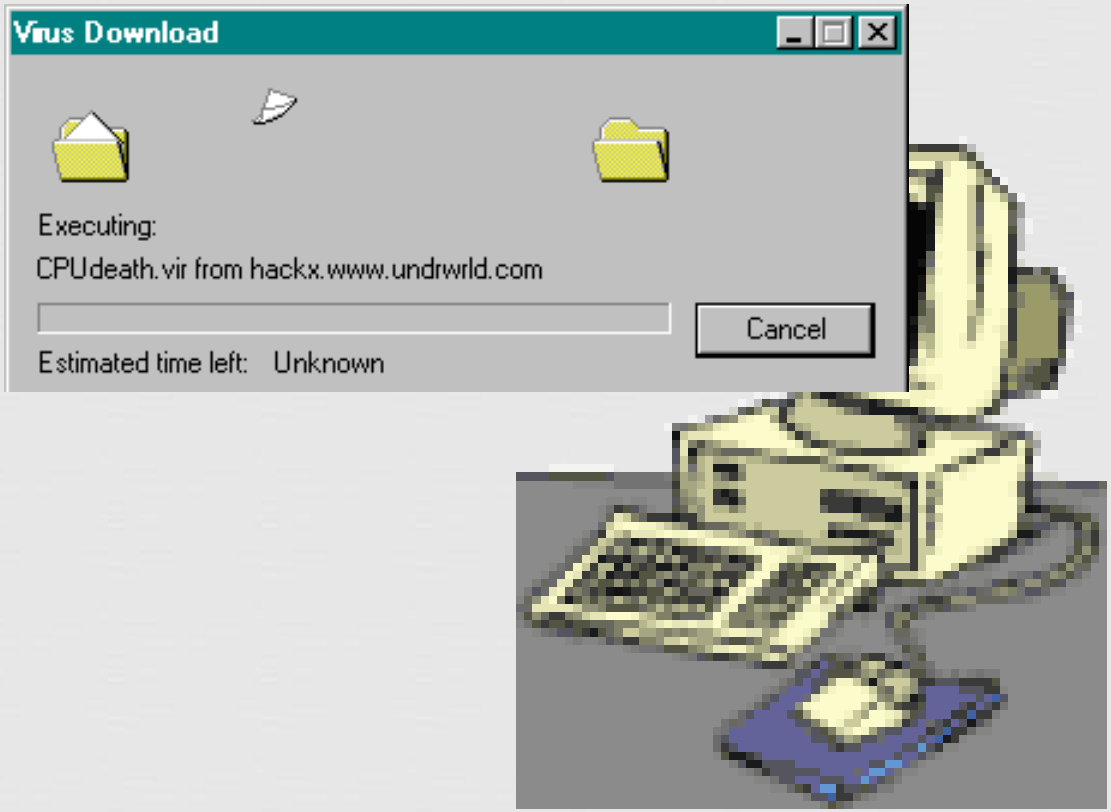
STIN2103

Knowledge & engineering & expert systems

Wan Hussain Wan Ishak

SOC 2079 Ext.: 4786 Email: hussain@uum.edu.my Url: http://www.wanhussain.com

Something to ponder

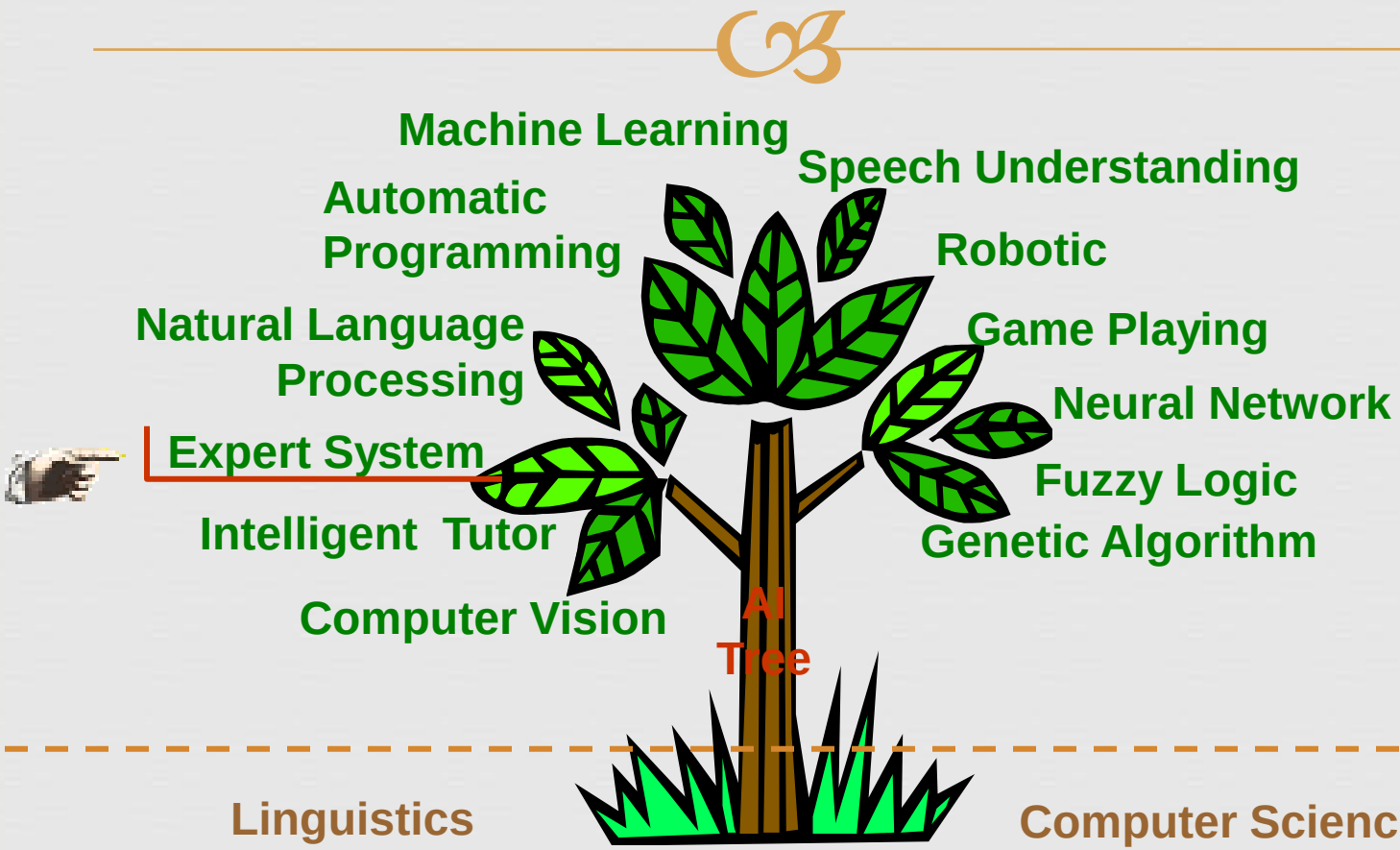


What?
Why?
How?

