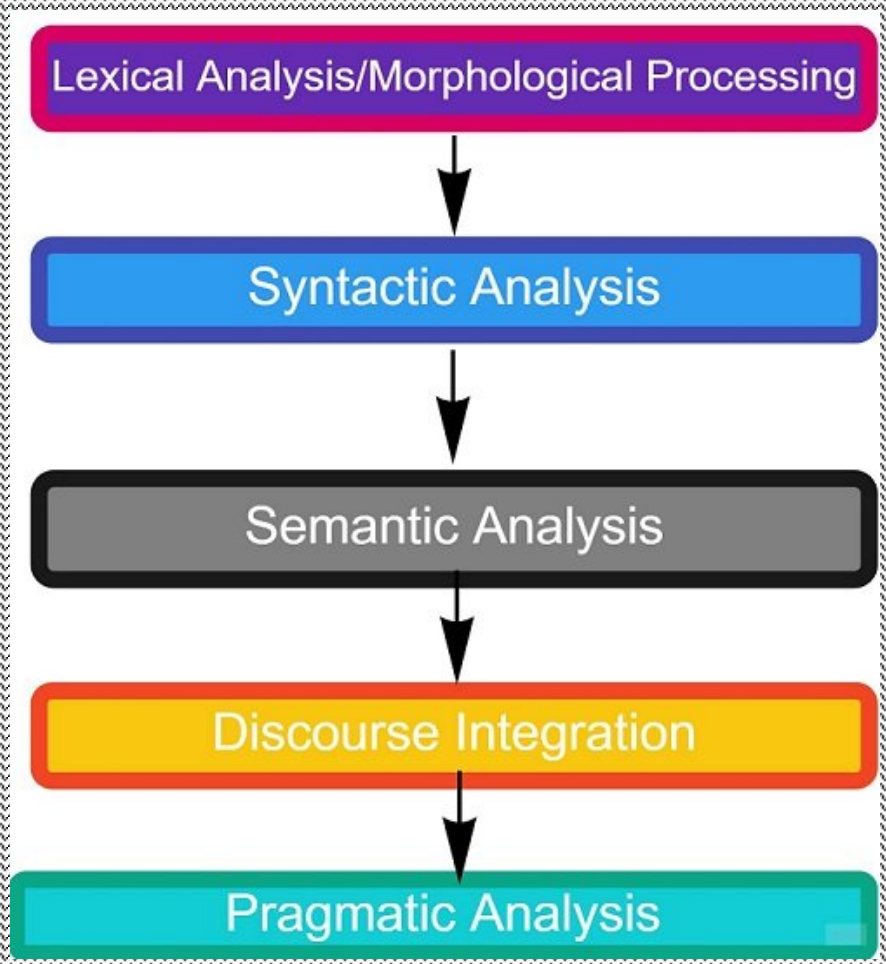
It consists −

- Text planning − It includes retrieving the relevant data from the domain.
- Sentence planning − It is nothing but a selection of important words, meaningful phrases, or sentences.

SENTENCE ANALYSIS PHASE

Top 5 Natural Language Processing Phases

- Lexical Analysis.
- Syntactic Analysis.
- Semantic Analysis.
- Discourse Analysis.
- Pragmatic Analysis.



1. Lexical analysis

- It involves identifying and analyzing the structure of words. Lexicon of a language means the collection of words and phrases in that particular language.
- The lexical analysis divides the text into paragraphs, sentences, and words. So we need to perform Lexicon Normalization.

The most common lexicon normalization techniques are Stemming:

- **Stemming**: Stemming is the process of reducing derived words to their word stem, base, or root form
- **Lemmatization**: Lemmatization is the process of reducing a group of words into their lemma or dictionary form. It takes into account things like POS, the meaning of the word in the sentence, the meaning of the word in the nearby sentences, etc. before reducing the word to its lemma.

2. Syntactic analysis

- Syntactic Analysis is used to check grammar, arrangements of words, and the interrelationship between the words.

Example:

Mumbai goes to the Sara

Here “Mumbai goes to Sara”, which does not make any sense, so this sentence is rejected by the Syntactic analyzer.

Syntactical parsing involves the analysis of words in the sentence for grammar. Dependency Grammar and Part of Speech (POS)tags are the important attributes of text syntactic.

3. Semantic Analysis

- Semantic analysis concerned with the meaning representations
- It is mainly focuses on the literal meaning of words, phrases and sentences
- Consider the sentence: “ The apple ate a banana”. Although the sentence is syntactically correct
- It doesn’t make any sense because apples can’t eat.

4. Discourse Integration

- In this phase, the impact of the sentences before a particular sentence and the effect of the current sentence on the upcoming sentences is determined.
- It deals with the effect of a previous sentence on the sentence in consideration
- In the text, “ Jack is bright student. He spends most of the time in the library”.
- Here discourse assigns “he” to refer to “Jack”.

5. Pragmatic Analysis

- It is a last phase of NLP
- It helps you to discover the intended effect by applying a set of rules that characterize cooperative dialogues.
- For example: “Open the door” is interpreted as a request instead of an order.

TYPES OF PARSES

- A parser in NLP uses the grammar rules to verify if the input text is valid or not syntactically.
- The parser helps us to get the meaning of the provided text (like the dictionary meaning of provided text).
- As the parser helps us to analyze the syntax error in the text; so the parsing process is also known as the syntax analysis or the Syntactic analysis.

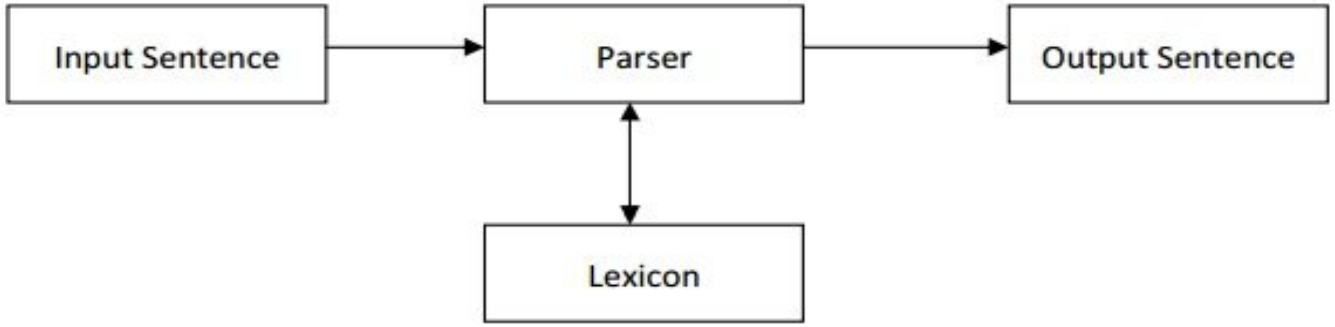
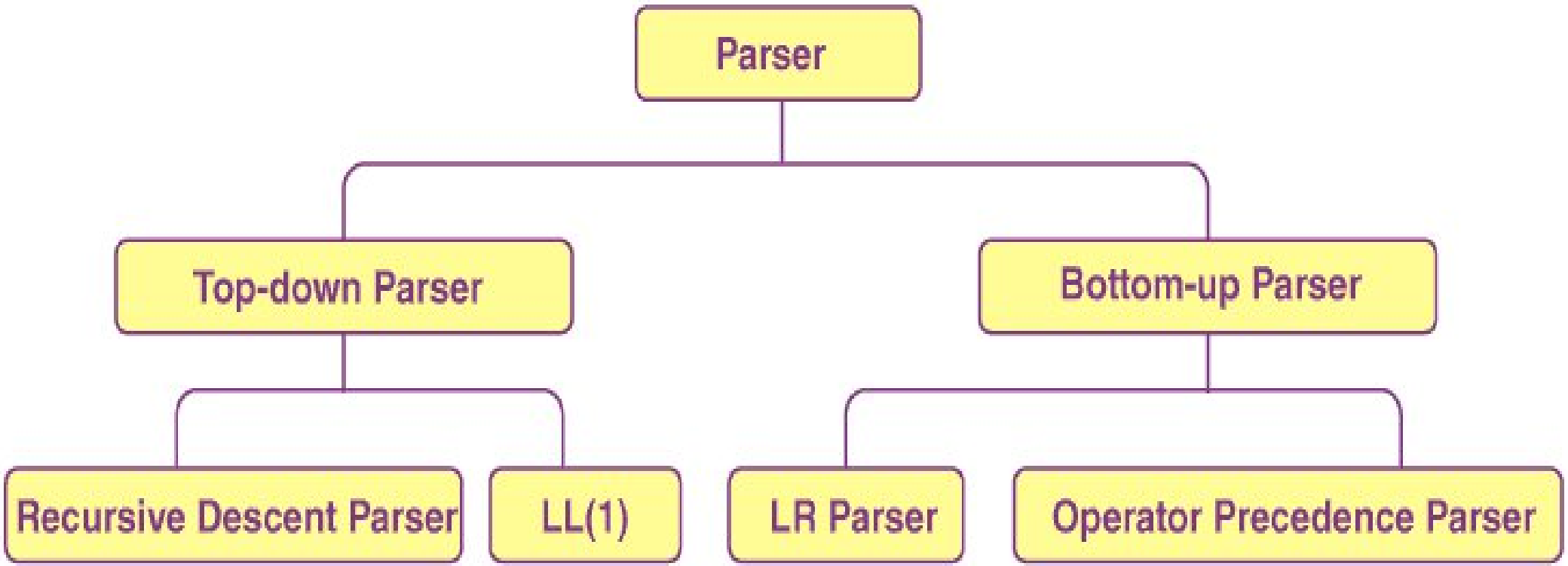


