**The need for Expert Systems and Applications**

1. **The Need for Expert Systems**

In many organizations, problem-solving expertise is scarce. Training people to become proficient in solving specialized problems takes time and requires substantial investment. Hence, experts are always in short supply. In an operational setting, the frequency with which problems occur often exceeds the capabilities of a limited number of experts. In some situations, experts may be geographically distant from the site of the problem, or problems may occur during times experts are unavailable. Consequently, problems must be handled by less qualified personnel. This can cause delays and lead to inconsistent or uneven decision making. One example is a factory floor in which highly specialized equipment problems must be diagnosed and repairs effected. Normally, this task is performed by a trained expert having years of experience. Work proceeds normally if the frequency of malfunctions is relatively low and the expert is readily available. However, a company may have factories at different locations, or the factories may operate around-the-clock. Under these circumstances, demand for experts may quickly exceed their availability, resulting in delays and problems. One solution is to develop an expert system to help identify frequently occurring machine malfunctions and suggest solutions. Such an expert system could be deployed on the factory floor and used to solve routine problems that would otherwise have to be handled by the expert. If the expert system could solve the problems the expert normally solves, delays could be eliminated and productivity improved. Copies of the expert system could be distributed throughout the company, making expertise available at several locations around the clock.

This is a simplified description of the productive use of an expert system. Certainly, there are potential problems in this scenario that could defeat effective use of expert system technology.

1. **When is an Expert System Appropriate?**

Here are factors which suggest an expert system is appropriate.

• Need justifies cost and effort

• Human expertise not always available

• Problem requires symbolic reasoning

• Problem domain is well structured

• Traditional computing methods fail

• Cooperative and articulate experts exist

• Problem is not too large

1. **Expert System Application Areas**

Expert systems have gained wider applications in different areas of human endeavor, especially in roles where human expertize are need. Some of these areas where expert systems are applied are discussed below:

**1. Accounting & Finance**

The financial services industry has been a vigorous user of expert system techniques. Advisory programs have been created to assist bankers in determining whether to make loans to businesses and individuals. Insurance companies have used expert systems to assess the risk presented by the customer and to determine a price for the insurance. A typical application in the financial markets is in foreign exchange trading.

Other areas in accounting and finance applications are **-** 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...

**2. 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.

**3. 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.

**4. 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...

**5. Computer -** Software System Diagnostic Modeling, Application Sizing, Software Quality Assurance, Program Classification, Locating Component Failure & Analysis, New Technology Selection, Training Systems, Custom Hardware Diagnostics, Decision Support Systems, MIS Support System, Program Library Maintenance, Fault Detection and Diagnostics of Wide Area Networks, Analysis of Statistical Data, Personal Computer Configuration, Shielding Technique Selection, Database Design, Computerized Technical Service Representation, Hardware and Software Selection by Non-Technical users, New User of Computer Assistance, Documentation Recommendations to Users, Monitoring, Repair Assistance and Problem Prediction of Operating System.

**6. 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.

**7. Education -** 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.

**8. Engineering**

Expert systems are widely used in engineering, they can help in configuration, whereby a solution to a problem is synthesized from a given set of elements related by a set of constraints. The technique has found its way into use in many different engineering industries, for example, modular home building, manufacturing, and other problems involving complex engineering design and manufacturing. Other areas of ES applications in engineering are:

- Engineering Change Control Demonstrating, Diesel Engine Lube Oil Wear Analysis, Super-alloys 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...

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

**10. Medical:** Expert systems have strong presence in medical applications. It should be noted that

Medical diagnosis was one of the first knowledge areas to which ES technology was applied. Other medical applications of expert systems are: 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. E.t.c

**11. 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...

**12. Trouble-Shooting**

This class comprises systems that deduce faults and suggest corrective actions for a malfunctioning device or process. This has wide applications in areas such as

- 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.

**13. Knowledge Publishing:** This is a relatively new, but also potentially explosive area. The primary function of the expert system is to deliver knowledge that is relevant to the user's problem, in the context of the user's problem. The two most widely distributed expert systems in the world are in this category. The first is an advisor which counsels a user on appropriate grammatical usage in a text. The second is a tax advisor that accompanies a tax preparation program and advises the user on tax strategy, tactics, and individual tax policy.