Introduction to Expert System

- Overview of AI paradigm
- Characteristics of Intelligent System
- Expert System
  - Definition, general concepts, characteristic of ES
  - Role/need
  - ES architecture
  - Problem domain
  - Advantages

Overview

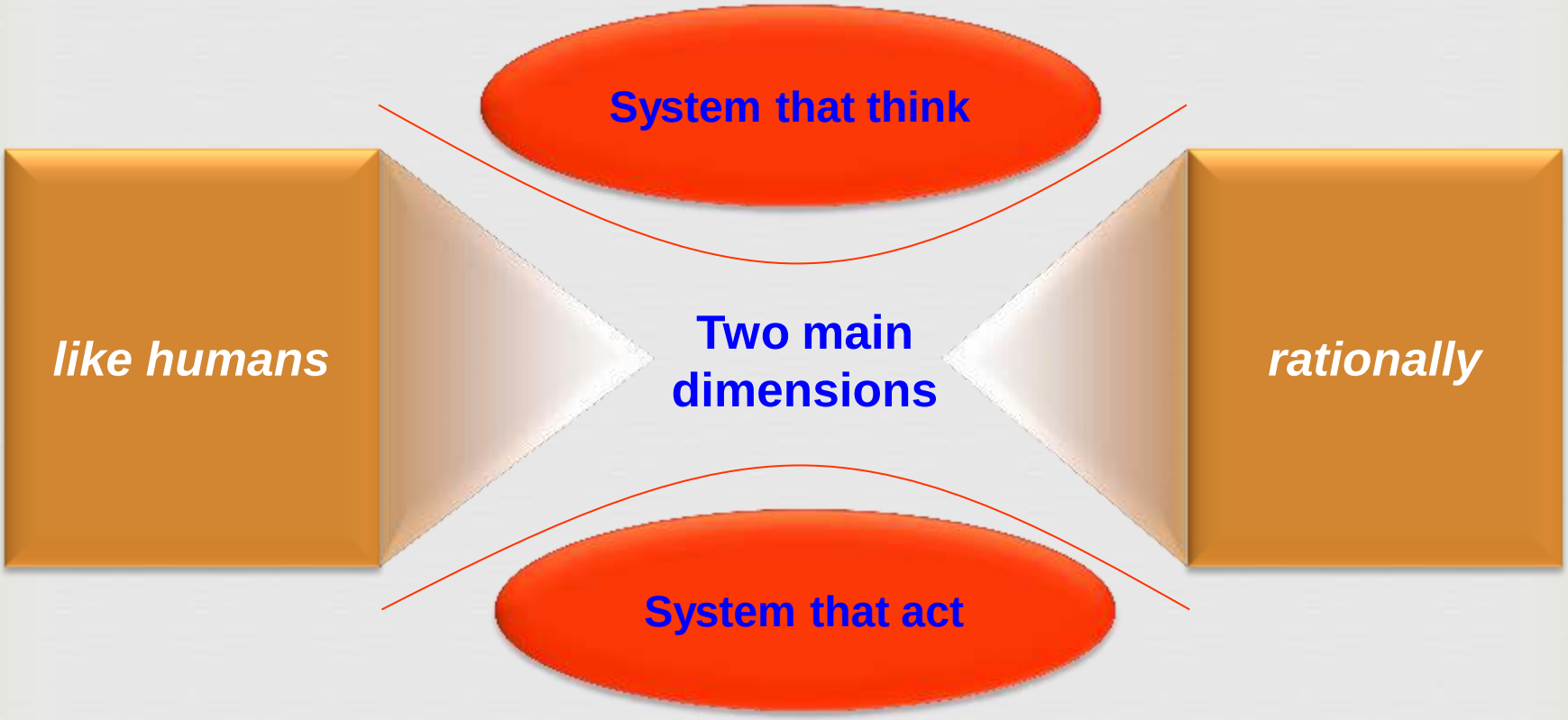

Machine Learning
Speech Understanding
Automatic Programming
Robotic
Natural Language Processing
Game Playing
Neural Network
Expert System
Fuzzy Logic
Intelligent Tutor
Genetic Algorithm
Computer Vision
AI Tree
Linguistics
Computer Science
Psychology
Management & Management Science
Philosophy
Electrical Engineering

What is Artificial Intelligence?

"Artificial Intelligence (AI) may be defined as the branch of computer science that is concerned the automation of intelligent behavior."

(Luger, 2002)

Definition of AI



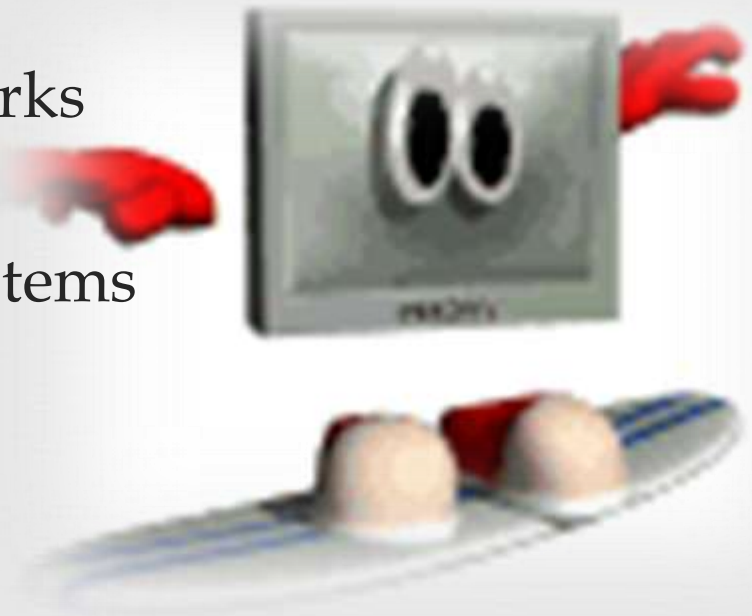
Source: Russell & Norvig, (2003)

Intelligent System?

