STIN2103

Knowledge engineering & expert systems

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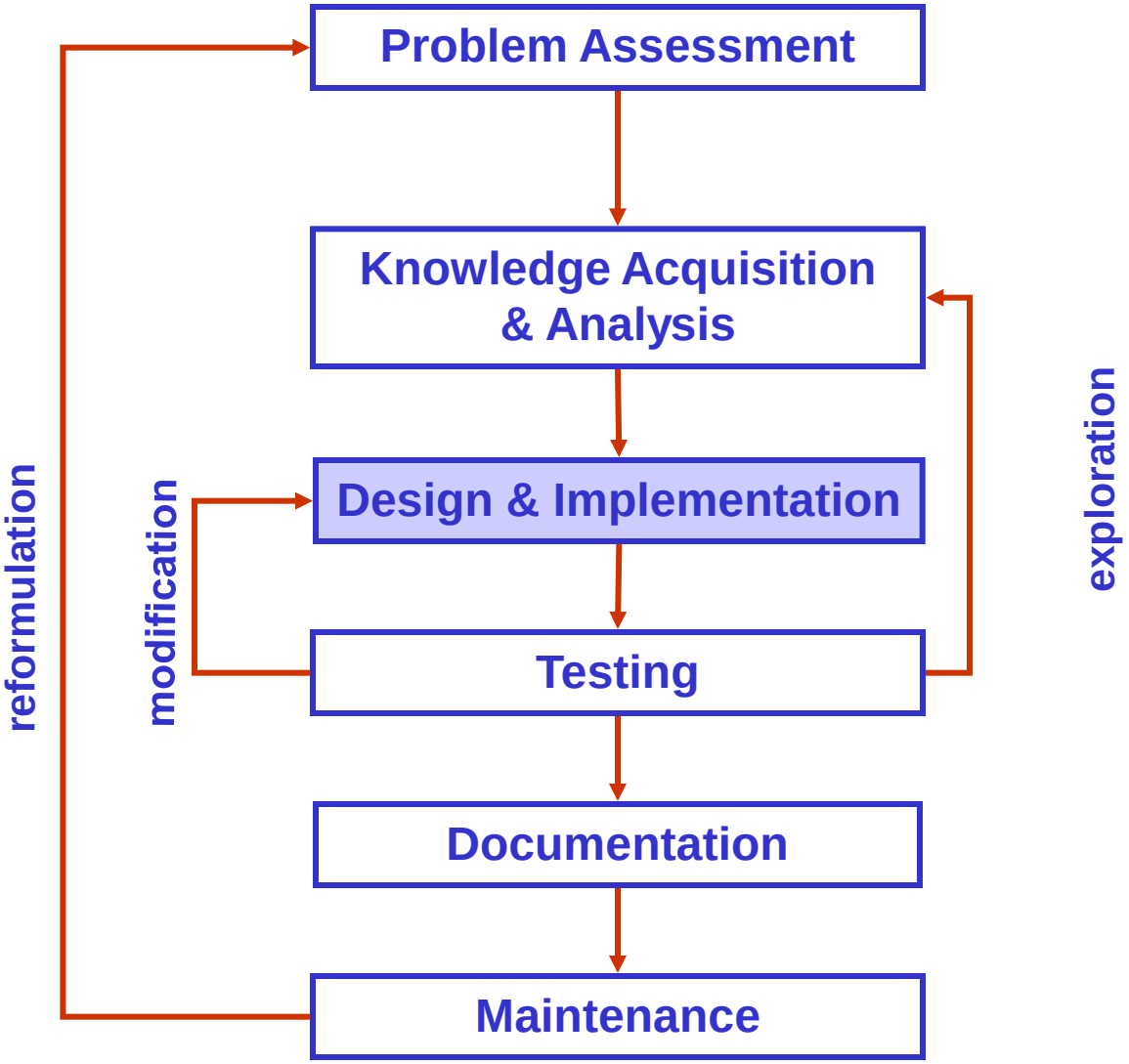
System Design

- System architecture and conceptual design
- Interface design
- Input method
- Explanation facility

