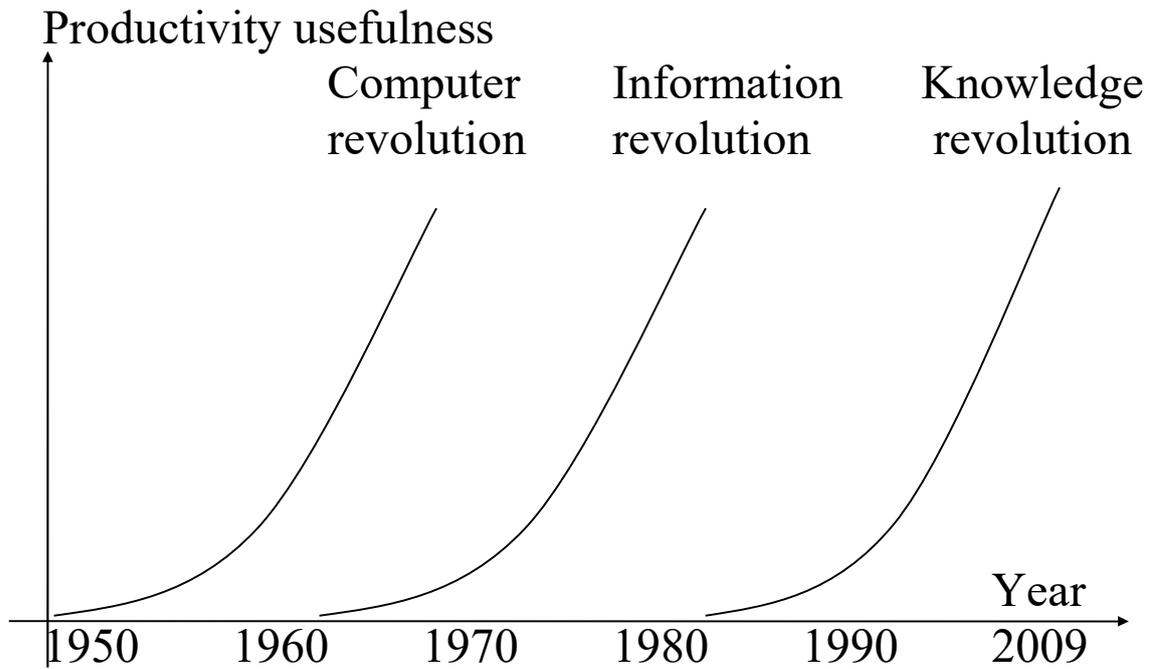


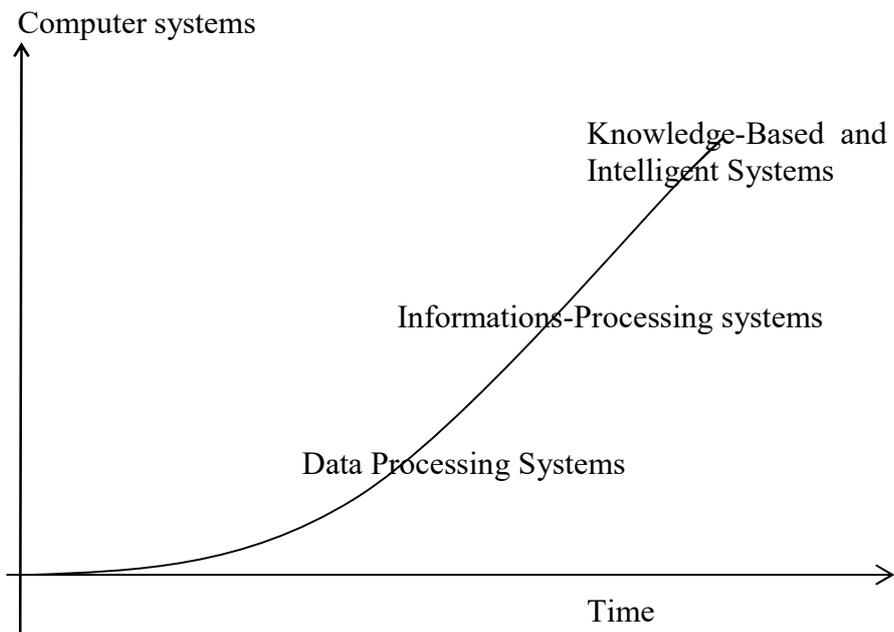
# KNOWLEDGE-BASED SYSTEM

## 1. Introduction and Definitions

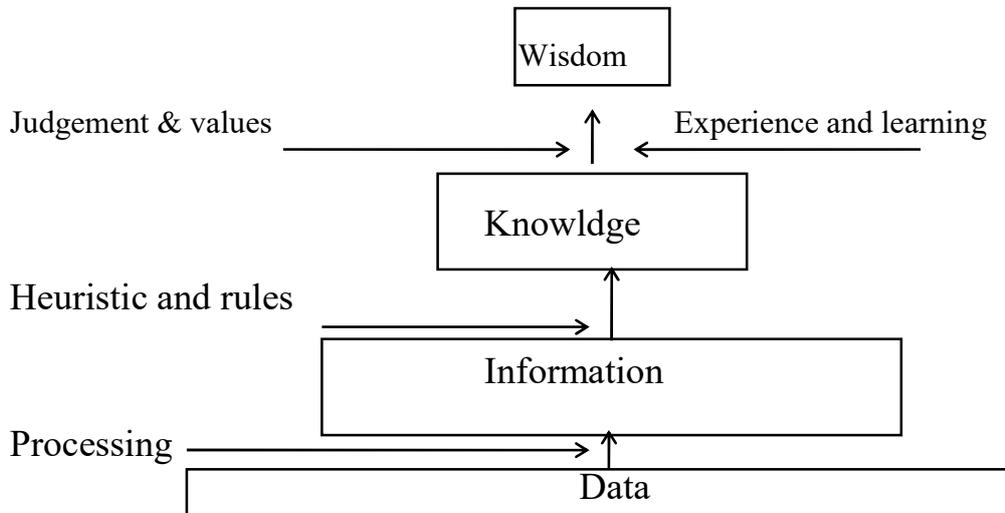
### 1.1. Evolution of Computer processing



### 1.2. Growth curves for Computing



### 1.3. Hierarchy of Data, Information and Knowledge Structure

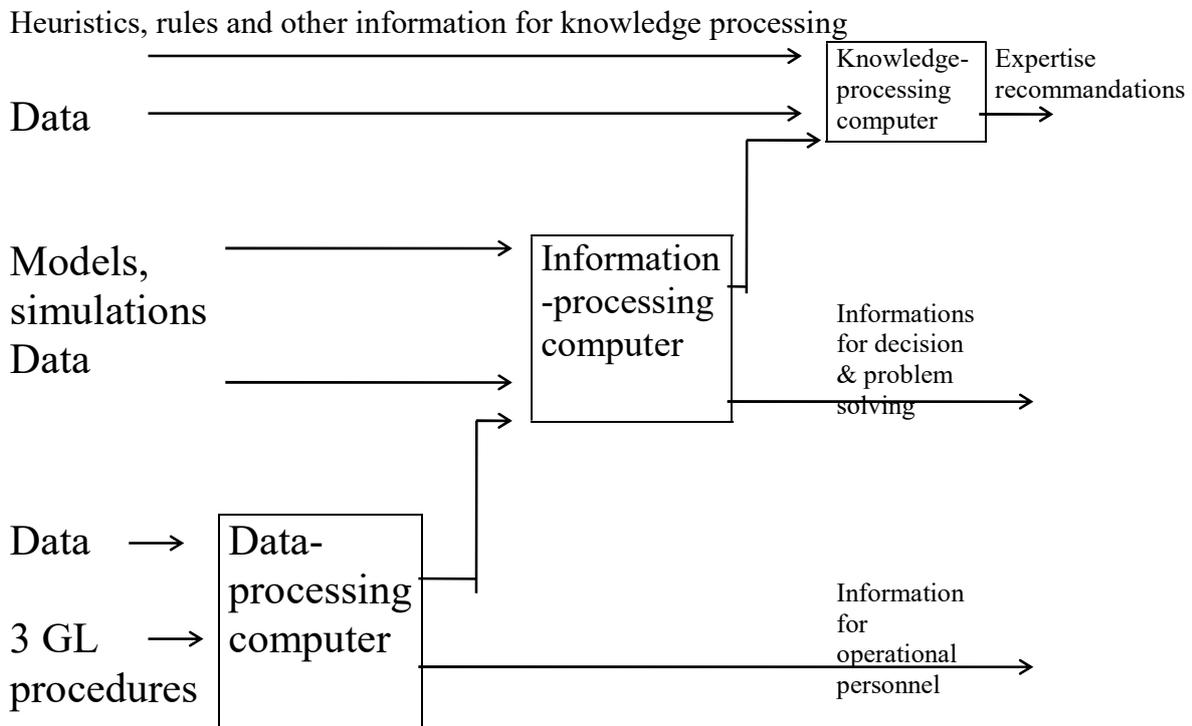


### 1.4. Definition of Knowledge-Based Systems

*What is Knowledge-based systems?*

« Knowledge-based systems(KBS) are computer programs, usually based on technologies developed by AI research, that performs task normally done by an expert or consultant ».

### 1.5. Relationship of Data Processing, Information Processing and KBS



### 1.6. Comparison of KBS with Transactional Systems

	Transactional System	KBS
<b>Objective</b>	To facilitate Operations	To replicate human decision making and to transfer expertise
<b>Type of task</b>	Number-crunching	Intellectual
<b>Unit of processing</b>	Data	Knowledge
<b>Scope</b>	Across the board	Narrow domain
<b>Mother discipline</b>	Data processing	Artificial intelligence
<b>Personnel involved</b>	Systems analyst & programmer	Domain expert & Knowledge engineer
<b>Programming</b>	3GL procedural	3GL and AI languages