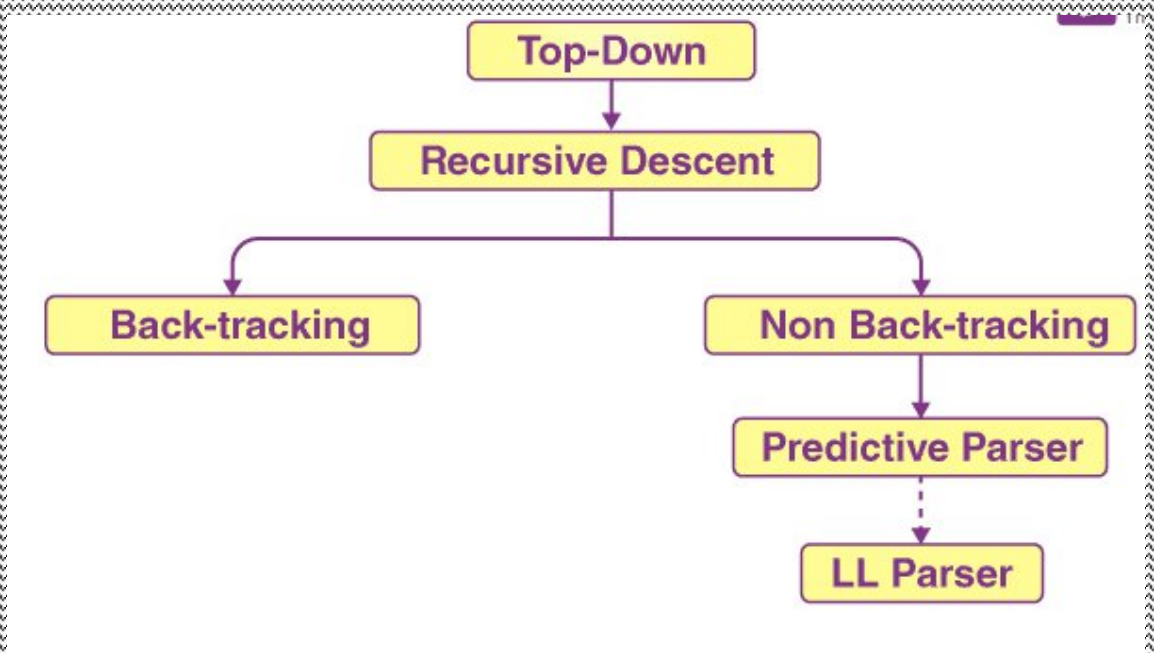
Figure Parsing Technique

Types of Parsers



TOP-DOWN PARSING:

- It is the process of construction the parse tree starting at the root and proceeds towards the leaves.
- In top down parsing words of the sentence are replaced by their categories like verb phrase (VP), Noun phrase (NP), Preposition phrase (PP), Pronoun (PRO) etc.



TOP-DOWN PARSING (cont..)

- **Recursive Descent Parsing:**
  a. This technique follows the process for every terminal and non-terminal entity.
  b. It reads the input from left to right and constructs the parse tree from right to left.
  c. As the technique works recursively, it is called recursive descent parsing.
- **Back-tracking:** The parsing technique that starts from the initial pointer, the root node. If the derivation fails, then it restarts the process with different rules.

Example

Let us consider a sentence “Rahul is eating an apple”

Symbolic representation:

S ->	NP		VP			
->	N		VP			[NP = N]
->	N	AUX	VP			[VP = AUX VP]
->	N	AUX	V	NP		[VP = V NP]
->	N	AUX	V	ART	N	[NP = ART N]
->	Rahul	AUX	V	ART	N	
->	Rahul	is	V	ART	N	
->	Rahul	is	eating	ART	N	
->	Rahul	is	eating	an	N	
->	Rahul	is	eating	an	apple	

Rahul - Noun
Is - Auxiliary word
Eating - verb
An - article
Apple - Noun

NP = NOUN PHRASE
AUX = AUXILIARY
VP = VERB PHRASE
V = VERB
ART = ARTICLE
N = NOUN

Example

Graphical Representation

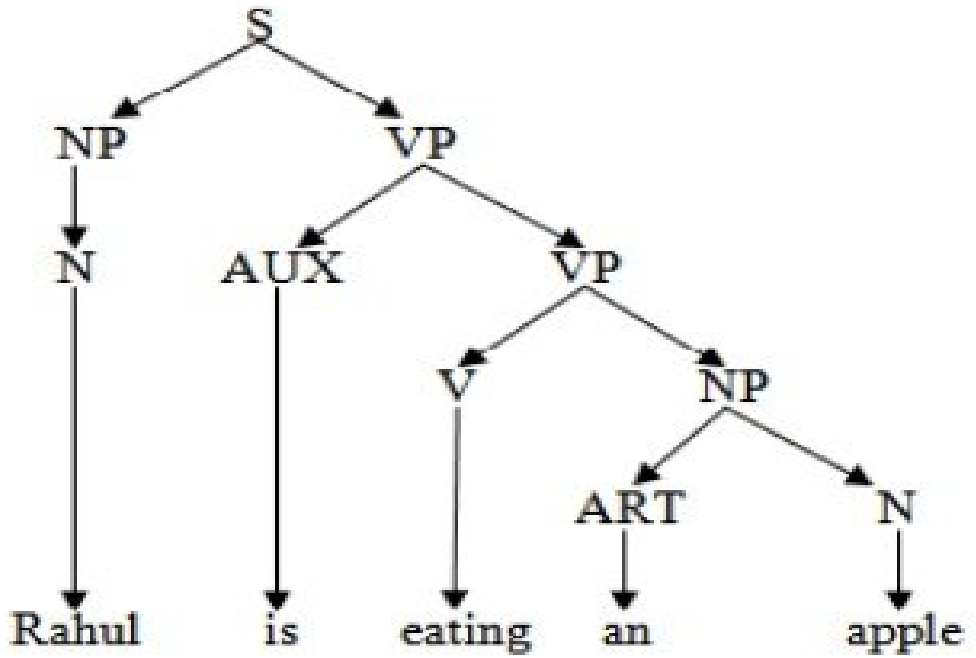


Figure Example of Top down Parsing

Example 2: The small tree shades the new house by the stream.

Symbolical Representation

Ṣ□NP VP

□ ART NP VP

□ The ADJ N VP

□ The small N V NP

□ The small tree V ART NP

□ The small tree shades ART ADJ NP

□ The small tree shades the ADJ N NP

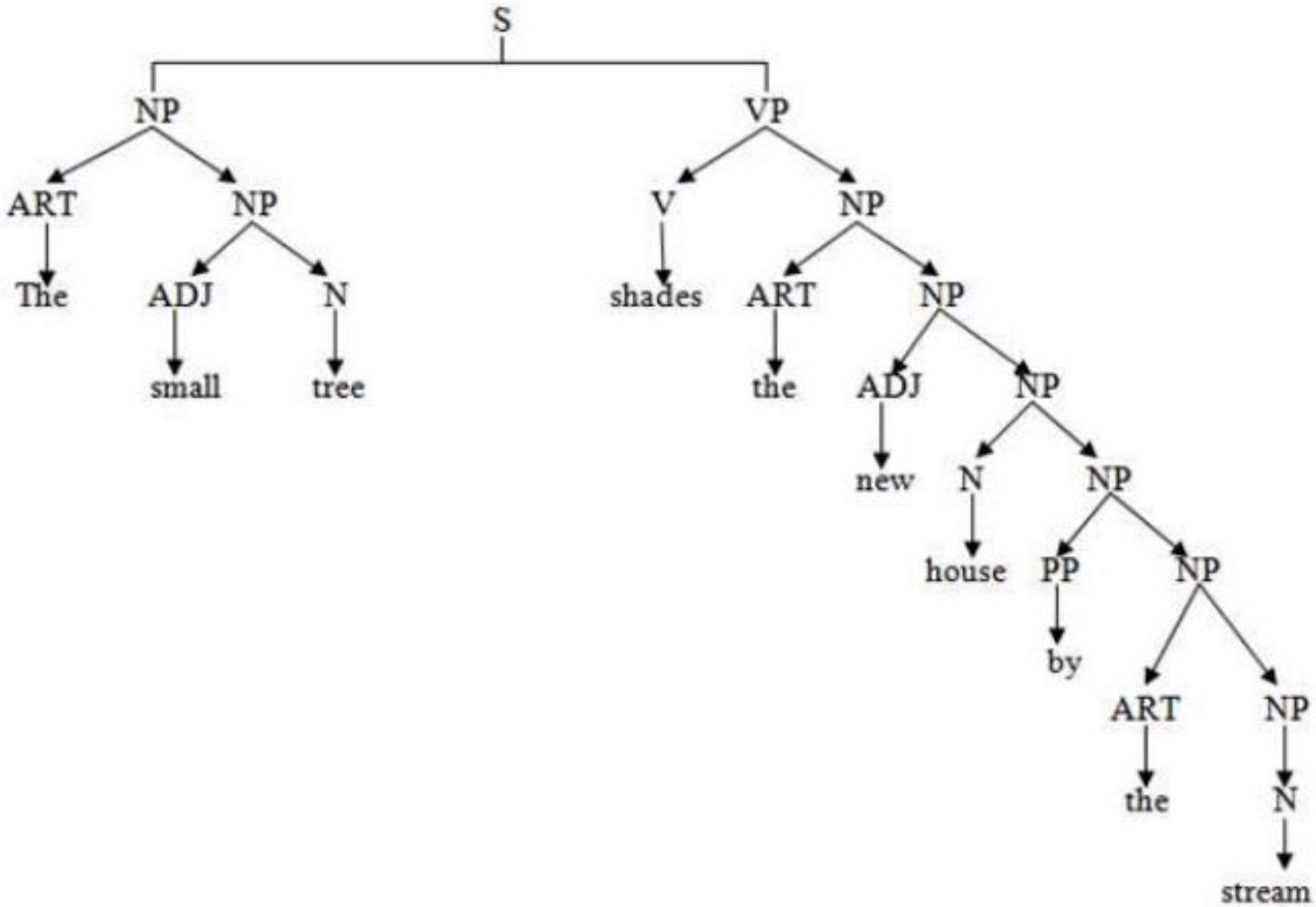
□ The small tree shades the new N PREP N