Knowledge Engineering Phases



Design & Implementation Tasks

- **Involve the following tasks:**
  - **Task 1: Select knowledge representation technique**
  - **Task 2: Select control technique**
  - **Task 3: Select ES development software**
  - **Task 4: Develop the prototype**
  - **Task 5: Develop the interface**
  - **Task 6: Develop the product**

Control Strategy

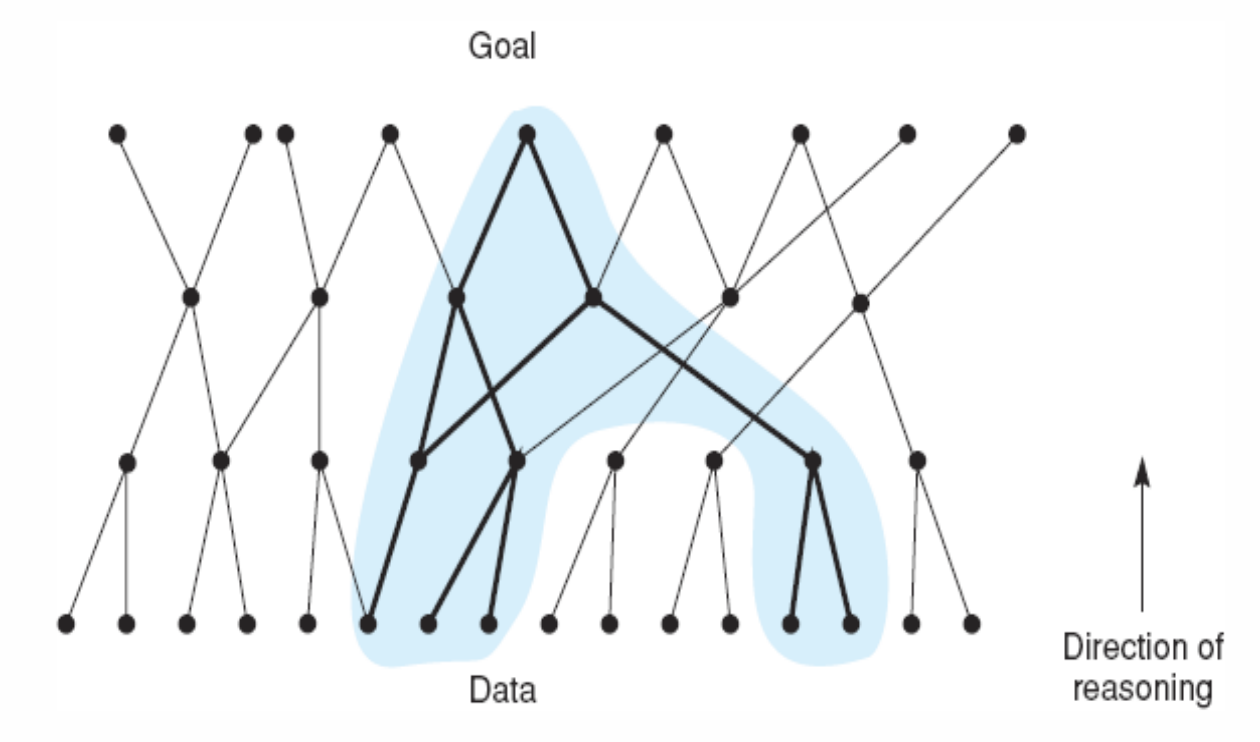
- Get some initial insight into how the system's knowledge can best be controlled by asking the expert to work through a typical problem.

- Forward chaining
  - Data driven
  - Is appropriate if the expert first collects information about the problem and then sees what can be concluded.
  - the amount of data < than the number of solutions

Forward Chaining

- Begins with initial information about the problem being asserted into working memory.
  - information from a database, sensors or users.
- The engine scans the rule looking for ones whose premises match the contents of the working memory.
- If a match is found
  - the system fires the rules
  - places the rule's conclusion in the working memory
  - pcans the rules again
  - repeats the same process until no additional rules fire

Forward Chaining



Designing Forward Chaining Sys.

- Input data is required by the forward chaining system to get started.
- This can be obtained through the use of a startup rule:

Rule 1:

IF task IS begin
THEN ASK car problem

Designing Forward Chaining Sys.