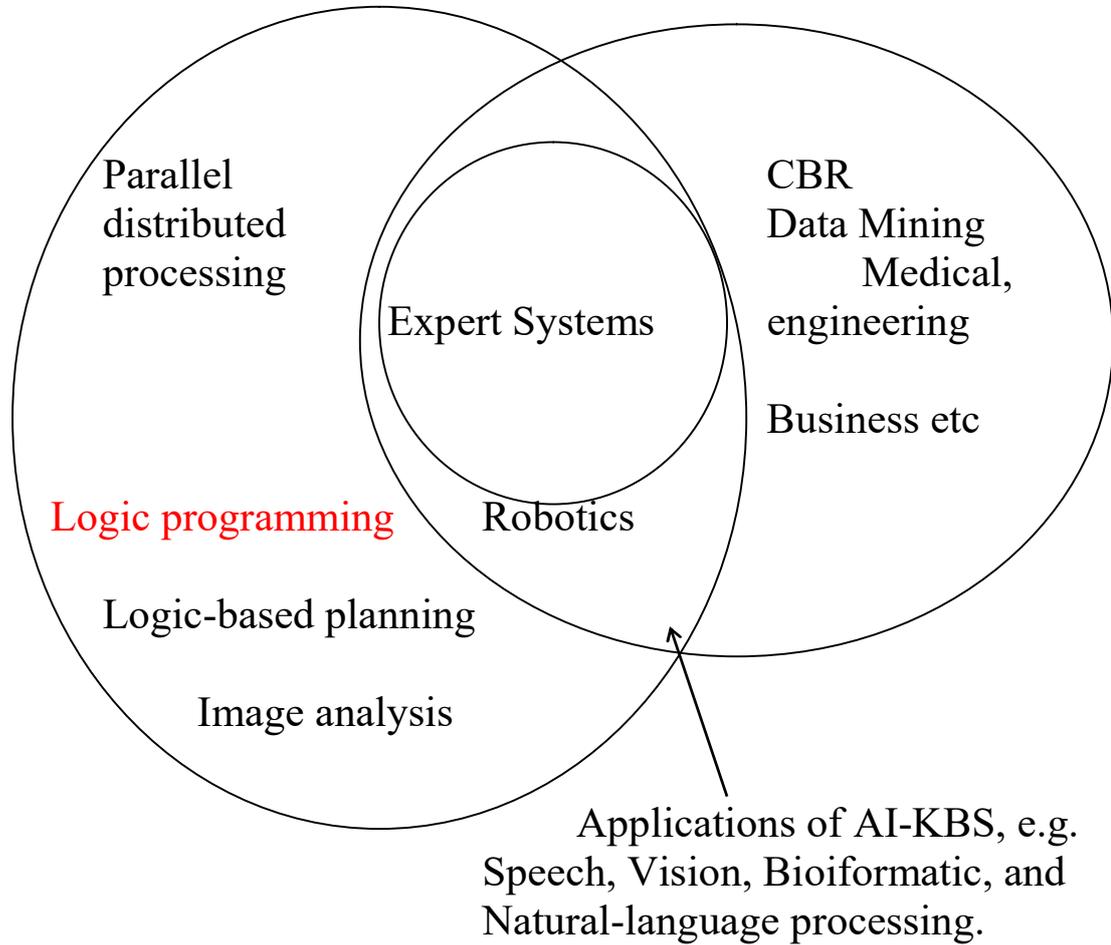
### 1.7. Comparison of Neural Net with KBS

	Neural Net	KBS
<b>Objective</b>	To be trained to exhibit the desired behaviour	To be built to replicate human decision making & to transform expertise
<b>Type of task</b>	Analyse data after previous training or learning sets	Analysis with conventional and KBS approaches
<b>Driver</b>	Numerical data	Knowledge and symbols
<b>Scope</b>	Self organizing (largely unknown)	Narrow domain and closed
<b>When invoked</b>	For massive parallel processing and pattern recognition	Sequential, logic-based repetitive symbolic manipulation
<b>Interface</b>	Not so friendly	Very friendly
<b>Reasoning</b>	Associative	Logical
<b>Mother discipline</b>	Biological science	AI
<b>Personnel involved</b>	Neurocomputing engineer	Domain expert & knowledge engineer
<b>Computer</b>	parallel processors	PC to mainframe

1.8. Relationship of AI to KBS

AI

KBS



## 2. Knowledge-Based System: Basic Concepts

### 2.1. Introduction

A Knowledge-Based System (KBS) is a computer program that draws upon the knowledge of human experts captured in a knowledge-base to solve problems that normally require human expertise.