□ The small tree shades the new house PREP ART N

□ The small tree shades the new house by ART N

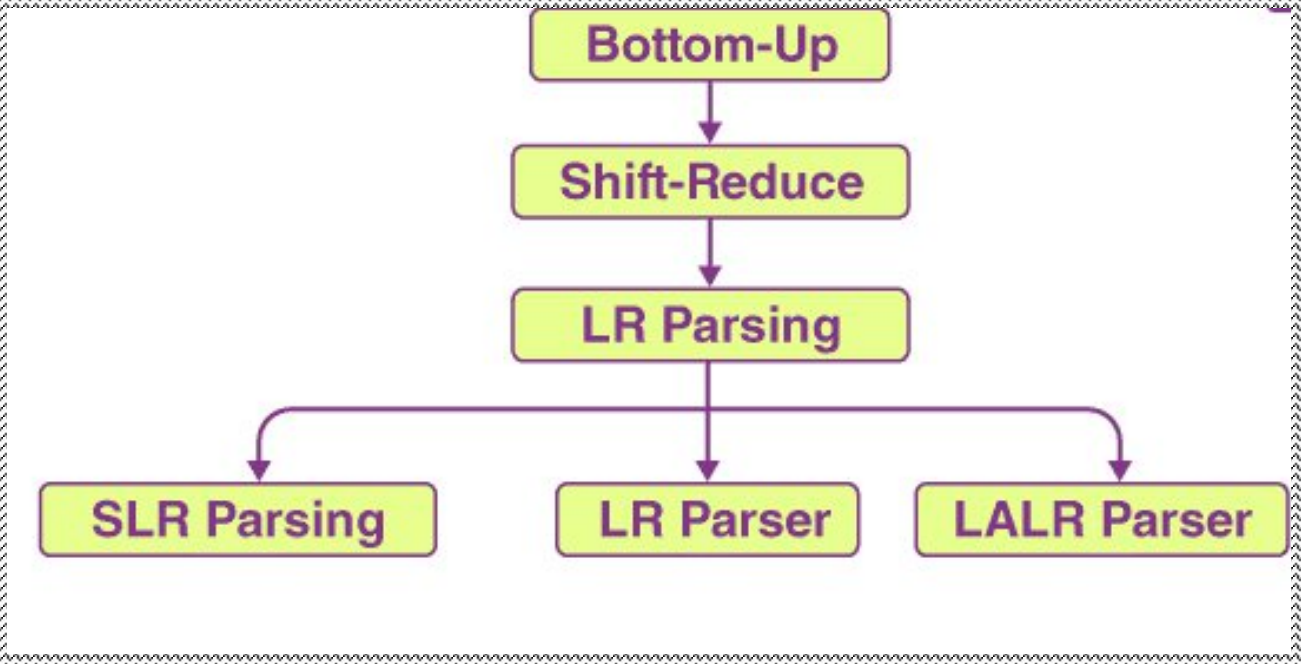
□ The small tree shades the new house by the N

Graphical Representation



BOTTOM-UP PARSING:

- In this parsing technique the process begins with the sentence and the words of the sentence is replaced by their relevant symbols.
- In bottom up parsing the construction of parse tree starts at the leaves and proceeds towards the root.



BOTTOM-UP PARSING:

- **Shift-Reduce Parsing**: Shift-reduce parsing works on two steps: Shift step and Reduce step.
  - **Shift step:** The shift step indicates the increment of the input pointer to the next input symbol that is shifted.
  - **Reduce Step:** When the parser has a complete grammar rule on the right-hand side and replaces it with RHS.
- **LR Parsing:** It is a syntax analysis techniques as it works with context-free grammar. In LR parsing L stands for the left to right tracing, and R stands for the right to left tracing.

Example

Example-1: Rahul is eating an apple.

□ is eating an apple.

□N AUX eating an apple.

□N AUX V an apple.

□N AUX V ART apple.

□N AUX V ART N

□N AUX V NP

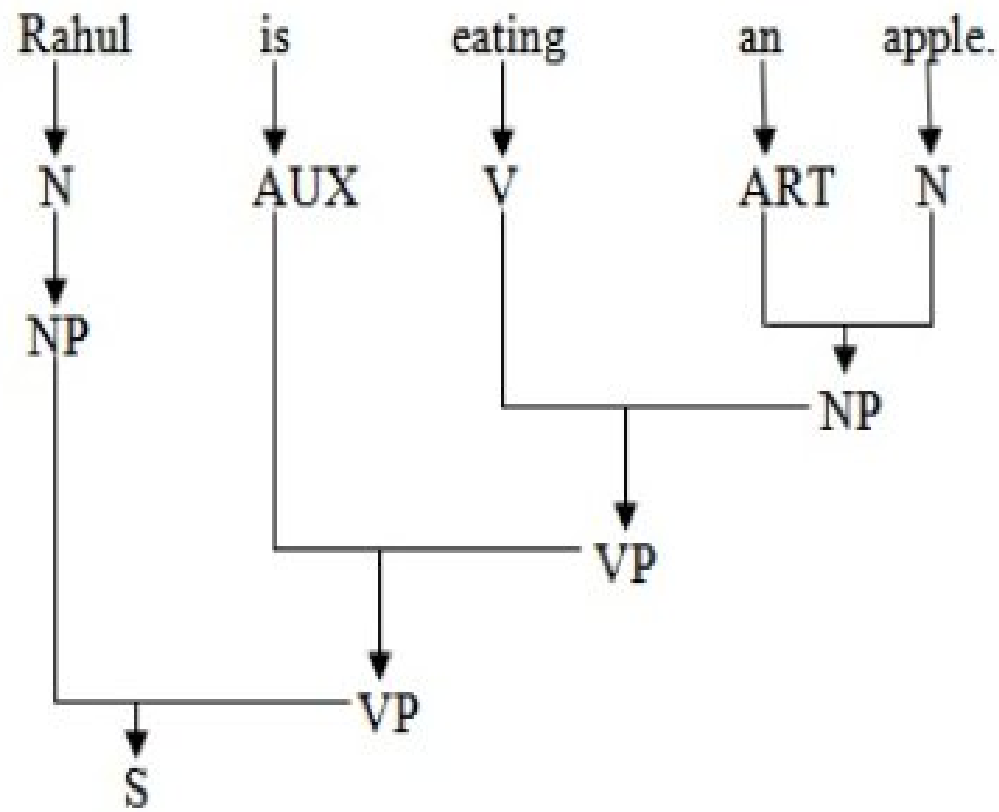
□N AUX VP

□N VP

□NP VP

□S

Graphical Representation



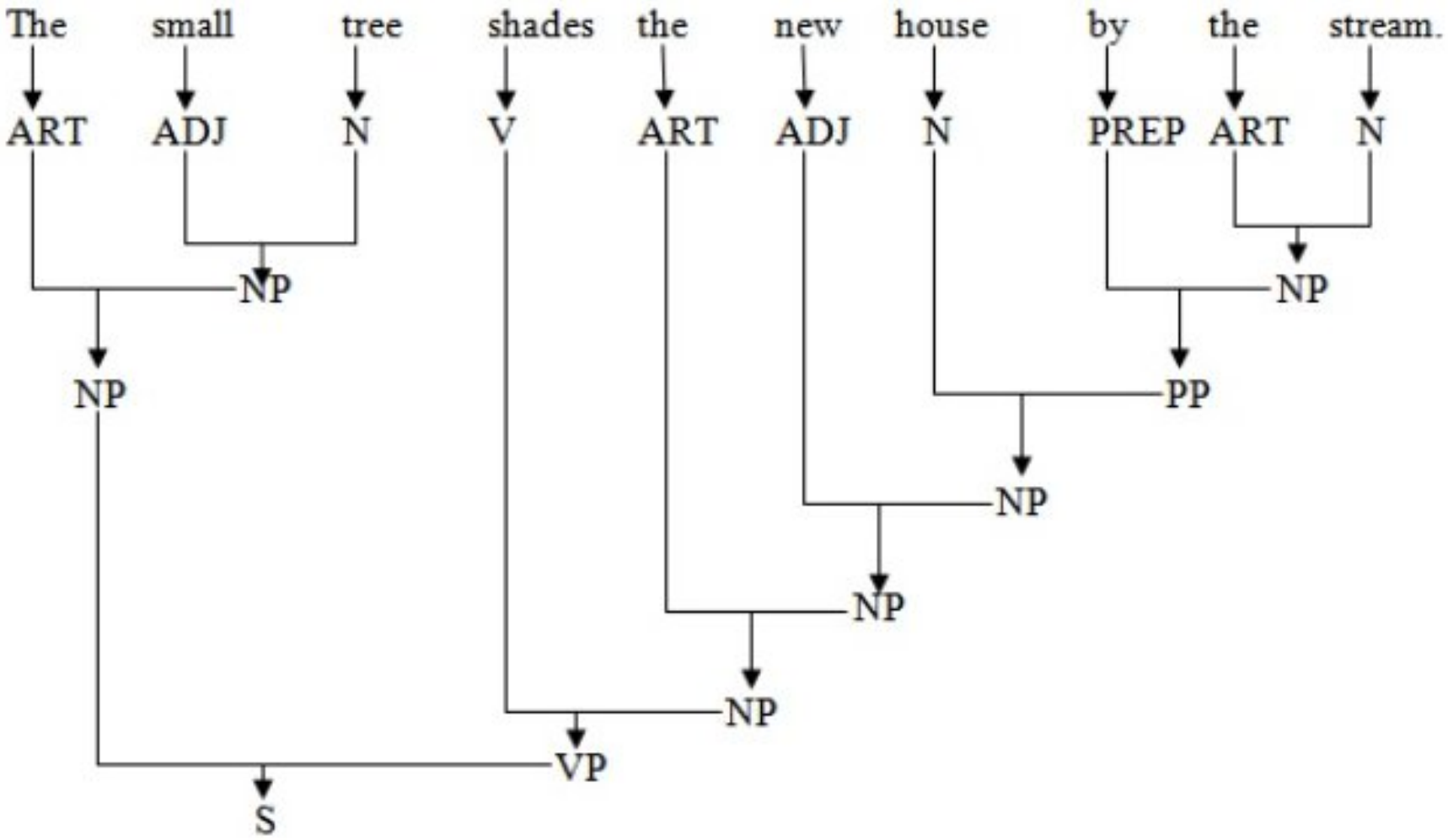
Example-2:

- The small tree shades the new house by the stream

- ART small tree shades the new house by the stream
- ART ADJ tree shades the new house by the stream
- ART ADJ N shades the new house by the stream
- ART ADJ N V the new house by the stream
- ART ADJ N V ART new house by the stream
- ART ADJ N V ART ADJ house by the stream
- ART ADJ N V ART ADJ N by the stream
- ART ADJ N V ART ADJ N PREP the stream
- ART ADJ N V ART ADJ N PREP ART stream
- ART ADJ N V ART ADJ N PREP ART N

- ART ADJ N V ART ADJ N PREP ART N
- ART ADJ N V ART ADJ N PREP NP
- ART ADJ N V ART ADJ N PP
- ART ADJ N V ART ADJ N PP
- ART ADJ N V ART ADJ NP
- ART ADJ N V ART NP
- ART ADJ N V NP
- ART ADJ N VP
- ART NP VP
- NP VP
- S

Graphical Representation



SEMANTIC ANALYSIS:

- Semantic analysis is the process of drawing meaning from text.
- It allows computers to understand and interpret sentences, paragraphs, or whole documents, by analyzing their grammatical structure, and identifying relationships between individual words in a particular context.
- Semantic analysis-driven tools can help companies automatically extract meaningful information from unstructured data, such as emails, support tickets, and customer feedback.

Elements of Semantic Analysis

1. **Hyponymy**: It represents the relationship between a generic term (word) and instances of that generic term. Here the generic term is known as hypernym and its instances are called hyponyms.
   - For example: The word color is hypernym, and the colors blue, yellow, green, etc. are hyponyms
1. **Homonymy**: It may be defined as the words having the *same spelling or same form but having different and* ***unrelated meanings***.

Example: The word “Bat” is a **homonymy** word because a bat can be an implement in two ways: *1. To hit a ball. 2. Bat is a flying mammal also.*

Elements of Semantic Analysis (cont..)

3. Polysemy: Polysemy is a Greek word, that means “many signs”. It is a word or phrase with a different but related sense. In other words, we can say that polysemy has the same spelling but different and **related meanings**.

- For Example: The word "Bank" is a Polysemy word. The word “Bank” is a polysemy word having the following meanings: ***“A financial institution”.”The building in which such an institution is located”.“A synonym for “to rely on”“.***

4. Synonymy: It represents the relation between two lexical items of different forms but expressing the same or a close meaning.

- For Example: ‘author/writer’, ‘fate/destiny

5. Antonymy: It is the relation between two lexical items having symmetry between their semantic components relative to an axis.

For Examples: ‘life/death’, ‘certitude/incertitude”, ‘rich/poor’, ‘hot/cold’, ‘father/son’, ‘moon/sun’.

Meaning Representation

The semantic analysis creates a representation of the meaning of a sentence. Firstly we have to understand the building blocks of the semantic system.

Building Blocks of Semantic System

- **Entities** : It represents the individual such as a particular organization, location, people's name, etc.

  For Example: Punjab, China, Chirag, Kshitiz all are entities.

- **Concepts**: It represents the general category of the individuals such as a person, city, etc.
- **Relations**: It represents the relationship between entities and concepts.

  For Example: Sentence: Ram is a person

- **Predicates**: It represents the verb structures.

  For Example: Semantic roles and Case Grammar

Techniques of Semantic Analysis

Depending on the type of information you'd like to obtain from data, you can use one of two semantic analysis techniques

- Semantic classification model:
  a. **Topic classification**: It is a method for processing any text and sorting them according to different known predefined categories on the basis of its content.
  b. **Sentiment Analysis**:It is a method for detecting the hidden sentiment inside a text, may it be positive, negative or neural
  c. **Intent classification**: It is a method of differentiating any text on the basis of the intent of your customers. The customers might be interested or disinterested in your company or services

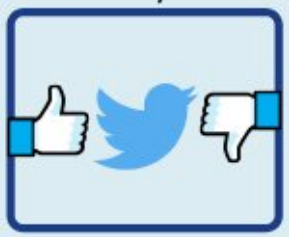
Techniques of Semantic Analysis

- Semantic extraction models:
  a. **Keyword Extraction:** It is a method of extracting the relevant words and expressions in any text to find out the granular insights. It is used to analyze different keywords in a corpus of text and detect which words are ‘negative’ and which words are ‘positive’.
  b. **Entity extraction:** Any sentence or phrase is made up of different entities like names of people, places, companies, positions, etc. This method is used to identify those entities and extract them. It can be very useful for customer service teams of businesses like delivery companies as the machine can automatically extract the names of their customers, their location, shipping numbers, contact information or any other relevant or important data.

Applications of NLP

Information Retrieval

Sentiment Analysis



Information Extraction

Natural Language Processing (NLP)

Machine Translation

Question Answering

Expert systems

Introduction to Expert Systems

- **Expert System** is an interactive and reliable computer-based decision-making system which uses both facts and heuristics to solve complex decision-making problems.
- The purpose of an expert system is to solve the most complex issues in a specific domain.
- The expert system is a part of AI, and the first ES was developed in the year 1970, which was the first successful approach of artificial intelligence.
- The performance of an expert system is based on the expert's knowledge stored in its knowledge base.
- The more knowledge stored in the KB, the more that system improves its performance. One of the common examples of an ES is a suggestion of spelling errors while typing in the Google search box.

Examples of Expert Systems

MYCIN: It was based on backward chaining and could identify various bacteria that could cause acute infections. It could also recommend drugs based on the patient's weight.

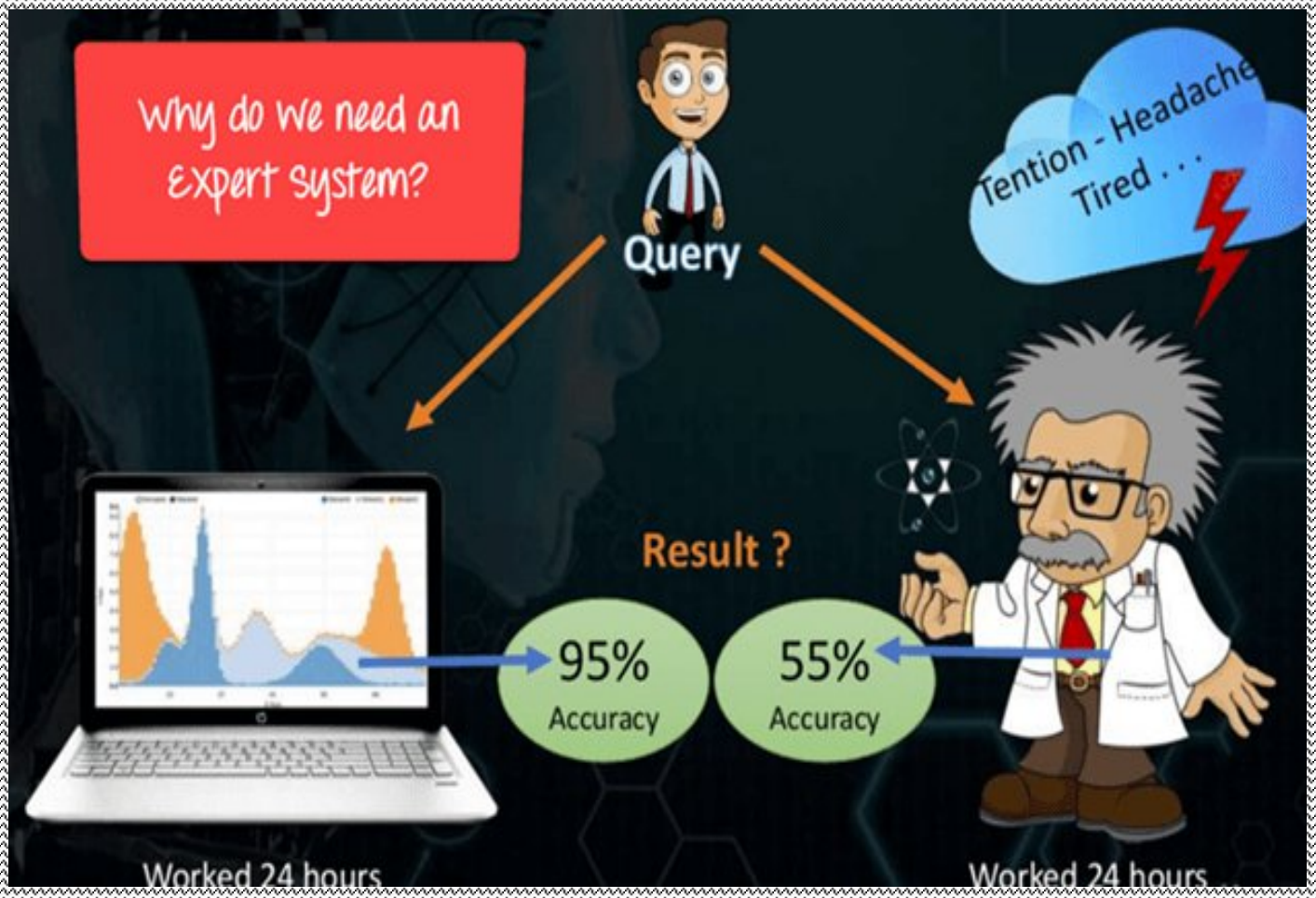
DENDRAL: Expert system used for chemical analysis to predict molecular structure.