- Data-driven structures is used to control or determine when a rule can fire:

Compare:

IF lights don't brighten
THEN tasks is test battery

with:

IF task is test battery connection
AND lights don't brighten
THEN task is test battery

Designing Forward Chaining Sys.

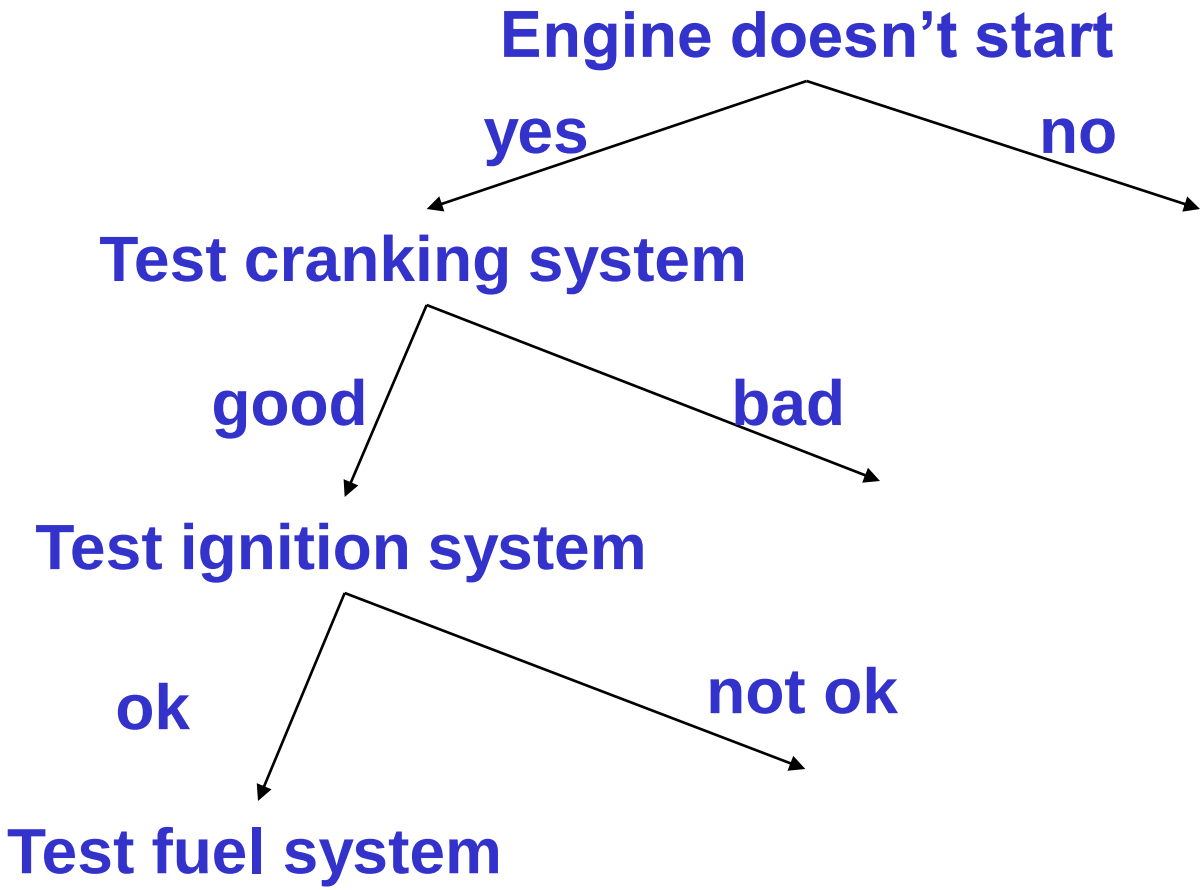
- Consider example of automobile diagnostic domain
  - Forward chaining is suitable for diagnostic problems with very large number of possible faults.
  - One problem in automobile diagnostic domain is 'engine does not start'
    - This could caused by faulty with cranking system, ignition system, fuel system or engine compression.

Designing Forward Chaining Sys.

- Startup rule is written to automatically fire when the system starts.
- The premise of the startup rule must be asserted into the working memory, then when the rule fires, it will cause question to be asked:

  what is the problem?
  - Car won't start
  - Car hesitates at high speeds
  - …

Designing Forward Chaining Sys.