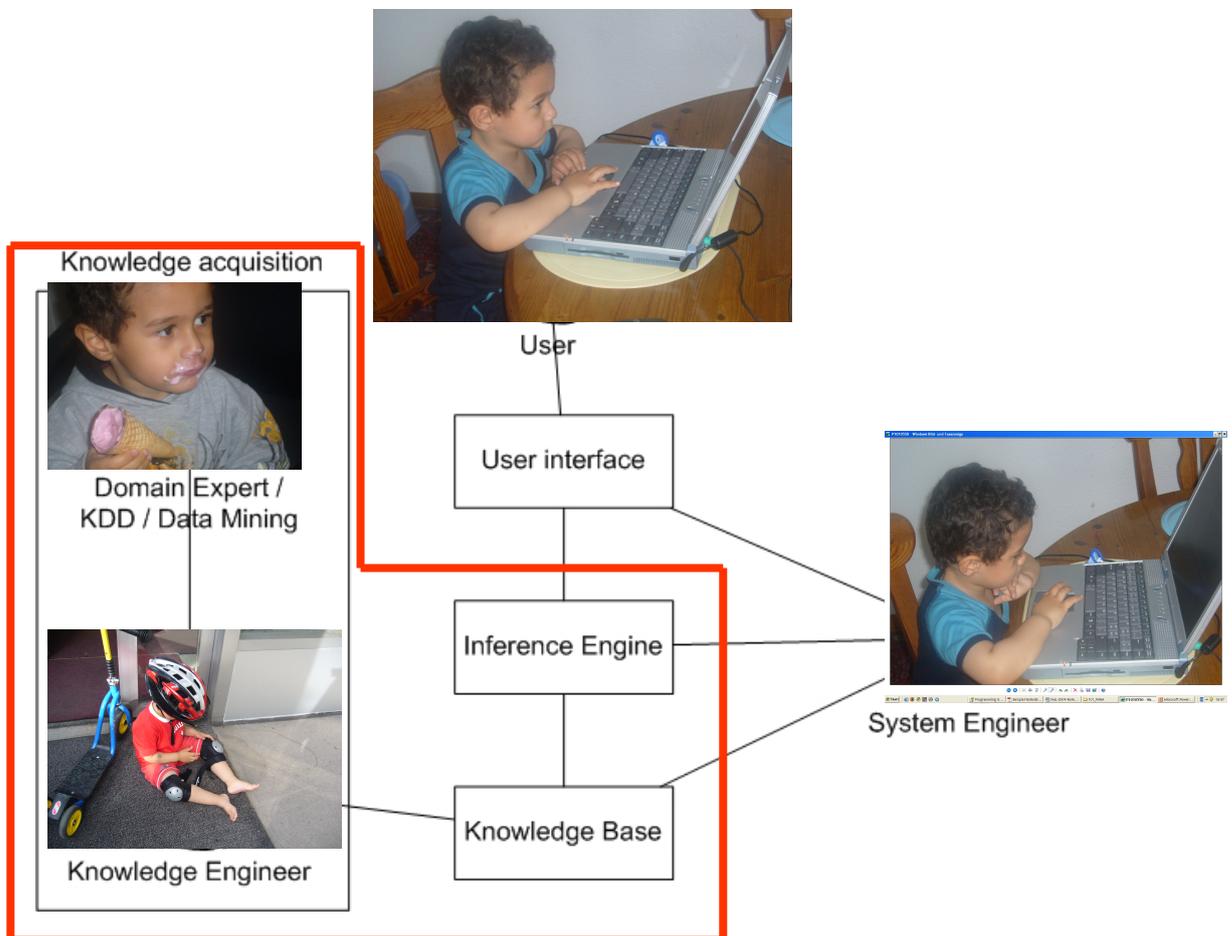
In this chapter we first introduce the reason why KBS are developed, then look at the components of such systems. We also describe the benefits, limitations and use of KBSs. The chapter concludes with a comparison of KBS and KBS shell, types and examples of knowledge as well as an overview of KBS.

## 2.2. Why develop Knowledge-Based System?

Some reasons for wanting a KBS:

- ☞ Experts needed in different places.
- ☞ Danger of losing human experts.
- ☞ Human experts are more expensive than KBS.
- ☞ Experts needed in environments hostile to human.
- ☞ Competitors have advantages in expertise.

## 2.3. Components of Knowledge-Based System



## 2.4. **Appropriate Problem Environments and Applications of Knowledge-Based System**

- ☞ **Diagnosis:** To identify a problem given a set of symptoms or malfunctions (e.g. a KBS to diagnose reasons for engine failure, medical diagnosis ...). See KBS doctor.esi
- ☞ **Instruction:** To train students and correct their performance (e.g. a KBS to give medical students experience diagnosing illness). See the listing of KBS doctor.esi
- ☞ **Interpretation:** To infer a situation from sensor data (e.g. a KBS to estimate molecular structure of unknown compounds by analysing mass spectrographic and other data ...).
- ☞ **Prediction:** To predict a future state from a set of data or observations of given situations (e.g. KBS to evaluate the likelihood of oil or mineral deposits given soil samples ...).
- ☞ **Design:** configuring object under constraints (e.g. an KBS to configure mini-computer, IC, chess ...). See KBS Queens.l
- ☞ **Planing:** Both long and short term in areas such as project management, product development or financial planing (e.g. KBS to plan tax shelters)
- ☞ **Monitoring:** comparing observations to plan vulnerabilities
- ☞ **Debugging:** To identify and prescribe remedies for malfunctions (e.g. a KBS to identify errors on network and recommend ways to correct the errors).
- ☞ **Control:** Interpreting, predicting, repairing and monitoring system.

## 2.5. **Advantages and Limitations of Knowledge-Based System**

The characteristics of KBSs, which we have already presented, do imply their advantages and limitations. Nevertheless, we feel that it is useful to state them explicitly.