**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...

The spectrum of applications of expert systems technology to industrial and commercial problems is so wide as to defy easy characterization. The applications find their way into most areas of knowledge work. They are as varied as helping salespersons sell modular factory-built homes to helping NASA plan the maintenance of a space shuttle in preparation for its next flight.

**KNOWLEDGE REPRESENTATION IN EXPERT SYSTEMS**

1. **Definition: Knowledge-representation** is the field of in artificial intelligence that focuses on capturing information about the world that can be used to solve complex problems in a particular domain such as diagnosing a medical condition.

**Knowledge and Representation** are two distinct entities. They play central but distinguishable roles in intelligent system design.

**Knowledge** is a description of the world. It determines a system's competence by what it knows. On the other hand

**Representation** is the way knowledge is encoded so that the computer can understand on how to solve a problem. It defines a system's performance in doing something

Knowledge is a **progression** that starts with data which is of limited utility.

1. **Data** is viewed as collection of disconnected facts

**Example**: It is raining

2. By organizing or analyzing the data, we understand what the data means, and this becomes **information**. It provides answers to "who", "what", "where", and "when".

**Example:** The temperature dropped 15 degrees and then it started raining

3. The interpretation or evaluation of information yield **knowledge.** It provides answers as "how".

**Example:** If the humidity is very high and the temperature drops substantially, then atmospheres is unlikely to hold the moisture, so it rains

4. An understanding of the principles embodied within the knowledge is **wisdom**. It provides answers as "why".

* Knowledge is the most abstract and exists in the smallest quantity. Knowledge itself can have levels of abstraction: concrete (knowledge about the specific problem), domain specific (class of problems) and abstract (many classes of problems).

1. **Why do we need knowledge Representation?**

Knowledge representation is crucial because problem solving requires large amount of knowledge and some they should be mechanism for manipulating that knowledge into computer understandable form.

1. **How do we represent what we know?**

Representing knowledge requires an analysis to distinguish between knowledge “how” and knowledge “that.

Knowing "how to do something"

e.g. "how to drive a car" is a **Procedural knowledge**

Knowing "that something is true or false"

e.g. "that is the speed limit for a car on a motorway" is a **Declarative knowledge**.

1. **Knowledge is categorized into two major types: Tacit and Explicit**

The term “Tacit “corresponds to "informal" or "implicit" type of knowledge that is not codified.

1. Exists within a human being; it is embodied.

2. Difficult to articulate formally

3. Difficult to communicate or share

4. Hard to steal or copy.

5. Drawn from experience, action, subjective insight.

On the other hand the term “Explicit” corresponds to "formal" type of knowledge that is codified.

1. Exists outside a human being; it is embedded.

2. Can be articulated formally

3. Can be shared, copied, processed and stored

4. Easy to steal or copy

5. Drawn from artifact of some type as principle, procedure, process, concepts

1. **Knowledge Typology Map**

It shows the relationship between – Tacit and Explicit knowledge.

Tacit knowledge comes from "experience", "action", "subjective", "insight".

Explicit knowledge comes from "principle", procedure", "process", "concepts".

**Facts:** are data or instance that is specific and unique.

**Concepts:** are classes of items, words, or ideas that are known by a common name and share common features.

**Processes:** are flows of events or activities that describe how things work rather than how to do things. Procedures: are series of step-by-step actions and decisions that result in the achievement of a task.

**Principles:** are guidelines, rules, and parameters that govern; principles allow to make predictions and draw implications;

* A good knowledge representation enables fast and accurate access to knowledge and understanding of the content

1. **Knowledge Representation Methods**

Knowledge is represented by three methods in expert system; these are:

I. Production Rules

II. Semantic Net

III. Frames and Logic

**PRODUCTION RULES OR PRODUCTION SYSTEM:**

Rules are used to represent relationships. Rule-based knowledge representation employs

IF **condition** (premise or consequent)

THEN **action** (goal or antecedent) statements.