PXDES: An Example of Expert System used to predict the degree and type of lung cancer

CaDet: One of the best Expert System Example that can identify cancer at early stage

Characteristics of Expert systems

1. The Highest Level of Expertise
2. Right on Time Reaction
3. Good Reliability
4. Flexible
5. Effective Mechanism
6. Capable of handling challenging decision & problems

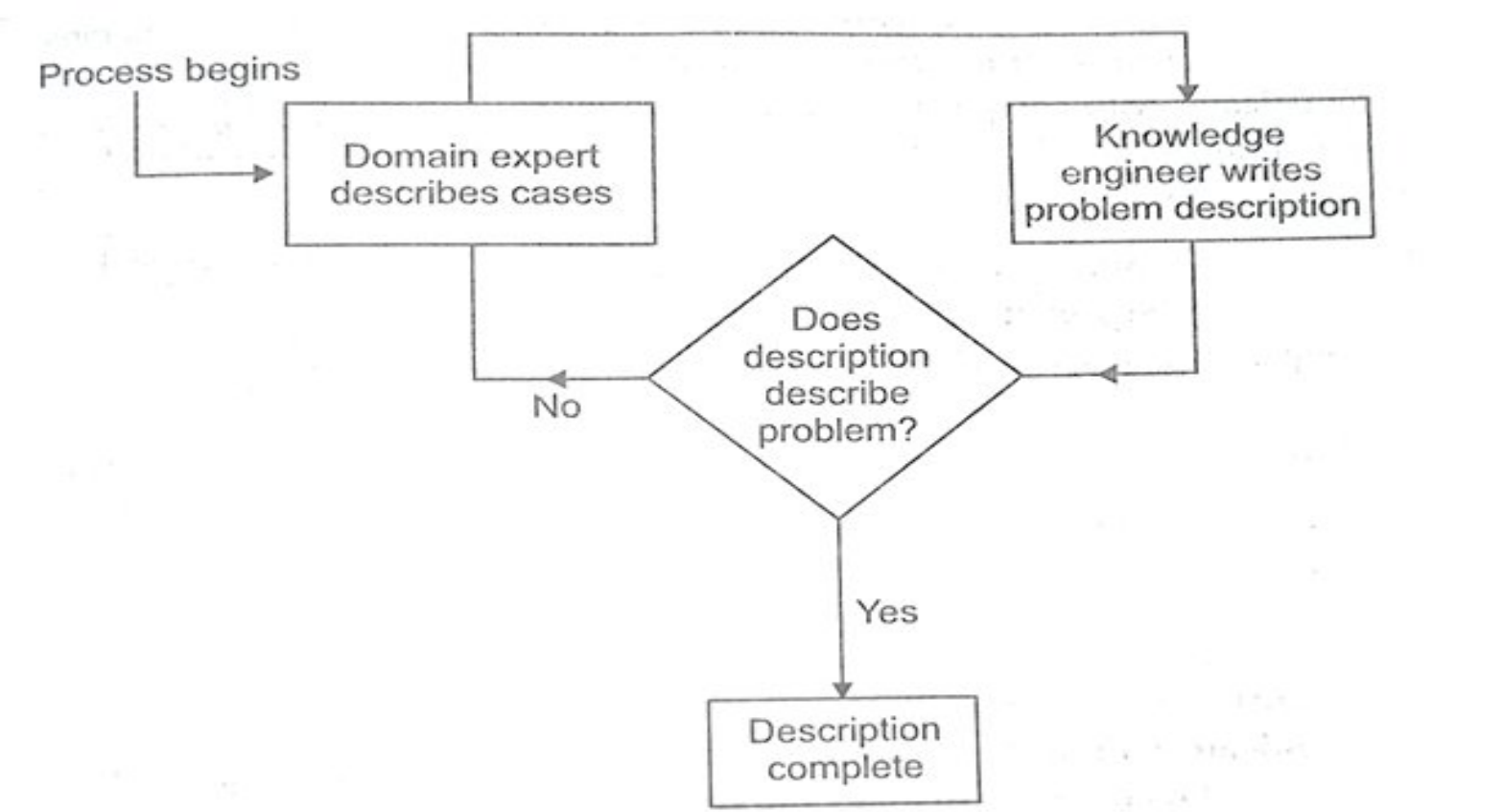


Phases of building Expert System

Step 1: Identification
Step 2: Conceptualization
Step 3: Formalization
Step 4: Implementation
Step 5: Testing

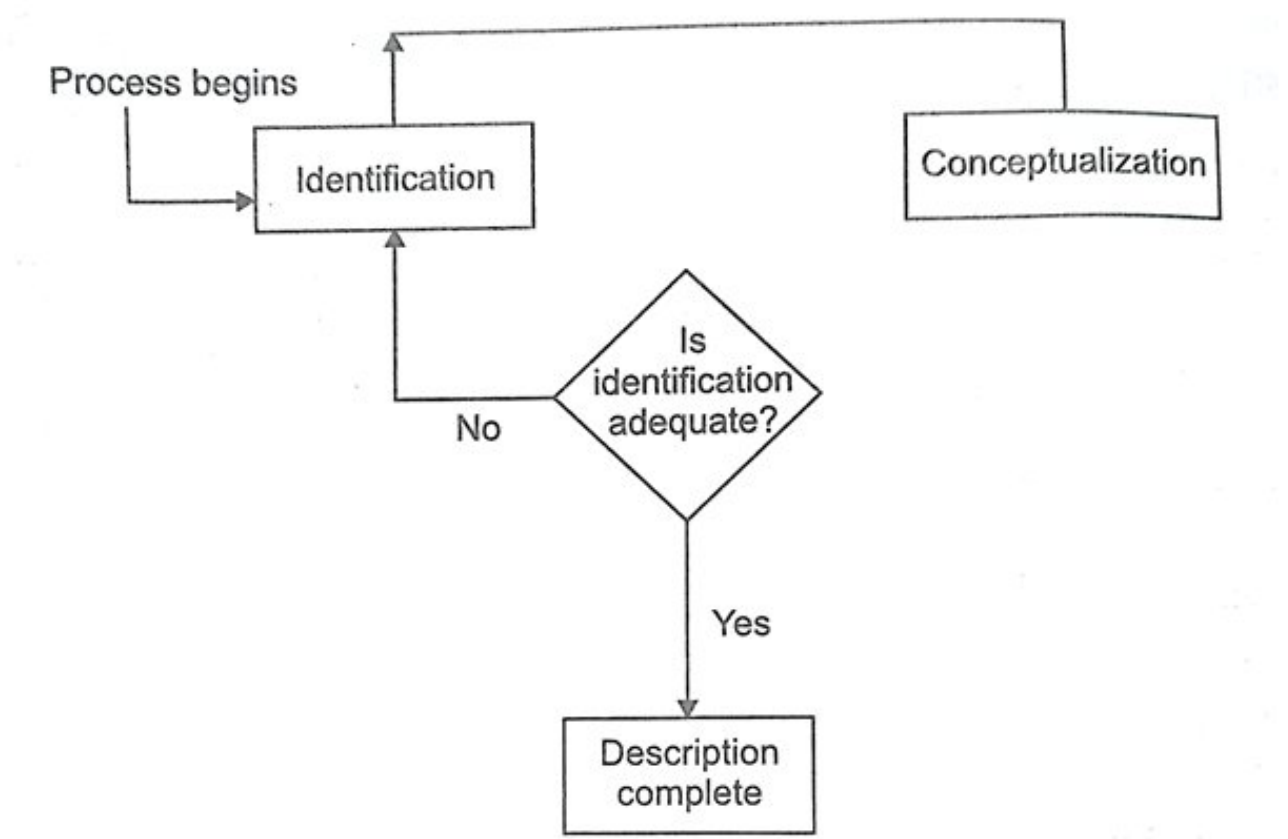
Step 1 - Identification

- Determining the characteristics of the problem



Step2: Conceptualization

- Finding the concept to produce the solution.

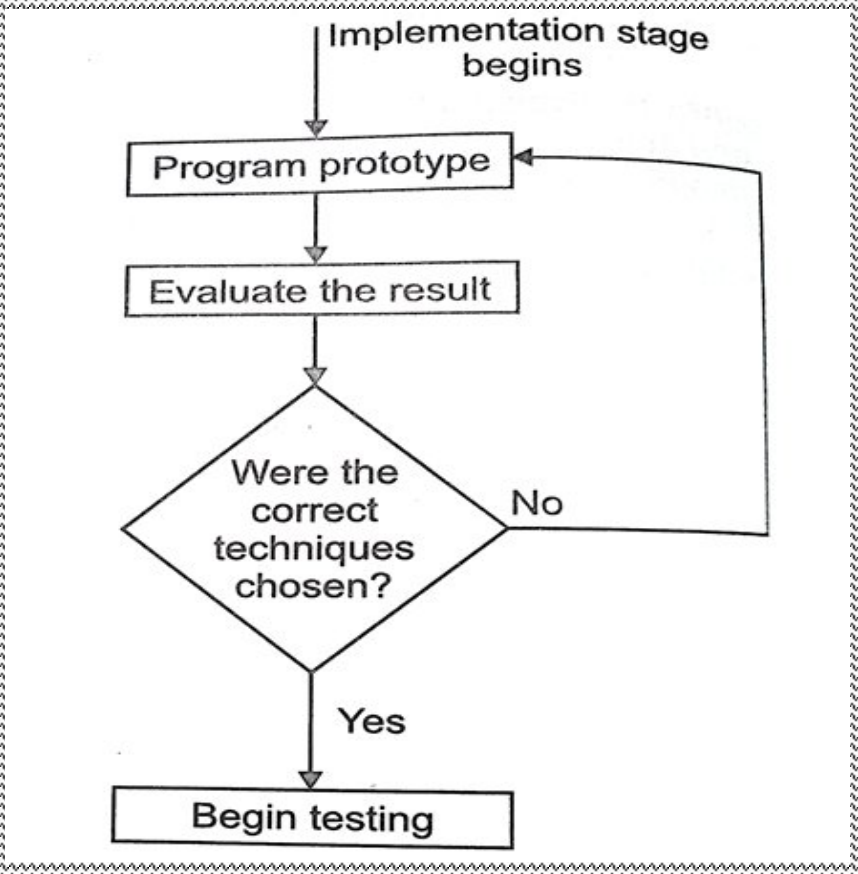


Step3: Formalization

- Designing structures to organize the knowledge.