- Contains knowledge representation and reasoning mechanisms.
- Ability to access and synthesize discrete pieces of information in creating a new understanding of any problem and its possible resolution.

Example of IS

- Expert systems
- Fuzzy systems
- Artificial neural networks
- Genetic algorithms
- Swarm intelligence systems



Characteristics of IS

- Humans have the ability to store and retrieve vast amounts of information efficiently which allows them to:
  - solve complex problems
  - reach decision
  - connect their thoughts and ideas in non-linear, associative ways

- Computer?

  Intelligent System?

Source: Padhy (2006)

Characteristics of IS

- Exhibit adaptive goal-oriented behavior
- Learn from experience
- Use vast amounts of knowledge
- Exhibit self-awareness
- Interact with human using language and speech
- Tolerate error and ambiguity in communication
- Respond in real-time

Source: Reddy (1996)

Expert System?

Expert System?

"An intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solutions"

Prof. Edward Feigenbaum
Stanford University
an early pioneer of ES technology 1982

Expert System?

Practitioners:

> *"A systems can be said to be an ES if it performs at or near the level of human experts"*

Others:

> *"ES is one that is applied to the difficult and important problems that we associate with calling in human experts as consultants"*

(Black, 1986)

Expert System?

"ES is a computer-based system that uses knowledge, facts, and reasoning techniques to solve problems that normally require the abilities of human experts."

(Martin & Oxman, 1988)

"A computer program designed to model the problem solving ability of a human expert"

(Durkin, 1994)

Expert System?

"A Computer program that represents and reasons with knowledge of some specialist subject with a view to solving problem or giving advice"

(Jackson, 1999)

"A system that uses human knowledge captured in a computer to solve problems that ordinarily require human expertise"

(Turban & Aronson, 2001)

Overview of ES

- ES makes extensive use of specialized knowledge to solve problems at the level of human expert.
- An expert is a person who has expertise in a certain area.
- ES is often applied to any system that uses ES technology - Include special ES languages, programs, and hardware designed to aid in the development and execution of ES.

Characteristics of ES

- Separates knowledge from control
- Processes expert knowledge
- Focuses expertise
- Reasons with symbols
- Reasons heuristically
- Permits inexact reasoning
- Is limited to solvable problems
- Thrives on reasonable complexity
- Makes mistakes

Source: Durkin (1994)

Characteristics of ES

- Basic characteristics required for an expert system:
  - High performance
  - Expertise
  - Adequate response time – perform within a reasonable amount of time
  - Good reliability
  - Self-knowledge – ability to examine their reasoning process and explain their operation
  - Understandable – be able to explain the steps of reasoning while executing.
  - Justification – justify the answers or advice.
  - Flexibility – mechanism for adding, changing and deleting knowledge.

Source: Padhy (2005) based on Giarratano & Riley (2002)

ES vs. Conventional Programs (CP)

- **ES simulate human reasoning about a problem domain while CP simulate the domain itself.**
  - Building a computer model with the aim of realizing problem-solving capabilities comparable to a domain expert.
  - Not intended to create a cognitive adequate model, i.e, to simulate the cognitive processes of an expert in general, but create a model which offers similar results in problem-solving for problems in the area of concern.

ES vs. Conventional Programs (CP)

- **ES perform reasoning over representations of human knowledge, numerical calculations and data retrieval while CP perform numerical calculations and data retrieval.**

- **ES solve problems using heuristic of approximation methods that do not guarantee success while CP provide an algorithmic solutions.**

ES vs other AI prog.

- **ES deal with problems that require human expertise while most AI programs focus on abstract mathematical problems of simplified version of the real problems.**
- **ES must be fast and reliable while most AI programs do not run very fast.**
- **ES must be able to explain and justify their solutions while other AI programs do not have to meet this requirement.**

ES Problem Categories

Mundane tasks:

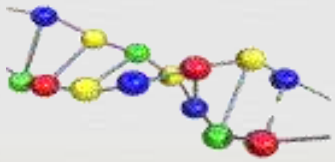
Perception, natural language, commonsense reasoning, planning, etc.

Formal tasks:

Game playing, solving mathematical problems etc.

Expert tasks:

Scientific analysis, medical diagnosis, etc.