## Advantages of Knowledge-Based System

1. The KBS is a **repository of valuable information** that might otherwise be lost and inaccessible to the firm creating the system and even a loss to society as a whole.
2. The KBS can be indispensable when **human expertise is not accessible**. This could be critical in disciplines such as medicine and in remote areas.
3. KBS could be more **efficient and cost effective** than **human systems**, and will become increasingly so as wages of human professionals rise.
4. The KBS could be better **than local** and even national **human experts** if the expertise of world-renowned experts is captured within **the knowledge-base** of the system.
5. A KBS that is predictive can be particularly valuable when the predictions are generated **fast and tirelessly**.
6. A flexible, adaptable KBS can grow **modularly and be constantly kept up to date**. Human expertise often lags way behind the state of the art when the human lacks both time and inclination to **assimilate new knowledge**.
7. A KBS can be used for training **future human experts**. One such system can be duplicated, at **very little cost**, to yield as many copies as are required.
8. A **KBS will always be able to** (and be prepared to) **explain its premises and lines of reasoning if so requested**. It will readily explain the why and how of its conclusions and predictions. **This adds to system credibility and user friendliness**.
9. A KBS **deals with uncertainty and fuzzy data in an explicit manner**. Its methods in such ill-understood areas are open to inspection; a human expert's are not.
10. **A KBS can be particularly useful in an organization with high employee turnover**, low human performance, and a rapidly changing product mix.
11. KBS may be in high **demand in developing countries where human expertise** (such as agricultural or medical experts) is rare and expensive, where education levels are low, and where professional expertise is limited or substandard when available.
12. Advice from KBS in an organization will be consistent; it could even be faster and more efficient.

## Limitations of Knowledge-Based System

1. A KBS cannot reason on the basis of a human 'gut feeling', of intuition, or even of common sense, because these modes of reasoning are not easily representable as a knowledge-base of rules and facts.
2. A KBS is confined to a restricted domain of expertise; it cannot easily integrate expertise from other domains.
3. Many of the conceptually complex and tough problems in business, industry, and society (e.g. high-level planning decision making) do not appear to be applicable to current KBS technology.
4. There are whole classes of problems in our society, especially procedural and behavioural problems (e.g. evaluating people for their future performance and behaviour, especially at hiring time), for which we have few (or no?) human experts, and hence, little or no chance to acquire a knowledge-base for a KBS.
5. KBS do not learn as humans do, at least not yet. The benefit of human learning can be used to update a knowledge database, but the process is not automatic.
6. Current KBSs cannot reason reliably from theories or from analysis.
7. The knowledge in a KBS is highly dependent upon the human expert expressing and articulating knowledge in the form that can be used in a knowledge-base.

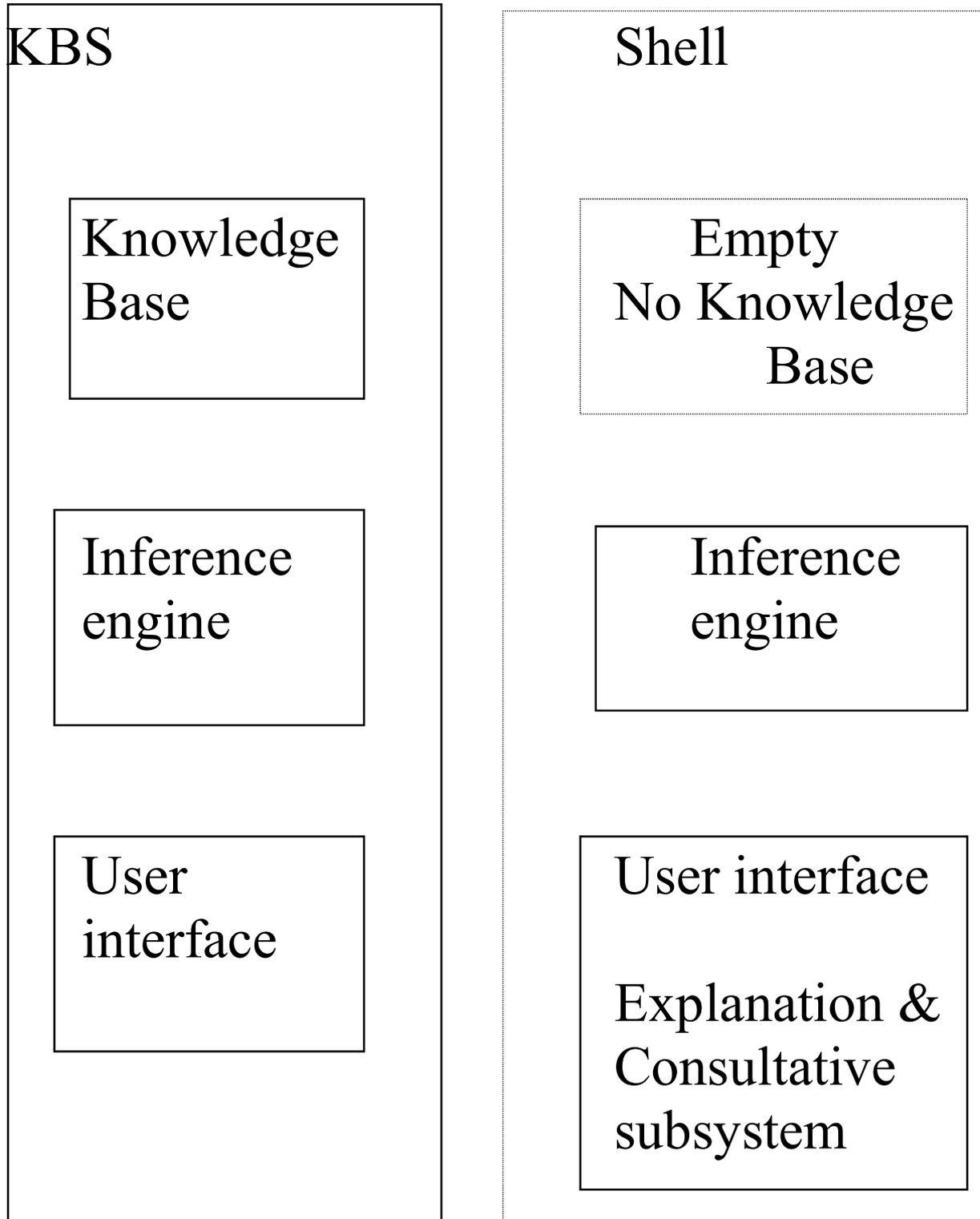
## 2.6. Knowledge-Based System Versus Traditional Systems

In examining the advantages and limitations of KBSs, it is clear that they are different from traditional systems for data processing, and from conventional approaches to computer programming. We present some of these differences.