Step4: Implementation

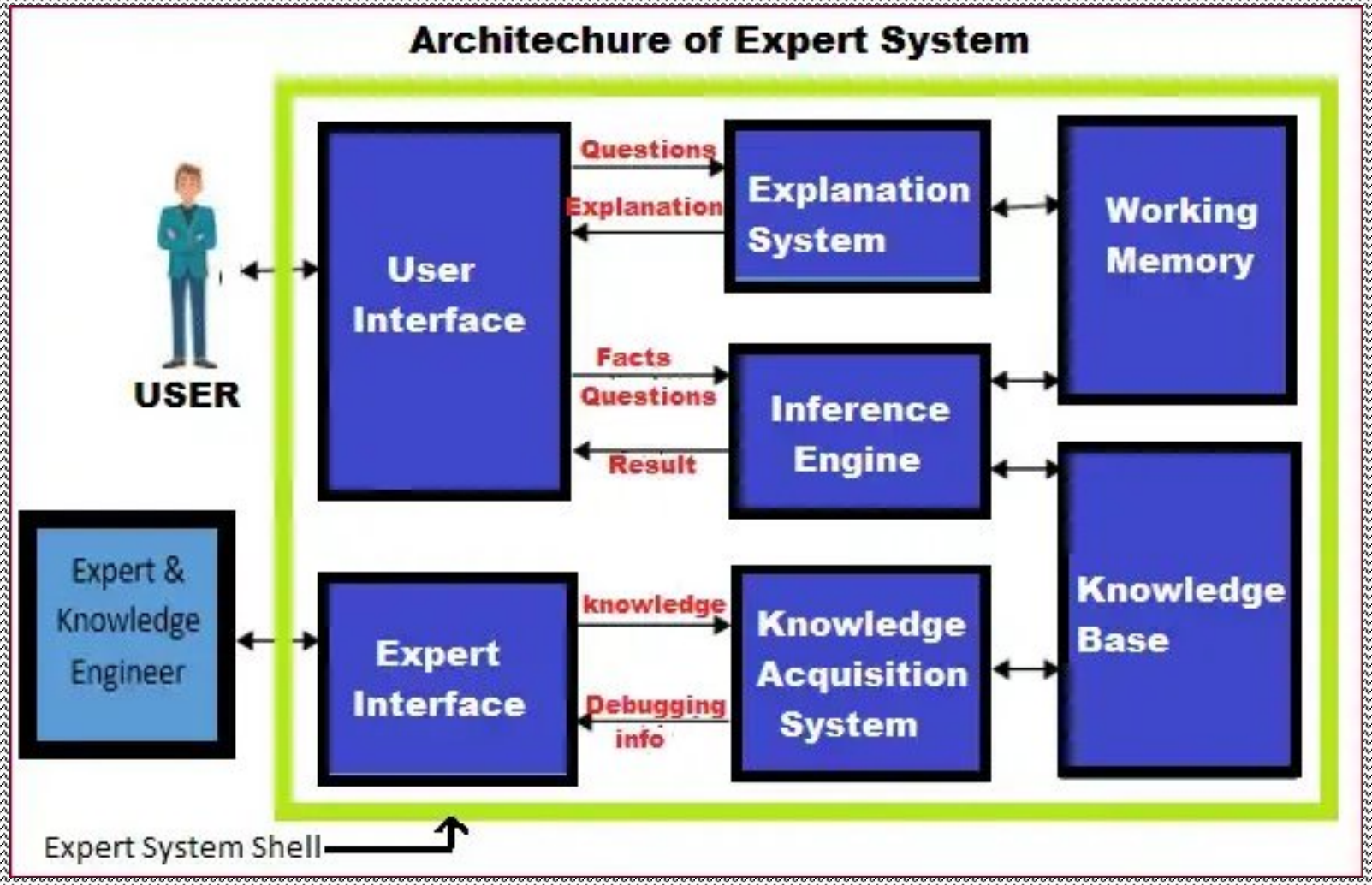
- Formulating rules which embody the knowledge



Step5: Testing

- Validating the rules.
- Testing provides an opportunity to identify the weaknesses in the structure and the implementation of the system.
- Testing includes are:
  - The system implements correctly or incorrectly.
  - Rules implement correctly or not.
  - An Expert System is finally tested to be successful only when it is operated at the level of a human expert.
  - The testing process is **NOT** complete until it indicates that the solutions suggested by the expert system are consistently valid.
  - Expert systems are typically interactive, they work in question-and-answer form.
  - This interaction between users and the Experts system continues until the system can conclude.

Expert System Architecture



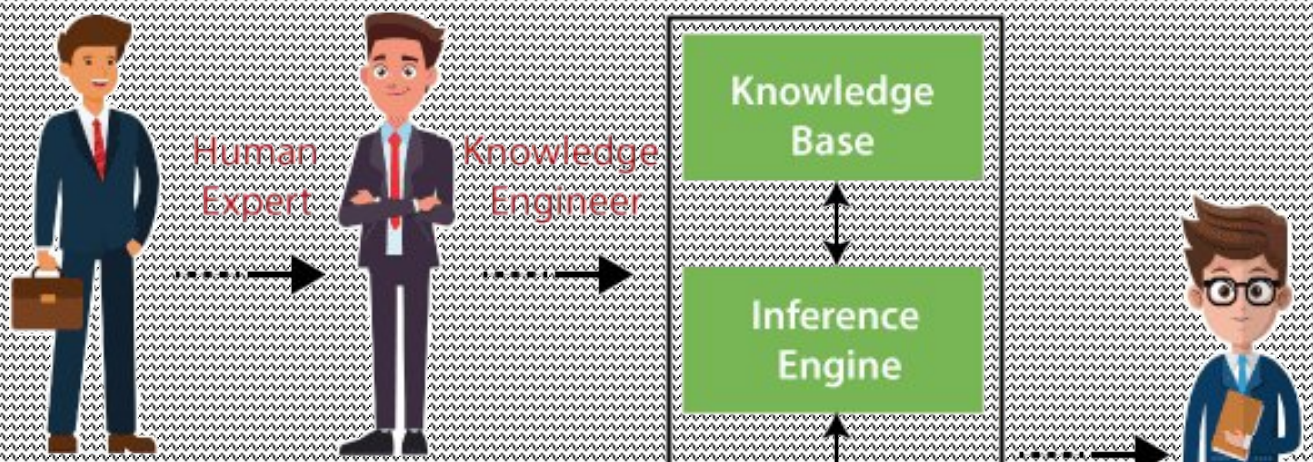
Expert System Architecture

- **Knowledge Base** – It is warehouse of special heuristics or rules, which are used directly by knowledge, facts (productions). It has knowledge that is needed for understanding, formulating, & problem solving.
- **Working Memory** – It helps to describe the current running problem and record intermediate output. Records Intermediate Hypothesis & Decisions: 1. Plan, 2. Agenda, 3. Solution
- **Inference Engine** – It is heart of expert system as well as helps to manage entire structure of expert system, and it delivers to different methodology for reasoning.
- **Explanation System** – It helps to trace responsibility and justify the behavior of expert system by firing questions and answers, such as Why, How, What, Where, When, Who.
- **User Interface** – It allows users to insert their queries with using own Natural Language Processing otherwise menus & graphics.

Expert System Architecture

- **Knowledge Engineer** – Main objective of this engineer is to design system for specific problem domain with using of expert system shell.
- **System Engineer** – To design user interface and declarative format of knowledge base as well as to build inference engine
- **Users** – They are non expert person who want to seek direct advice.
- **Expert System Shell:** shell contains the special software development environment, and it has basic components of expert system such as – Knowledge-based management system, Workplace, Explanation facility, Reasoning capacity, Inference engine, user interface.