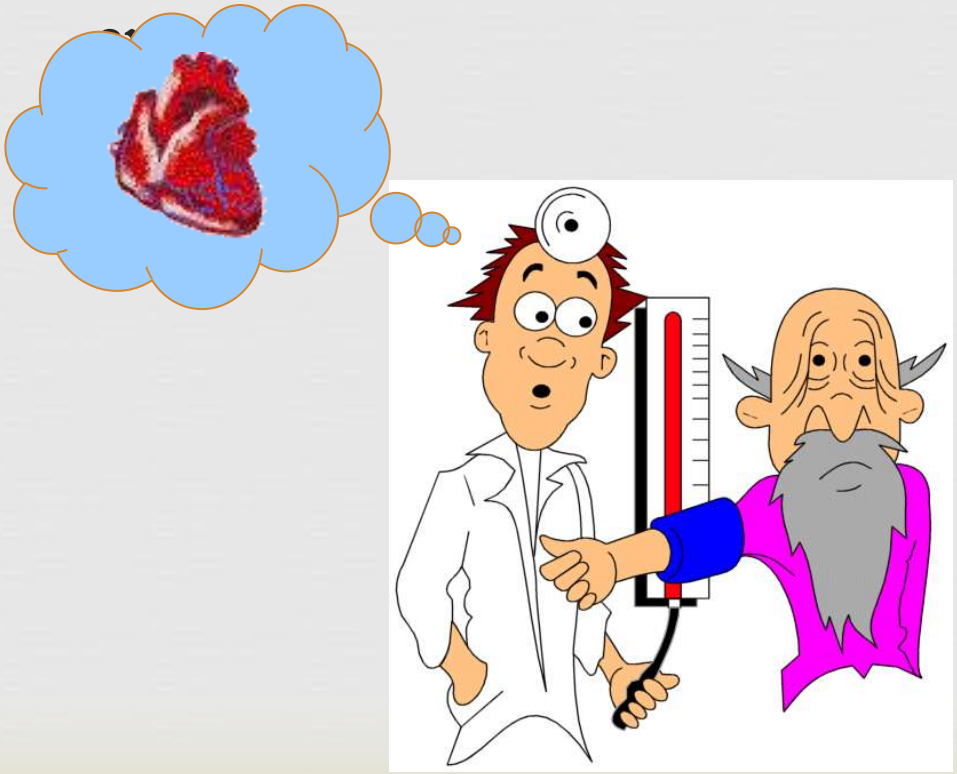
ES Problem Domain

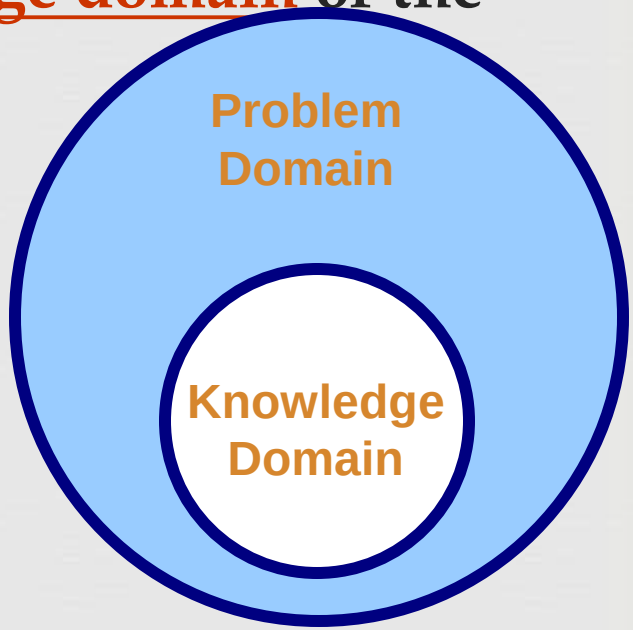
- ES is develop based on expert's knowledge.

- Expert's knowledge is specific to one problem domain.
  - Problem domain is the special problem area such as medicine, finance, science, and etc.

ES Problem Domain

- Expert's knowledge about solving specific problems is called the knowledge domain of the





Why Build ES?

- **Reasons:**
  - **Time availability (always available)**
  - **Geographic (available anywhere)**
  - **Safety (replaceable)**
  - **Not perishable**
  - **Performance (consistent)**
  - **Speed (consistent)**
  - **Cost (affordable)**

Why Build ES?

Factor	***Human Expert***	***Expert System***
Time availability	Workday	Always
Geographic	Local	Anywhere
Safety	Irreplaceable	Replaceable
Perishable	Yes	No
Performance	Variable	Consistent
Speed	Variable	Consistent (usually faster)
Cost	High	Affordable

Source: Durkin (1994)

ES Role

- To replace a human expert?
  - Replacing \= eliminating
  - Reasons underlying:
    - To make expertise available after hours
    - To make expertise available in other locations
    - To automate a routine tasks that requires an expert
    - To retain expertise after retirement of an expert
    - To reduce consultation fees
    - To avoid experts from danger

ES Role

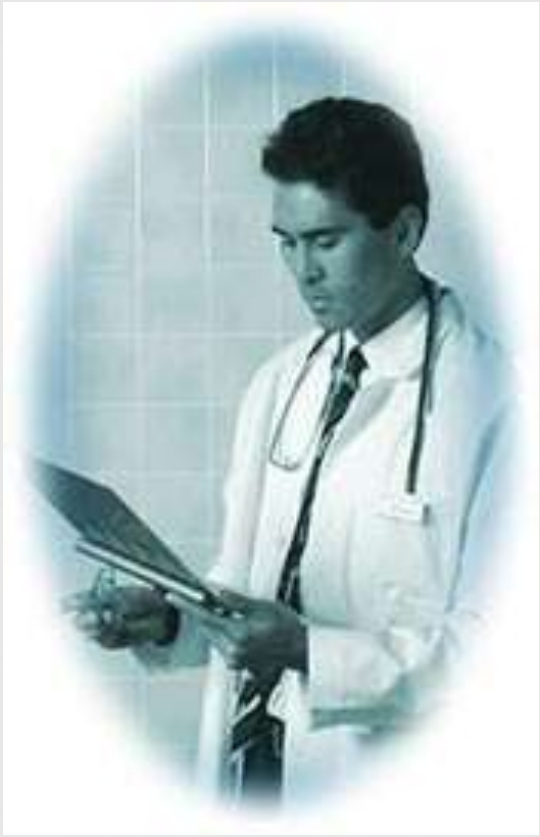
- To assist an expert?
  - The system aids the expert in a routine o mundane tasks.
  - Reasons underlying:
    - To improve productivity
    - To effectively manage the complexity of a task
    - To make available the information that is difficult to recall.

Advantages

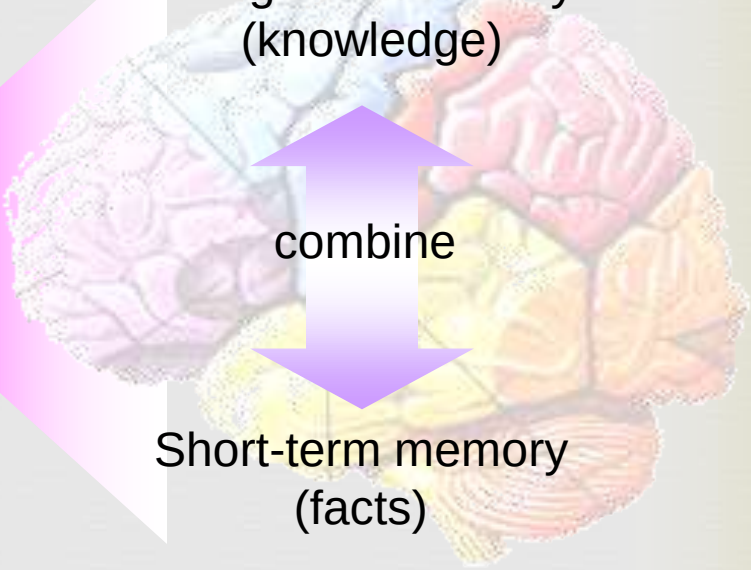
- Increased availability
- Reduced cost
- Reduced danger
- Permanence
- Multiple expertise
- Increased reliability
- Explanation
- Fast response
- Steady, unemotional, and complete response at all times
- Intelligent tutor
- Intelligent database

ES Structure

- Human Expert
  - Has specialized knowledge about the problem – domain knowledge.
  - Expert stores domain knowledge in his long-term memory (LTM).
  - New facts stores in short-term memory (STM).