1. What most differentiates a KBSs from traditional and conventional systems is the basis of **symbolic processing** as opposed to **numeric processing** that dominates most traditional systems.
2. KBSs are driven by heuristics rather than guaranteed algorithms (i.e. they use strategies, or rules of thumb, just because they 'work', **rather than algorithms** that are in some sense 'correct').
3. KBSs are interactive; explanations, in particular, are usually obtainable at any point in a run of the system. This can be contrasted with many batch-processing, transactional systems where mid-run feedback is unobtainable.
4. KBSs must be created and maintained by relatively scarce knowledge engineers while traditional computer systems analysts and programmers perform this role with conventional data-processing systems.
5. The knowledge-base of a KBS is often more flexible and easier to modify than many a conventional database.
6. Processing within a KBS is an open inferential process when compared with the fixed-operation, repetitive nature of data processing systems.
7. A KBS must operate under uncertainty and with incomplete information.
8. As for data, KBSs have to deal with 'fuzzy' data i.e. data that are qualitative and derived from a consensus of expert opinion

## 2.7. Comparison of a KBS and KBS shell

See the KBS for sentence analysis.



## 2.8. Types of Knowledge

**Fact:** A fact is something real that is actual, objective and demonstrable. A fact is knowledge that is widely available and universally agreed upon, it should be documented.

**Heuristic or surface knowledge:** A heuristic is developed partly through the knowledge of the expert and partly through a study of the logic schema formed by rules. Heuristics are called « surface knowledge », it is derived from experience and apprenticeship.

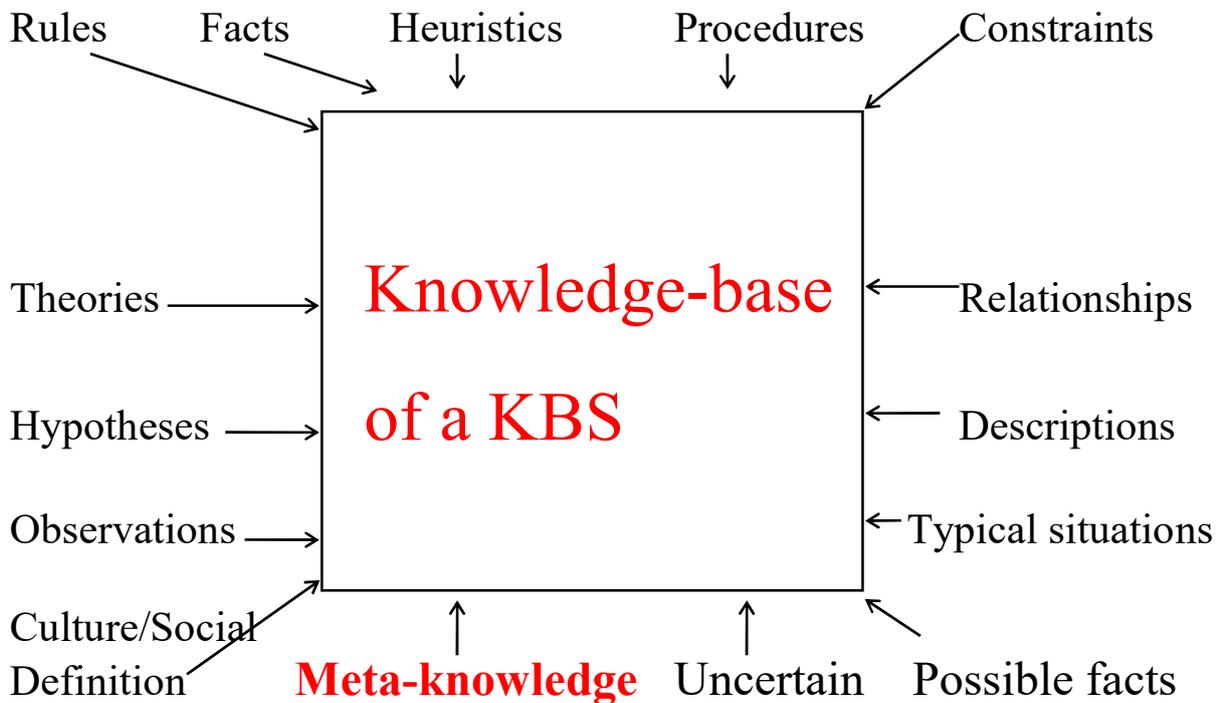
**Procedure:** A procedure is set of instructions on how to carry out a task. Every step in the procedure must be unambiguously stated in detail. Procedures stated the « how », while declarative knowledge states the « what ».