Components of Expert Systems

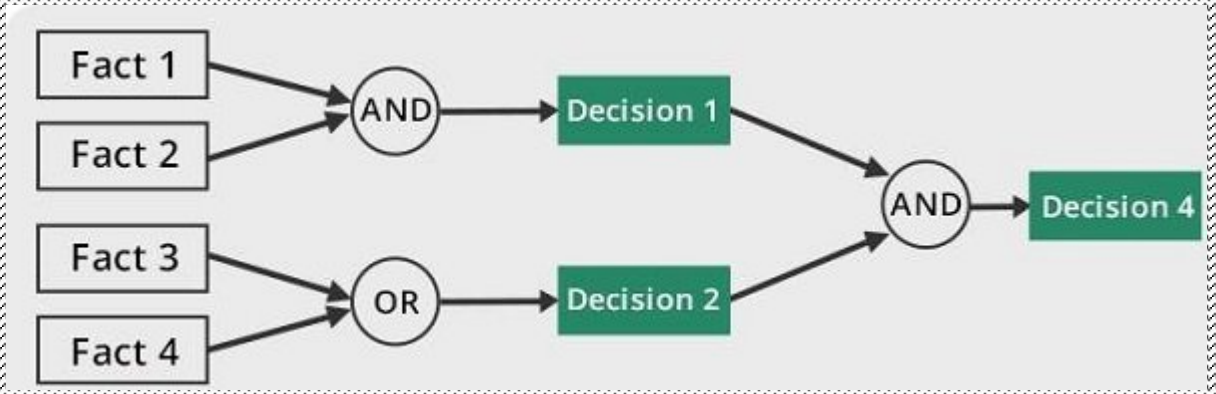


Components of Expert Systems

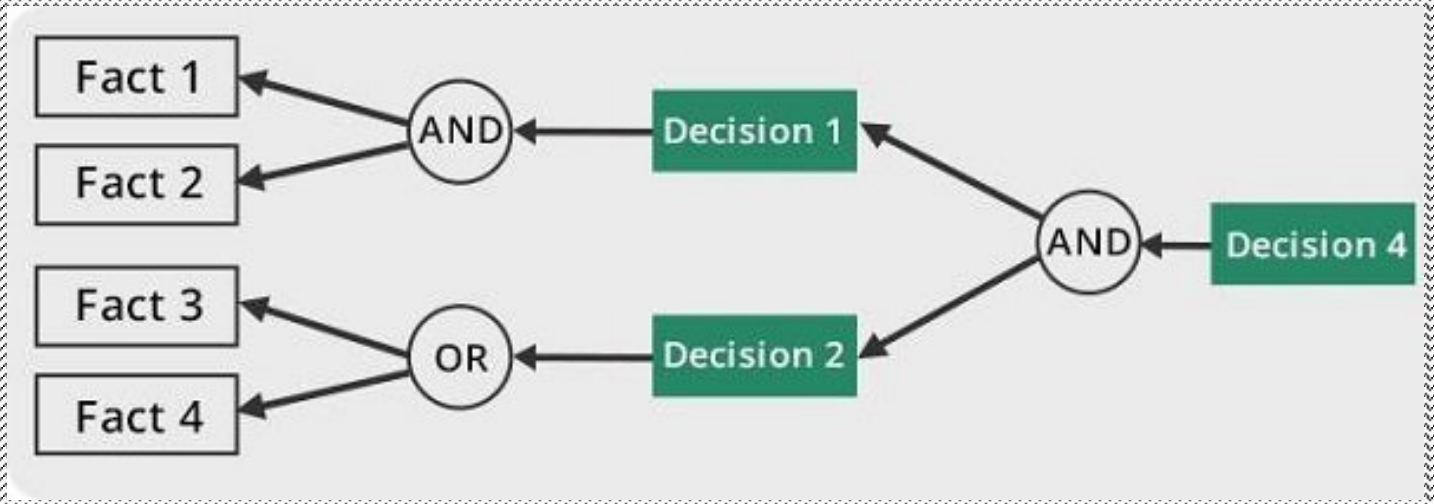
1. **User interface:** It is an interface that helps a non-expert user to communicate with the expert system to find a solution.
2. **Inference Engine(Rules of Engine):**
   - It applies inference rules to the knowledge base to derive a conclusion or deduce new information. It helps in deriving an error-free solution of queries asked by the user.
   - With the help of an inference engine, the system extracts the knowledge from the knowledge base.
   - There are two types of inference engine:
     a. **Deterministic Inference engine:** It uses established rules and logical reasoning to analyze information and draw conclusions, and these conclusions are assumed to be true because they are based on the known facts and rules provided to the engine.
     b. **Probabilistic Inference engine:** This type of inference engine contains uncertainty in conclusions, and based on the probability.

Inference engine uses the below modes to derive the solutions:

- **Forward Chaining:**
  a. It is a strategy of an expert system to answer the question, “What can happen next?”
  b. the Inference Engine follows the chain of conditions and derivations and finally deduces the outcome. It considers all the facts and rules, and sorts them before concluding to a solution.
  c. This strategy is followed for working on conclusion, result, or effect.
  d. For example, prediction of share market status as an effect of changes in interest rates.



- **Backward Chaining:**
  a. With this strategy, an expert system finds out the answer to the question, “Why this happened?”
  b. On the basis of what has already happened, the Inference Engine tries to find out which conditions could have happened in the past for this result.
  c. This strategy is followed for finding out cause or reason.
  d. For example, diagnosis of blood cancer in humans.



Components of Expert Systems

3. Knowledge base:

- The knowledgebase is a type of storage that stores knowledge acquired from the different experts of the particular domain.
- The more the knowledge base, the more precise will be the Expert System.
- It is similar to a database that contains information and rules of a particular domain or subject.

Components of Knowledge Base

- **Factual Knowledge:** The knowledge which is based on facts and accepted by knowledge engineers comes under factual knowledge.
- **Heuristic Knowledge:** This knowledge is based on practice, the ability to guess, evaluation, and experiences.

Components of Expert Systems

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- **Factual Knowledge:** The knowledge which is based on facts and accepted by knowledge engineers comes under factual knowledge.
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Knowledge Representation: It is used to formalize the knowledge stored in the knowledge base using the If-else rules.

Knowledge Acquisitions: It is the process of extracting, organizing, and structuring the domain knowledge, specifying the rules to acquire the knowledge from various experts, and store that knowledge into the knowledge base.

Development of Expert System

Here, we will explain the working of an expert system by taking an example of MYCIN ES. Below are some steps to build an MYCIN:

- Firstly, ES should be fed with expert knowledge. In the case of MYCIN, human experts specialized in the medical field of bacterial infection, provide information about the causes, symptoms, and other knowledge in that domain.
- The KB of the MYCIN is updated successfully. In order to test it, the doctor provides a new problem to it. The problem is to identify the presence of the bacteria by inputting the details of a patient, including the symptoms, current condition, and medical history.
- The ES will need a questionnaire to be filled by the patient to know the general information about the patient, such as gender, age, etc.
- Now the system has collected all the information, so it will find the solution for the problem by applying if-then rules using the inference engine and using the facts stored within the KB.
- In the end, it will provide a response to the patient by using the user interface.

Capabilities of an Expert System

- **Advising:** It is capable of advising the human being for the query of any domain from the particular ES.
- **Provide decision-making capabilities:** It provides the capability of decision making in any domain, such as for making any financial decision, decisions in medical science, etc.
- **Demonstrate a device:** It is capable of demonstrating any new products such as its features, specifications, how to use that product, etc.
- **Problem-solving:** It has problem-solving capabilities.
- **Explaining a problem:** It is also capable of providing a detailed description of an input problem.
- **Interpreting the input:** It is capable of interpreting the input given by the user.
- **Predicting results:** It can be used for the prediction of a result.
- **Diagnosis:** An ES designed for the medical field is capable of diagnosing a disease without using multiple components as it already contains various inbuilt medical tools.

Expert Systems vs Traditional Systems

	Expert Systems	Traditional Systems
Decision Making	These are designed to make decisions based on knowledge and expertise	typically rely on pre-programmed rules and algorithms.
Knowledge Representation	It use knowledge representation techniques such as frames, rules, and semantic networks to represent knowledge,	uses data structures such as tables, lists, and arrays.
Learning ability	Expert systems can learn from experience and adapt to new situations	Do not have this ability and require manual reprogramming to adapt to new situations.
Human Interactions	can interact with humans in a more natural way through the use of natural language processing and other advanced interfaces,	Rely on forms and menus for interaction.
Complexity	Generally more complex than traditional systems due to the need to represent and reason with complex knowledge	These are typically simpler and more straightforward.
Domain Specificity	Expert systems are designed to operate within a specific domain of knowledge or expertise	traditional systems can be applied to a wide range of domains and applications.

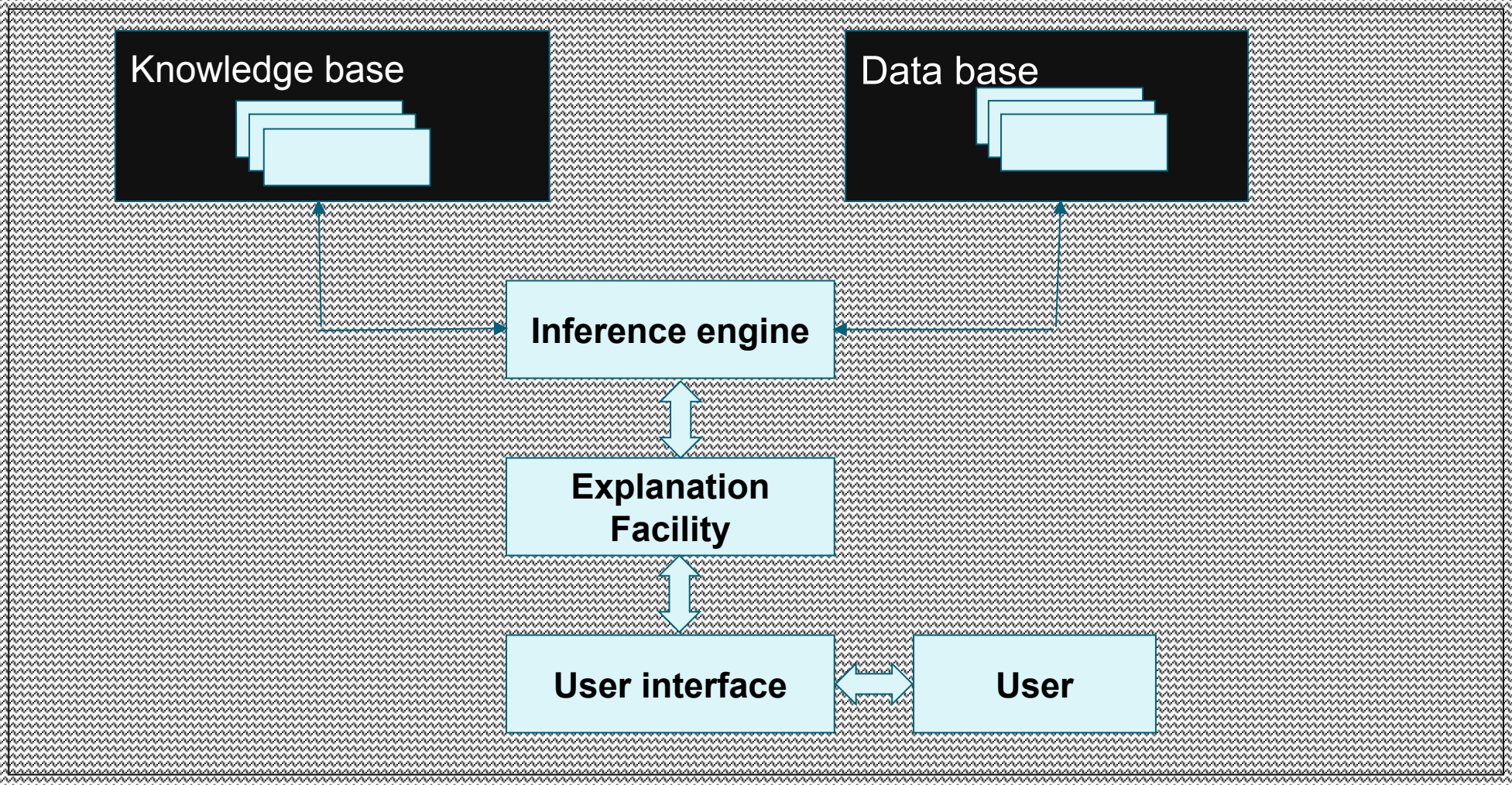
Rule Based Expert Systems

- A rule-based system is a system that applies human-made rules to store, sort and manipulate data.
- Rule-based systems require a set of facts or source of data, and a set of rules for manipulating that data.
- These rules are sometimes referred to as ‘If statements’ as they tend to follow the line of ‘IF X happens THEN do Y’