For example,

**IF** the heating element glows **AND** the bread is always dark

**THEN** the toaster thermostat is broken

When the problem situation matches the IF part of a rule, the action specified by the THEN part of the rule is performed

* Production rules are one of the most popular and widely used knowledge representation languages
* Production rule system consists of three components

I. Working memory contains the information that the system has gained about the problem thus far.

II. Rule base contains information that applies to all the problems that the system may be asked to solve.

III. Interpreter solves the control problem, i.e., decide which rule to execute on each selection - execute cycle.

**Advantages of Production System rule method:**

* Naturalness of expression
* Modularity
* Restricted syntax
* Ability to Represent Uncertain Knowledge

**Disadvantages of Production System:**

* Inefficient
* Less expressive

**SEMANTIC NET**

It is **formalism/mechanism** for representing information /Knowledge about objects, people, concepts and specific relationship between them.

**The syntax of semantic net is simple. It is a network of labeled nodes and links**.

It is a directed graph with nodes corresponding to concepts, facts, objects etc. and arcs showing relation or association between two concepts.

**The commonly used links in semantic net are of the following types.**

**isa →** subclass of entity (e.g., child hospital is subclass of hospital)

**inst →** particular instance of a class (e.g., India is an instance of country)

**prop →** property link (e.g., property of dog is “bark”)

**Representation of Knowledge in Semantic Net**

Every human, animal and bird is living things that breathe and eat. All birds can fly.

All man and woman are humans who have two legs. Cat is an animal and has a fur.

All animals have skin and can move. Giraffe is an animal who is tall and has long legs.

Parrot is a bird and is green in color

**Inheritance in Semantic Net**

-Inheritance mechanism allows knowledge to be stored at the highest possible level of abstraction which reduces the size of knowledge base.

* It facilitates inference of information associated with semantic nets.
* It is a natural tool for representing taxonomically structured information and ensures that all the members and sub-concepts of a concept share common properties.
* It also helps us to maintain the consistency of the knowledge base by adding new concepts and members of existing ones.

- Properties attached to a particular object (class) are to be inherited by all subclasses and members of that class.

**Advantages of Semantic nets**

* Easy to visualize
* Formal definitions of semantic networks have been developed
* Related knowledge is easily clustered.
* Efficient in space requirements
* Objects represented only once
* Relationships handled by pointers

**Disadvantages of Semantic nets**

* Inheritance (particularly from multiple sources and when exceptions in inheritance are wanted) can cause problems.
* Facts placed inappropriately cause problems.
* No standards about node and arc values

**FRAME**

* Frame is a semantic net with properties
* It represents general concept or specific entry
* Frames represent objects as sets of slot/filler pairs
* Object can contain programs as well as data (if-needed, if-added, if-removed).
* The utility of frames lies in hierarchical frame system and inheritance.
* This makes it easy to construct and manipulate a complex knowledge base.
* Frames are implicitly associated with one another because value of a slot can be another frame

There are three components of a frame

(i). Frame name

(ii). Attributes (slots)

(iii). Values (Fillers)

- Fillers can be links to other frames

**Advantages**

* Domain knowledge model reflected directly
* Support default reasoning
* Efficient
* Support procedural knowledge

**Disadvantages**

* Lack of semantics
* Expressive limitations

**OVERVIEW OF NATURAL LANGUAGE INTERFACE FOR EXPERT SYSTEMS**

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 utilized 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. The user would have to learn to utilize a small subset of the English language in order to operate most of these interfaces. Some experts however feel that this is not an effective NLI as users would have to learn how to use the system before being able to utilize it effectively. They argue that applications that utilize natural language should stimulate conversation between the human user and the computer in order to have a successful communication between the two parties. Human-to-human conversations take place by taking turns between speaker and listener. When NLIs are designed this should therefore be taken into account. NLIs were first utilized 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 utilizing them to pick out keywords. These keywords were then utilized 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. Though ELIZA did not utilize any sophisticated processing techniques, it was still a notable NLI as it was the first natural language interface.