Human Expert Problem Solving



Advice

Making conclusion

Patient

Obtains facts

Reasoning

Expert

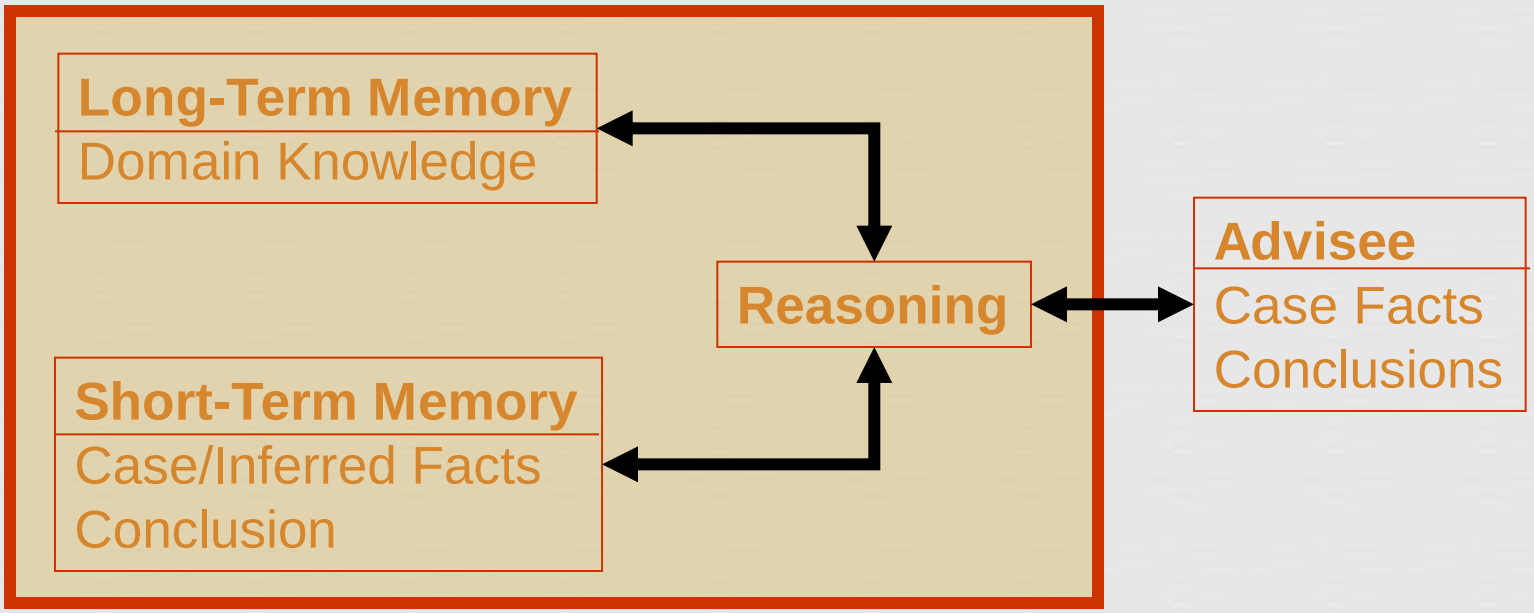
Long-term memory (knowledge)

combine

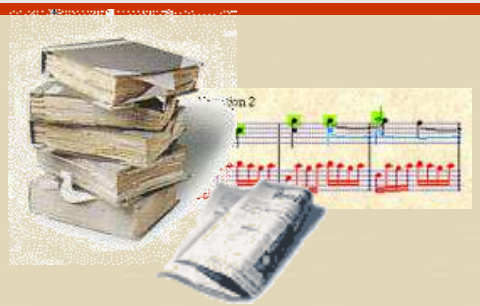
Short-term memory (facts)

Stores facts

Human Expert Problem Solving



Expert System



Knowledge base
(Domain knowledge)

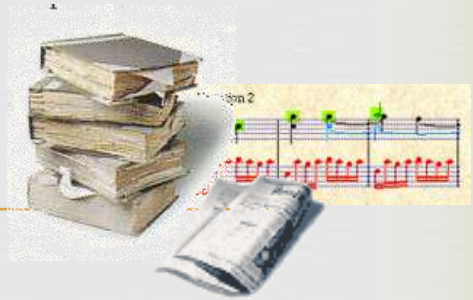
Inference engine

Interface

User
(Case Facts
Conclusions)

Working memory
(Case/Inferred facts
Conclusions)

ES Components

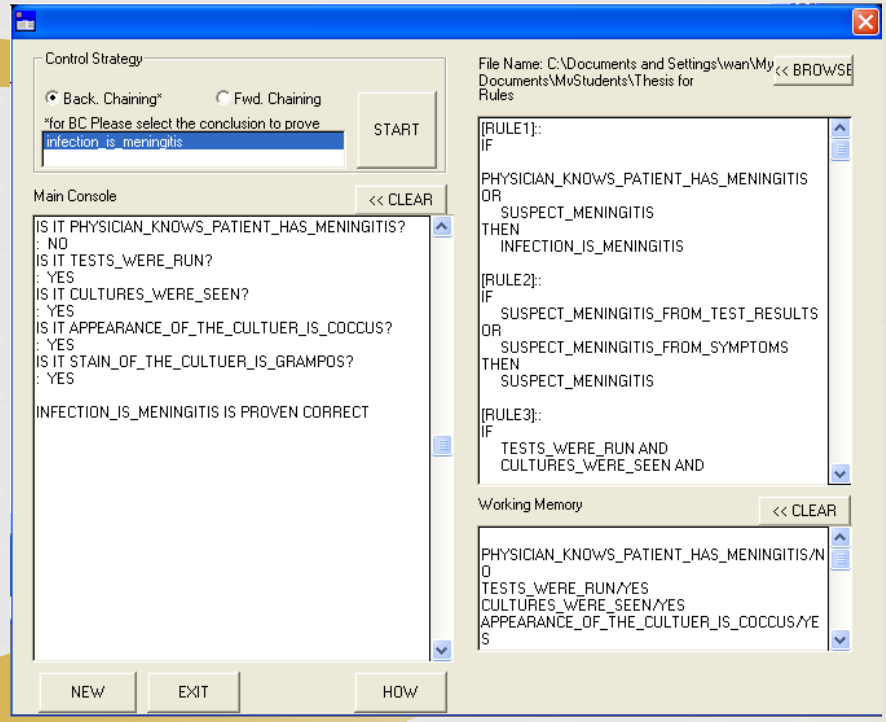


- **Knowledge base**
  - **Definition: Part of an ES that contains the domain knowledge.**
  - **The key bottleneck in developing ES.**
  - **Contain everything necessary for understanding, formulating and solving a problem.**
  - **Contain facts and heuristics.**
  - **The most popular approach to representing domain knowledge is using production rules.**