**Deep knowledge:** is derived from first principles, axioms, laws and theories, and is possibly generalized over many domains.

**Descriptions:** Is the description of domain's real world object, e.g. « Your chair has four legs » or « your chair should have three legs ».

**Chunks:** One approach to the organization of knowledge is to arrange it in chunks, where chunk is a meaningful portion of knowledge that can be stored and retrieved as a functional unit. A chunk has often been used as one measure of a domain expert, who would have 50 000 to 100 000 chunks of domain-specific knowledge organized and stored in long term memory.

**Meta knowledge:** is the organization of the knowledge(knowledge on knowledge)



Types of knowledge in a knowledge-base

## 2.9. *Examples of knowledge*

### a) **Words:**

- boat, paper, abstraction, analogy, propeller.

### b) **Encyclopedic knowledge:**

- London is the capital of England.
- Earth revolves around the sun.
- Ice is solidified water.

### c) **World knowledge (or common sense knowledge):**

- If you drop a glass 2 meters from the floor, it will shatter.
- You cannot fit in the same space occupied by another person.
- You can't make a car run without fuel.
- You must open the door first before leaving the room.

### d) **Algorithms, recipes or procedure:**

- To change your tire, first grab your jack, raise the car, unscrew the Nuts.
- To go to a party, first check if you have been invited, then take a shower, dress your best cloth.."

e) **Stories:** Not too long ago, there was a big ship named Titanic...

f) **Plans:** To make this Titanic movie we will have to:  
find a studio with lots of money to invest.  
find a charismatic couple for the main roles.  
etc.

g) **Indeterminate knowledge:** John is married with Jane or Mary

### h) **Fuzzy knowledge:**

Here I would like to offer some comments. Representing fuzzy knowledge is a little bit more complicated than apparent. It's easy to say "The temperature is high". But this can be wrong, even in fuzzy ways. If you are going to get into the shower and the temperature of the water is 50 C, so I would say that it's high. However, if you are trying to cook an egg, this same temperature is low. So, representing fuzzy knowledge demands a representation of context too.

### i) **Time, time intervals:**

Over a period of ten years he was employee of GM.  
My lunch time is between 1:00 and 2:00 pm.  
I spend 20 minutes for lunch between 12:00 and 1:00.

j) **Vagueness**, similar to fuzzy.

### k) **Mental Properties:**

Degrees of belief (like "If it rains, I believe my son will get wet"), assertions on other people's knowledge ("Mary knows how to play the piano").

l) **Probabilistic knowledge:** "The probability of flipping a coin and getting a face is 50%"

**m) Imprecise data:** "There are about 100 people on the auditorium"

**n) Heuristic:** If

age(X) > 35  
and phone(X) = « NO »  
and adress(X) = « NO »

Then credit card = « BAD ».

**Heuristic:** Chess game: don't put your knight on a border line (in border line the knight has 4 potential moves, by other position it has 8 potential moves).

**Heuristic:** Water houseplants when the soil feels dry to the finger.

**Heuristic:** Allow one cup of uncooked rice for four servings.

**o) Rule:** If

cold is yes  
and much.cough is yes  
and squeaky.breath is yes  
and vibration.chest is yes  
and fever is yes

then type.disease is bronchitis

• If

fatigue is yes  
and fever is yes  
and cough is yes  
and sputum is yes

then type.disease is tuberculosis

• If

fever is yes  
and headache is yes  
and touch.to.chest is yes

then type.disease is anterior.poliomyelitis

**p) Fact:**

- Plants need water.
- Rice increases in bulk when cooked in water.

**r) Typical situation:** If the TV is placed the put the chair in front of the TV. It is like a plan.

## **2.10. Review and Discussion Questions**

- 1) What is a KBS?
- 2) What advantages does a KBS have over a human expert and vice versa
- 3) What is the meaning of the term « heuristic »?
- 4) What are the reasons an organization may choose to develop a KBS?
- 5) What are the major components of a KBS? What is the role of an inference engine?
- 6) What is the purpose of the explanation facility of a KBS? How does this facility serve the users?
- 7) Give examples of KBS for functional applications?

- 8) For which type of problems are KBS appropriate?
- 9) What is a fact and a chunk?
- 10) What are the advantages of a KBS? What are the limitations of a KBS?
- 11) Did you expect to find resistance to KBS? If so, Why, How can it be managed?
- 12) Give examples of heuristics, facts, rules, constraints and observations?

**2.11. Exercise: Visual Prolog Demo (GeoBase, Sentence analysis)**

Run some larger [Visual Prolog examples](http://www.pdc.dk/vip) (www.pdc.dk/vip) on the WEB. *Prolog Inference Engine (PIE) Licences Web, Password*

## 2.12. Overview of a Knowledge-Based system

Listed below is a listing of the knowledge-base of KBS doctor.esi.

goal is type.disease  
legalanswers are yes no

if rest.temp.over.100 is yes then fever is yes  
question rest.temp.over.100 is "Has the child been resting for over an hour and his temp is greater than 100?"

if active.temp.over.101 is yes then fever is yes  
question active.temp.over.101 is "Has the child been active in the last hour and his temp is greater than 101?"