Natural language can be processed by computers through *speech recognition, speech synthesis, text-based pattern matching* or *gesture interaction*.

*Speech recognition* has come of age in recent years but has not matured to an extent that it can be utilized to have a conversation with a computer. Most speech recognition systems are restricted to certain keywords within a domain and, therefore cannot be utilized for accomplishing tasks outside a particular domain (Dusan and Flanagan 2004). Furthermore, these systems do not adequately cover all utterances a user might utilize in order to accomplish a task in a certain domain. Research in the area of natural language processing is moving towards the creation of systems that are capable of learning human knowledge and obtaining related knowledge as a conversation proceeds (Dusan *et al*. 2004).

*Speech synthesis* is the process of outputting simulated human speech. Speech synthesis has been more successful than speech recognition and has a variety of applications. Contact centres use speech synthesis to present the customer with menus with which they interact. Furthermore feedback is also provided to the customer using speech synthesis.

*Text-based pattern matching* has mostly been utilized by conversational agents or search engines. These systems utilize pattern matching in order to interact with the user. An example of text-based pattern matching is called ALICE, which utilizes pattern matching techniques to converse with the user. Pattern matching is the act of checking text for a given structure and if it matches a certain task is performed. In the case of ALICE when a pattern is matched a template will be triggered. *Gesture interaction* is the process of analyzing human gestures. Humans usually gesture when using human language in order to interact with other human beings. These gestures can convey the mood and sometimes the context of a conversation. In some cultures bowing in front of someone is a method of saying hello (therefore the context of the conversation at that point is introduction). Gesture interaction is usually utilized as a complimentary technique to speech. They provide a method through which context can be maintained in a conversation. Furthermore, the mood of the conversation can also be understood by the system.

**Conversational Speech Interfaces**

A conversational speech interface is one that utilizes speech as an interaction technique and is an example of a natural language interface. This interface operates utilize 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. Though speech is easy for humans it is not so easy for computers. The reason for this is that speech technologies lack 100% accuracy (Lai and Yankelovich 2003), and there is a problem with ambiguity when utilising natural languages. The main problem when designing these interfaces is that system developers do not design these systems with speech in mind from the beginning but rather in terms of the graphical user interface. This brings about a problem of merely designing a command line interface which utilizes speech through a graphical user interface (Lai *et al*. 2003). Another crucial factor in determining whether or not the application will be successful is to determine whether there is a clear benefit to utilizing speech. This involves assessing whether speech is absolutely necessary, in other words when the users hand or eyes are busy or when the task to be completed cannot be accomplished without the use of speech. Speech is not suitable in situations such as when large amounts of information need to be presented to the user.

**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.

Systems performance in speech recognition can be affected by a number of factors including large vocabularies, multiple users, continuous speech and noisy environments. When a user speaks into a microphone, phonemes are extracted from the user speech. Phonemes are the linguistic units of human language (Zue, Cole and Ward 2000; Matthews 2002). These sounds are grouped together to form words utilized in human language. When the sounds are grouped together the actual process of understanding user input is initiated. Over the years, many approaches have been utilized but only two will be discussed here namely pattern matching and knowledge-based approaches. These two approaches are not mutually exclusive and are discussed below:

* **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 utilized to compare the pattern and compute a similarity score (Zue et al. 2000; Schroeder 2004). The template with the highest score is then chosen as it will have the highest acoustic similarity to the users input.
* **Knowledge-based approaches** - This approach makes use of a rule-based expert system which utilizes a base classification of rules in order to function. However to utilize 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.

**Speech Synthesis**

Speech synthesis enables computers and other electronic devices to output simulated human speech. A computer system that is utilized for the purpose of producing human speech is known as a speech synthesizer. A text-to-speech (TTS) system is an example of a speech synthesizer that converts normal text into speech. The quality and effectiveness of speech produced by these systems are measured by utilizing these characteristics:

* 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 personalized 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.