Knowledge base (example)

```
[rule1] ::
if   physician_knows_patient_
     has_meningitis
or  suspect_meningitis
then      infection_is_meningitis.


[rule2] ::
if   suspect_meningitis_from_
     test_results
or   suspect_meningitis_from_
     symptoms
then
     suspect_meningitis.
```



ES Components

- **Working memory**
  - **Definition: Part of an ES that contains the problem facts that are discovered during the session.**
  - **The engine matches this info with the knowledge contained in the system's knowledge base to inference new facts or conclusion.**
  - **The info is either supplied by the user or by the system.**

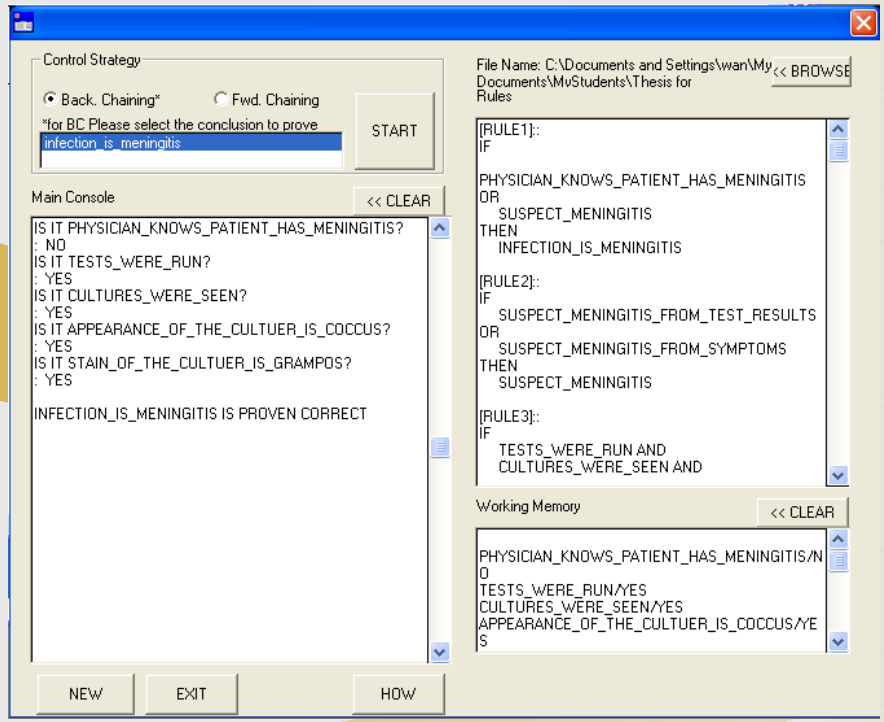
Working memory - example

PHYSICIAN_KNOWS_PATIENT_HAS_MENINGITIS/NO

TESTS_WERE_RUN/YES
CULTURES_WERE_SEEN/YES

APPEARANCE_OF_THE_CULTUER_IS_COCCUS/YES

STAIN_OF_THE_CULTUER_IS_GRAMPOS/YES



ES Components

- **Inference engine**
  - **Definition: Processor in an ES that matches the facts contained in the working memory with the domain knowledge contained in the knowledge base, to draw conclusions about the problem.**

ES Components

- **Inference engine**
  - **Knowledge processor which is modeled after the expert reasoning process.**
  - **Work with facts contained in the working memory and knowledge contained in the knowledge base - to draw conclusion.**
  - **When finds a match, it adds the rule's conclusion to the working memory and continues to scan the rules looking for new matches.**

Inference engine

Final Conclusion

Matching

Firing new fact or conclusion

Retrieving

Acquiring

```
[rule1] ::
if   physician_knows_patient_
     has_meningitis
or  suspect_meningitis
then
    infection_is_meningitis.

[rule2] ::
if  suspect_meningitis_from_
    test_results
or suspect_meningitis_from_
    symptoms
then
    suspect_meningitis.
```

Knowledge base

```
PHYSICIAN_KNOWS_PATIENT
_HAS_MENINGITIS/NO

TESTS_WERE_RUN/YES
CULTURES_WERE_SEEN/YES

APPEARANCE_OF_THE_CULT
UER_IS_COCCUS/YES

STAIN_OF_THE_CULTUER_IS_
GRAMPOS/YES
```