if clear.nasal.discharge is yes and scratchy.throat is yes then cold is yes  
question clear.nasal.discharge is "Does the child have a clear nasal discharge?"

question scratchy.throat is "Does the child have a scratchy throat?"

if cold is yes  
and much.cough is yes  
and squeaky.breath is yes  
and vibration.chest is yes  
and fever is yes  
then type.disease is bronchitis

question much.cough is "Does the child cough a lot, and cough syrup is roughly ineffective?"

question squeaky.breath is "Does the child squeake as he breaths?"

question vibration.chest is  
"Can you feel a vibration in the child's chest as he breaths?"

if high.fever is yes and rapid.breathing is yes and cough is yes then type.disease is pneumonia

question high.fever is "Is the child's temperature over 103?"

question rapid.breathing is "Does the child have rapid, shallow breathing?"

question cough is "Does the child have a cough?"

if hoarse.cough is yes and difficulty.breathing is yes and fever is yes and cold is yes then type.disease is severe.croup

if hoarse.cough is yes and difficulty.breathing is yes then type.disease is croup

question hoarse.cough is "Does the child have a hoarse cough?"

question difficulty.breathing is "Does the child have difficulty breathing?"

if cough.when.move is yes and sinus.pain is yes then type.disease is sinusitis

question cough.when.move is "Does the child start coughing violently when he either lays down or gets up?"

question sinus.pain is "Does the child have any sinus pain?"

if high.fever is yes and headache is yes and vomiting is yes and tonsils.swollen is yes then type.disease is tonsillitis

question headache is "Does the child complain of headache?"

question vomiting is "Is the child vomiting?"

question tonsils.swollen is "Are the child's tonsils swollen with white patches on them?"

if sneeze is yes and itchy.nose is yes then type.disease is allergy

question sneeze is "Is the child sneezing?"

question itchy.nose is "Does the child complain of an itchy nose?"

if cold is yes and wheezing is yes then type.disease is asthmatic.bronchitis

question wheezing is "Is the child wheezing?"

if itching is yes and hives.rash is yes then type.disease is hives

question itching is "Does the child complain of itchy or scratchy skin?"

question hives.rash is

"Does the child have raised welts that are white in color?"

if eczema is yes then type.disease is eczema  
question eczema is "Does the child have patches of rough, red, rash, scaly skin?"

if cold is yes and fever is yes and measles.rash is yes then type.disease is measles

if measles.rash is yes then type.disease is german.measles  
question measles.rash is "Does the child have flat pink spots on the skin?"

if pox.rash is yes then type.disease is chicken.pox

question pox.rash is "Does the child's skin have separate, raised pimples, several with blisters?"

if headache is yes and fever is yes and vomiting is yes and sore.throat is yes and scarlet.rash is yes then type.disease is scarlet.fever  
question sore.throat is "Does the child have a sore throat?"

question scarlet.rash is  
"Does the child have a red blush-like rash on his skin?"

if prickly.rash is yes then type.disease is prickly.heat  
question prickly.rash is "Does the child have patches of tan-pink pimples?"

if itching is yes and scabies.rash is yes then type.disease is scabies  
question scabies.rash is "Are there groups of pimples topped with scabs on the child?"

if ringworm.rash is yes then type.disease is ringworm  
question ringworm.rash is "Are there circular patches of rough skin on the child?"

if impetigo.rash is yes then type.disease is impetigo  
question impetigo.rash is "Are there pimples on the child with a partly brown crust?"

if itching is yes and ivy.rash is yes then type.disease is poison.ivy  
question ivy.rash is "Are there clusters of small blisters on reddened shiny skin?"

if cold is yes and delayed.cough is yes then type.disease is whooping.cough  
question delayed.cough is "Did the child start coughing about one week after getting the cold?"

if neck.swelling is yes then type.disease is mumps  
question neck.swelling is "Does the child have extensive swelling in the side of his neck?"

if sore.throat is yes and fever is yes and dirty.white.patches is yes then type.disease is diphtheria  
question dirty.white.patches is "Does the child have dirty white patches on his tonsils?"

if fever is yes and headache is yes and touch.to.chest is yes then type.disease is anterior.poliomyelitis  
question touch.to.chest is "Is it impossible for the child to touch his chin to his chest?"

if fatigue is yes and fever is yes and cough is yes and sputum is yes then type.disease is tuberculosis  
question fatigue is "Does the child complain of general fatigue?"

question sputum is "Is the child producing sputum?"

if fever is yes and fatigue is yes and tender.joints is yes then type.disease is rheumatic.fever  
question tender.joints is "Does the child complain of tender joints?"

if nervous.disease is yes then type.disease is chorea  
question nervous.disease is  
"Does the child have twitching or writhing movements in DIFFERENT places?"

if naval.pain is yes and tender.abdomen is yes then type.disease is appendicitis

question naval.pain is "Has the child complained of pain around his naval for several hours?"

question tender.abdomen is "Does the child have a tender abdomen on the right side?"

if inflamed.ears is yes and fever is yes then type.disease is serious.ear.infection  
if inflamed.ears is yes then type.disease is ear.infection

question inflamed.ears is "Does the child have inflamed ears?"

if high.fever is yes then type.disease is roseola  
answer is "Based on rudimentary knowledge, I believe the child has "  
type.disease

**For more informations on KBS see Appendix 2: « List of free and commercial expert system shells ».**