For a text-to-speech system to function, a narrator is utilized to record a series of text (such as reading from an encyclopedia, poetry, political news and various other texts). These narrations are carefully picked in order to ensure that every possible sound in a given language is recorded. These narrations are then sliced into the different phonemes found in the particular language and stored in a database. When the database is created, the various recorded utterances are segmented into one of the following: diaphones (sound-to-sound transitions), syllables (units of organization for a sequence of speech sounds), morphemes (smallest linguistic units that have semantic meaning), words, phrases and sentences.

The above-mentioned process occurs in the *back end* of the TTS system. The *front end* has two major tasks namely: *normalization* and *text-to-phoneme conversion*. *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. The various phonemes are then extracted for that particular sentence and produced as human speech through a speaker or any other device capable of producing sound. There are two types of speech synthesis that are utilized for commercial applications namely concatenated synthesis and formant synthesis (Karat *et al*. 2003). Concatenated synthesis employs computers to assemble narrators recorded voices into speech signals. Though this sounds fairly simple, it is very database intensive and has large storage needs to store all recorded speech. Formant synthesis, on the other hand, utilizes a rule-based expert system. This expert system applies a set of phonological rules to a specified audio waveform which simulates speech.

**Text-Based Natural Language Interfaces**

Text-based NLIs utilize 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 utilized 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. Conversational agents need to satisfy two sets of requirements for them to be effective (Lester *et al.* 2004):

* 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.

Conversational agents are generally deployed on retail websites and are utilised by customers to enquire about products and services. However as these agents gained popularity they were deployed in a variety of other domains such as education, banking, travelling agencies and a variety of others. Conversational agents have also been utilized in the virtual world and because these worlds are mostly text based in nature, they make an ideal environment for communication with the user. These types of virtual conversational agents can be found on social websites such as Second life. Another conversational agent known as ALICE utilizes simple pattern-matching techniques to engage users in a conversation. ALICE utilizes Artificial Mark-up Language (AIML), which is a derivative of XML to store its patterns and templates.

A Virtual World Personal Assistant Pattern matching is not the only technique utilized; various other methods such as Bayesian networks are also used. There are mainly two methods utilized by text-based interfaces to comprehend user input namely:

* *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. Moreover it is impossible to cater for all possible inputs.
* *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 analyzing current and previous user input. The question with the highest probability is usually always chosen.

**Shortcomings of Natural Language Interfaces**

Human-computer interaction experts believe that NLIs are not as attractive as they initially appeared to be. Early literature in this field focuses on the shortcomings of these interfaces in terms of user task completion. The shortcomings are brought upon by the ambiguous nature of a natural language and heavy dependence on a huge repository of knowledge. Consider the following quote: *At last, a computer that understands you like your mother*. A computer can interpret this quote in a number of different ways (ambiguity) and thus will show us the difficulties in analyzing human language. If we look at the sentence carefully there are three interpretations that are possible:

* the computer understands you as well as you mother understands you;
* the computer understands that you like your mother; and
* the computer understands you as well as it understands your mother.

This shows us how a simple sentence can be ambiguous for a computer, while we as humans can easily rule out all other alternatives except the first one. We do so, based on a great deal of background knowledge, including understanding what advertisements typically try to convince us of (Lee 2004). There are various techniques that could be used to get around this flaw. Another technique that could be used is the *use of certain linguistic theories*, which outline certain rules that should be followed while conversing. Examples of such rules include:

* users should not give more information than necessary;
* users should not make unnecessary speech contributions than is necessary; and
* users should not intentionally make ambiguous references but rather use references that they believe will unambiguously describe exactly what they what want to achieve.

The most popular technique used to combat ambiguity is to *engage in some form of clarification or confirmation dialogue* to confirm if the interpretation is, in fact, the correct one.

However, the advances in the field of natural language processing are changing the ways languages are processed in expert systems today. A lot of these shortcomings have been overcome.

**Benefits of Natural Language Interfaces**

Though NLIs have their disadvantages, they also have a variety of advantages. The main reason why NLIs are seen as beneficial is because no prior training is required in order to utilize them as people use natural language in order to interact with each other on a daily basis. Other benefits of conversational speech interfaces include:

* 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.