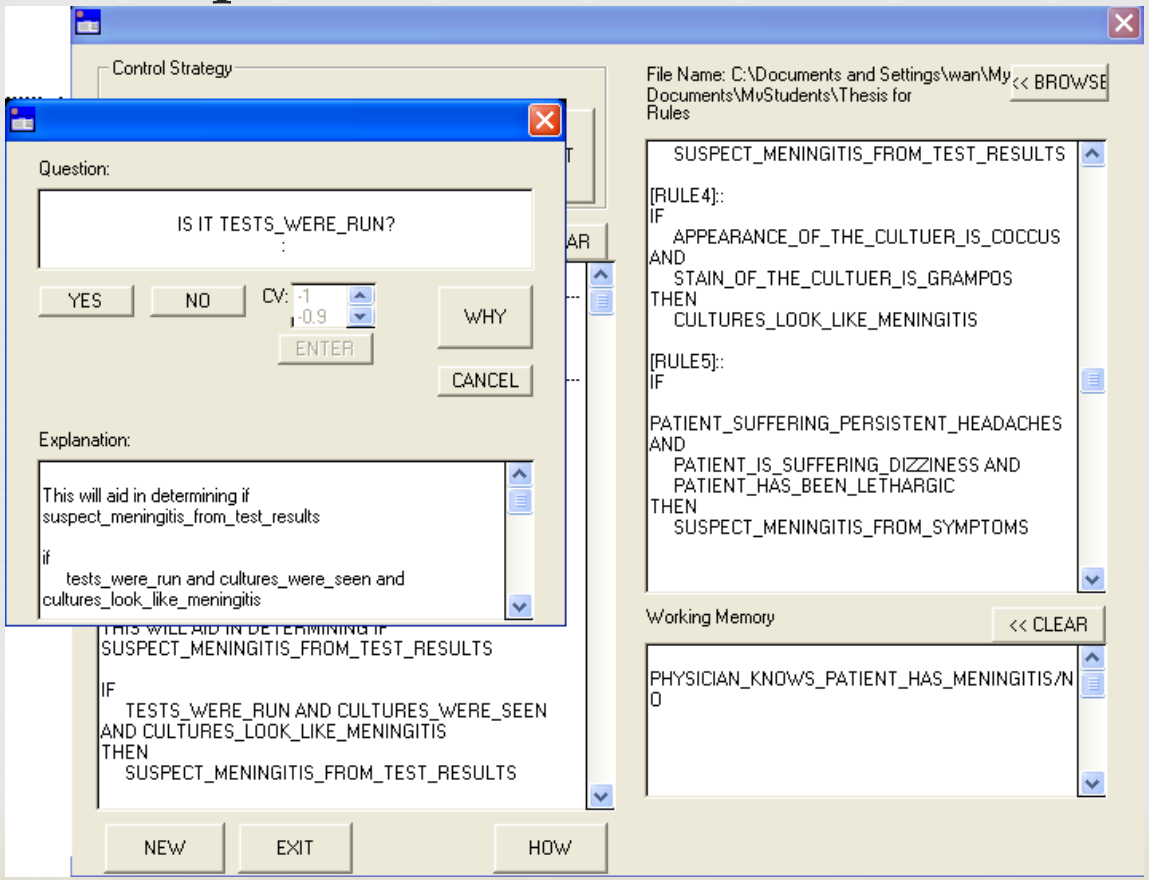
Working Memory

ES Components

- **User interface**
  - **A medium for a user to communicate with the system.**
  - **Allow users to submit queries, supply information and receive feedback.**

ES Components

- User interface - Example



ES Components

- **Explanation facility**
  - **Is an integral part of an ES.**
  - **A trademark of ES – ability to explain their reasoning.**
  - **Provide an explanation to the user about "WHY" it is asking a question and "HOW" it reached some conclusion.**

ES Components

- **Explanation facility - "WHY"**
  - **explain why ES ask a certain question to user.**
  - **The explanation**
    - make user feel more comfortable
    - provide insight into what issues the expert believes are important.

ES Components

- **Explanation facility - "WHY"**
  - **When "why" is asked – ES respond by describing what they might conclude from the answer.**
  - **Most ES respond by displaying the rule it is currently pursuing.**

ES Components

- Explanation facility - "**WHY**"
  - Example:

Rule 1:
IF The car will not start
THEN The problem may be in the electrical system

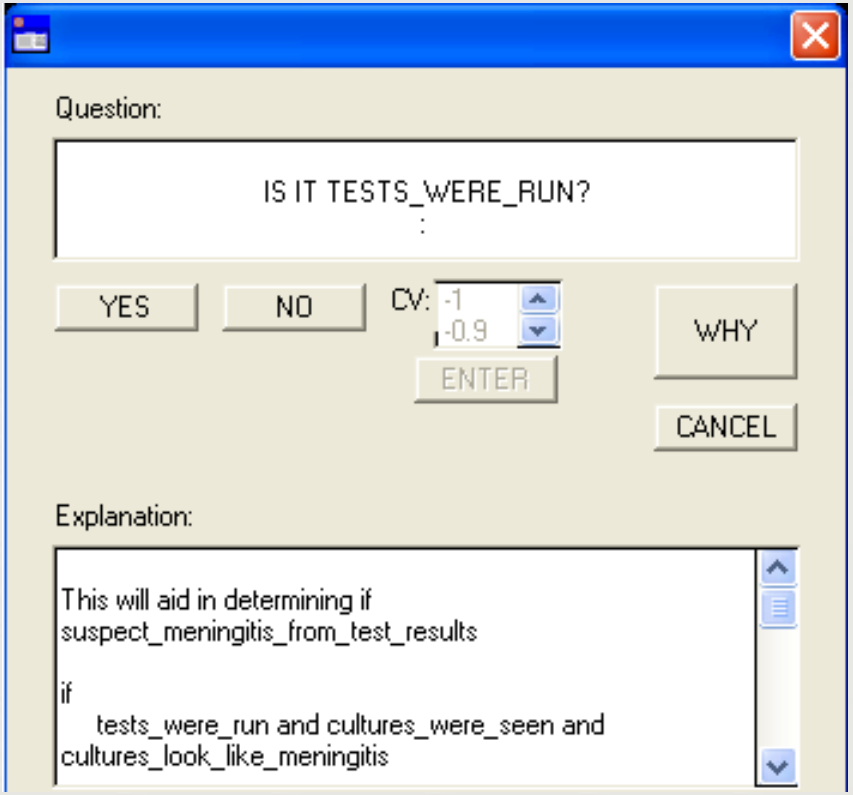
EXPERT: Will the car not start?

PERSON: WHY?

Expert: *"If I know that the car won't start, then I usually assume the problem is in the electrical system."*

ES Components

- **Explanation facility – "WHY"**



ES Components

- **Explanation facility - "HOW"**
  - **Explain how does ES derive a certain conclusion.**
  - **Very important in an ES – for the validity of ES results.**
  - **User will be more confident – if the rationale behind the recommendation is explained.**

ES Components

- **Explanation facility - "HOW"**
  - **Follows the reasoning process used by the human expert.**
  - **ES respond by tracking back through the rules that established the conclusion – a map of the system's line of reasoning.**

ES Components

- Explanation facility - "**HOW**"
  - Example:

Rule 1:
IF The car will not start
THEN The problem may be in the electrical system

Rule 2:
IF The problem may be in the electrical system
AND The battery voltage is below 10 volts
THEN The fault is bad battery