Elements in Rule Based Systems:

1. Set of Facts: These facts are assertions or anything that is relevant to the beginning state of the system.
2. Set of rules: This set contains all the actions that should be performed within the scope of a problem and defines how to act on the assertion set. In the set of rules facts are represented in an IF-THEN form
3. Termination criteria: This determines whether a solution exists or not and figures out when the process should be terminated

Structure of Rule based Expert System



Knowledge Base:

- In rule-based expert system, the knowledge is represented as a set of rules. Each rule specifies a relation, recommendation, directive, strategy or heuristic and has the IF (condition) THEN (action) structure.

Database:

- It includes a set of facts used to match against the IF (condition) parts of rules stored in the knowledge base.

Inference engine:

- It carries out the reasoning whereby the expert system reaches a solution.
- It links the rules given in the knowledge base with the facts provided in the database

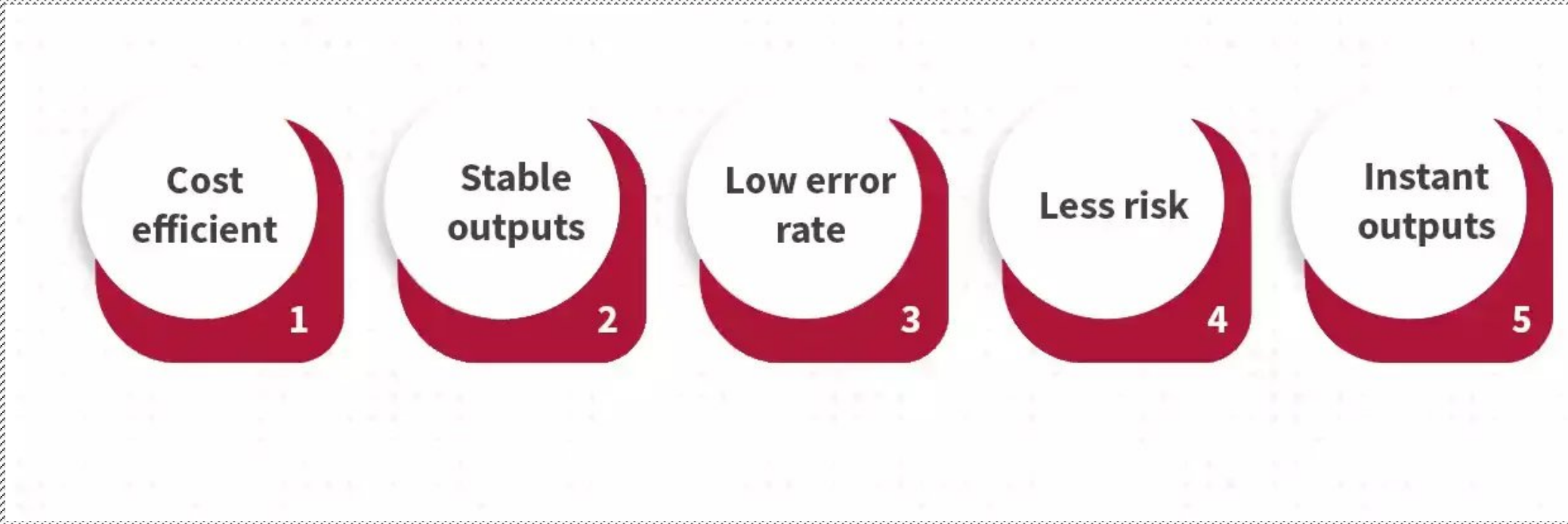
Explanation facilities:

- It enable the user to ask the expert system how a particular conclusion is reached and why a specific fact is needed.

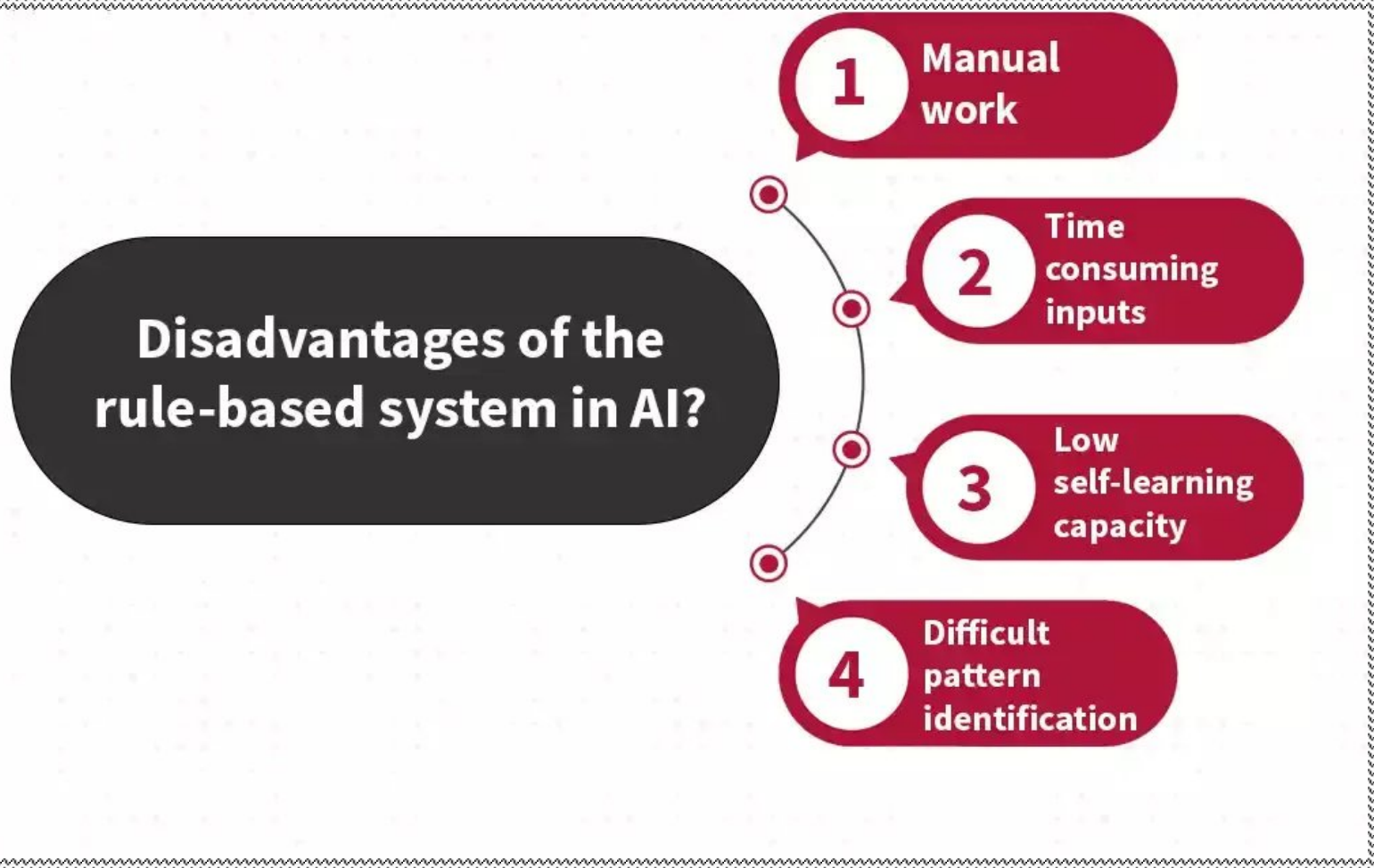
User interface:

- The **user interface** is the means communication between a user seeking a solution to the problem and an expert system.

Advantages of Rule Based Systems



Disadvantages



Applications of Expert Systems

Medical diagnosis: analyzing patient symptoms, medical history, and test results.

Financial analysis: analyze financial data and provide investment recommendations based on market trends and risk assessments

Quality control: identify potential quality issues by analyzing data from sensors and other sources.

Customer service: provide personalized customer service, providing recommendations

Agriculture: provide farmers with recommendations on crop management, pest control, and other agricultural practices based on weather conditions and soil data.

Transportation: used to optimize transportation routes, reduce fuel consumption,

List of Shells and Tools

- **CLIPS**: A rule-based programming language used to provide a powerful set of tools for knowledge representation and inference.
- **Jess:** A rule-based expert system tool that is similar to CLIPS but is based on the Java programming language.
- **Drools:** A business rule management system that can be used to build complex rule-based systems for decision-making.
- **Prolog**: A logic-based programming language that can be used to build expert systems for a variety of domains.
- **MATLAB**: A powerful tool for developing expert systems in the field of engineering and data science.
- **Rete algorithm**: A pattern matching algorithm that is commonly used in expert systems to perform rule-based reasoning.
- **Neural networks**: Artificial neural networks can also be used as a tool for building expert systems, especially for domains that require pattern recognition

THANK YOU