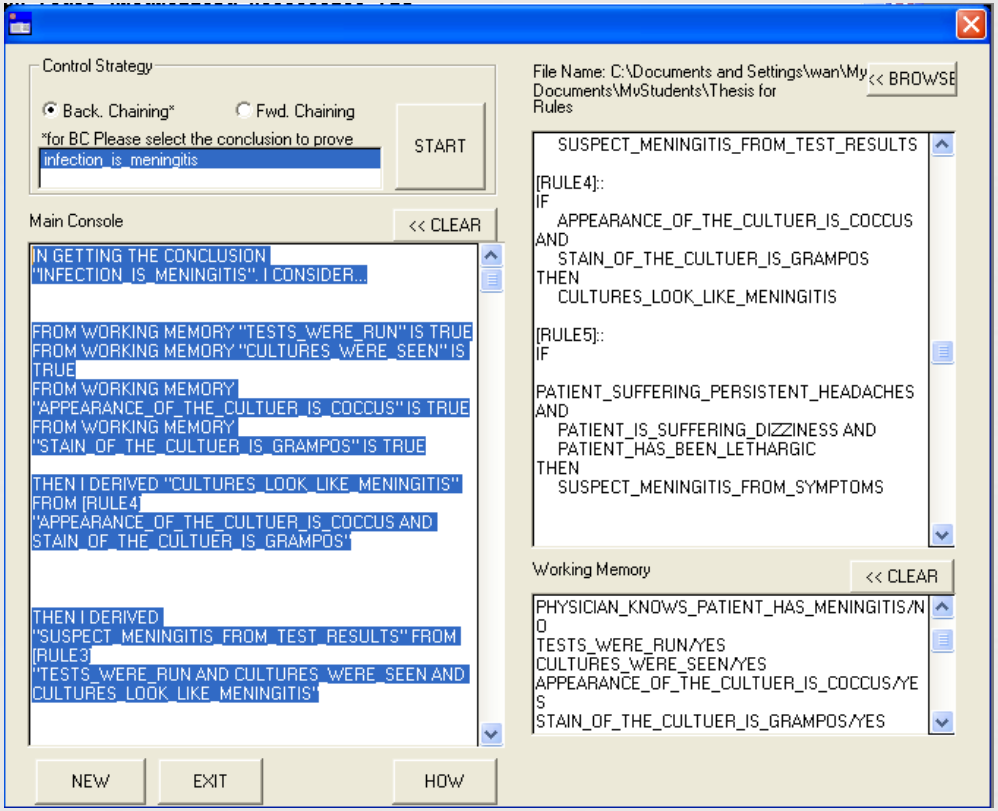
EXPERT: The battery is bad.

PERSON: HOW?

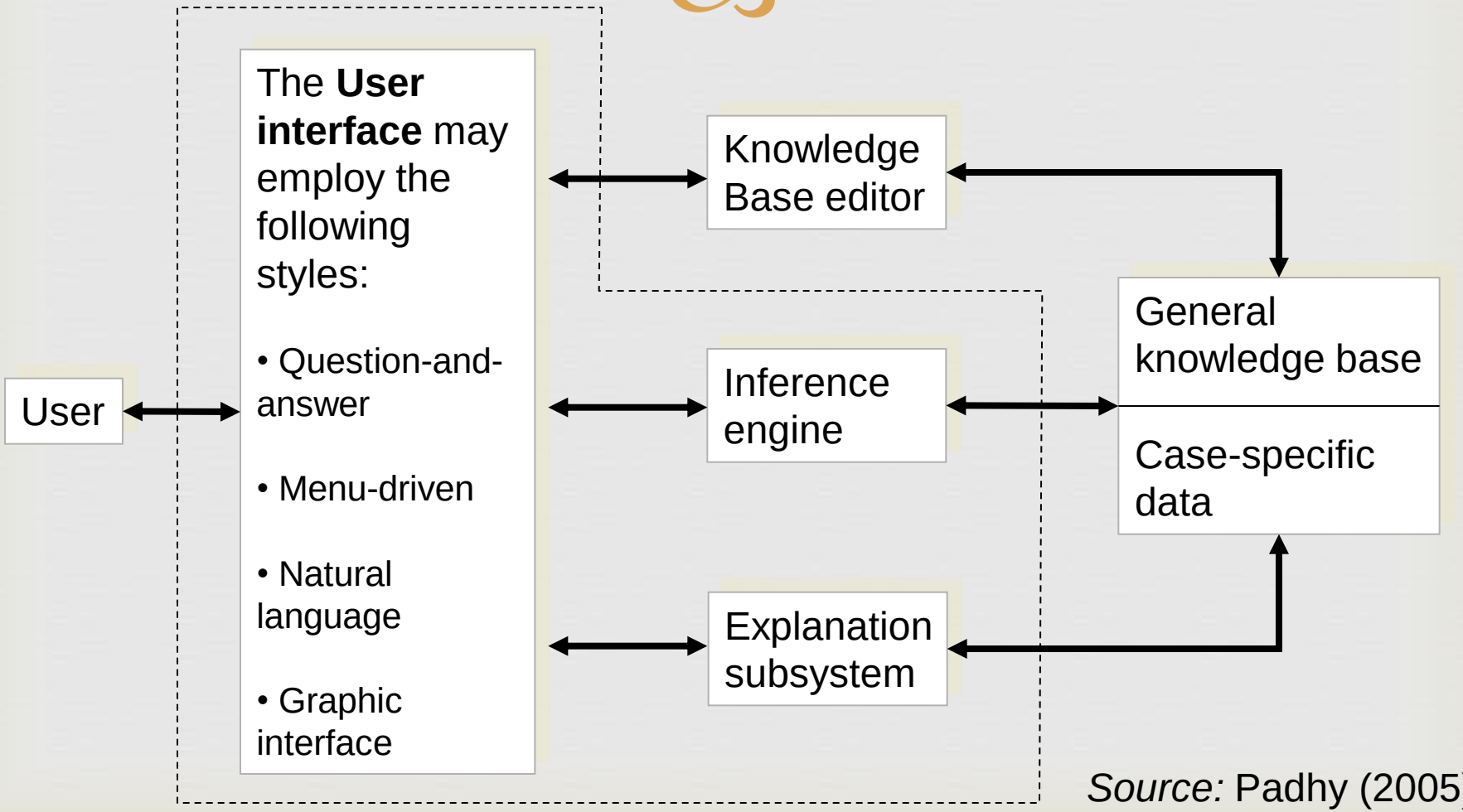
Expert: *"Since your car won't start, I assumed there was a problem with the electrical system. Once I found the battery voltage was below 10 volts, I knew the batter was bad."*

ES Components

- Explanation facility – How?



ES Components



Source: Padhy (2005)

Well Known ES

- MYCIN
  - Was developed at Stanford University to aid physicians in diagnosing and treating patients with infectious blood diseases caused by bacteremia (bacteria in the blood) and meningitis (bacterial disease that causes inflammation of the membrane surrounding the brain and spinal cord).
  - Developed during the mid-1970s.

Well Known ES

- MYCIN
  - A benchmark for today's rule-based ES.
  - Uses backward chaining.
  - Incorporates approximately 500 rules.
  - Written in INTERLISP (a dialect of the LISP).

Well Known ES

- MYCIN - Major features
  - Utilizes a backward-chaining system
  - Separates knowledge from control
  - Incorporates meta-rules
  - Employs inexact reasoning
  - Remembers prior session
  - Accommodates the user
  - Natural language interaction
  - Spelling checker
  - Provides explanations
  - Provides alternative recommendations