Forward Chaining with Prolog

```
1)new_derived_fact(Conc1):-
      if Cond then Conc1,
      not fact(Conc1),
      composed_fact(Cond).

2)composed_fact(Cond):-
      fact(Cond),!.

3)composed_fact(Cond):-
      new_derived_fact(Cond),!.

4)composed_fact(Cond1 and Cond2):-
      !,
      composed_fact(Cond1),
      composed_fact(Cond2).

5)composed_fact(Cond1 or Cond2):-
      composed_fact(Cond1);
      !,
      composed_fact(Cond2).
```

```
6)composed_fact(Cond):-
      write('Q: '),
      write(Cond),
      write('? [yes/no]'),
      nl,
      write('ANS'),
      read(Ans),
      process(Ans,Cond).
```

R1	IF	physician knows patient has meningitis
	OR	we suspect meningitis
	THEN	infection is meningitis
R2	IF	we suspect meningitis from test results
	OR	we suspect meningitis from patient symptom
	THEN	we suspect meningitis
R3	IF	tests were run
	AND	cultures were seen
	AND	cultures look like meningitis
	THEN	we suspect meningitis from test results
R4	IF	the appearance of the culture is coccus
	AND	the stain of the culture is grampos
	THEN	cultures look like meningitis
R5	IF	patient is suffering persistent headaches
	AND	patient is suffering dizziness
	AND	patient has been lethargic
	THEN	we suspect meningitis from patient symptom

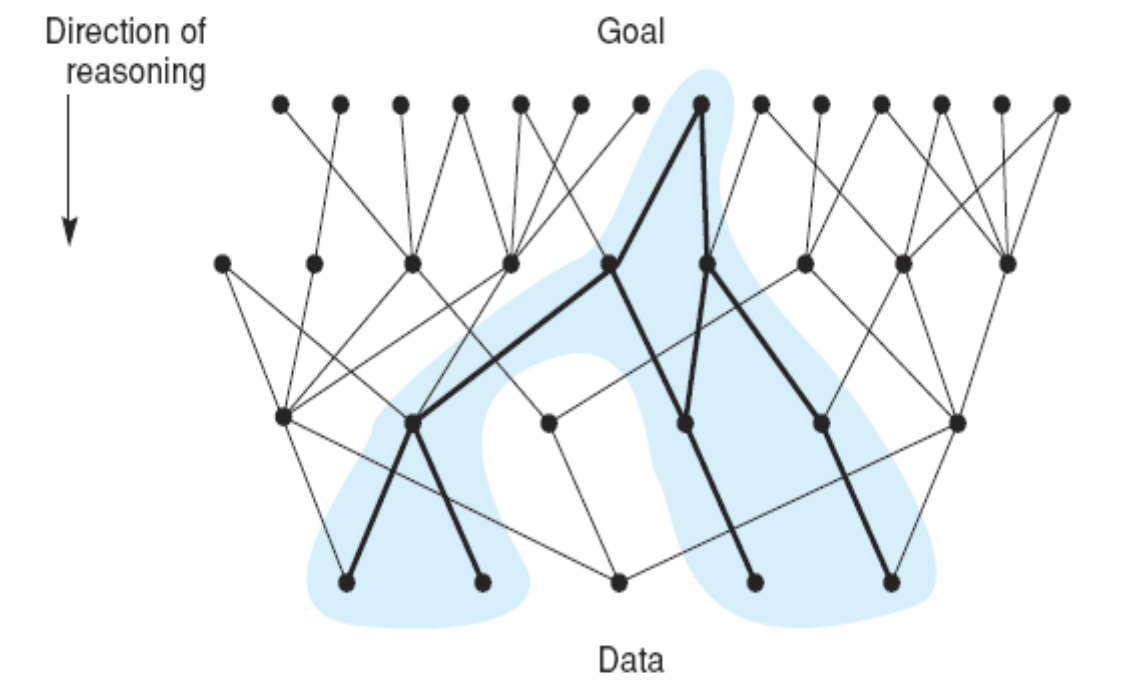
Control Strategy

- **Backward chaining**
  - Goal driven
  - If expert first considers some conclusion or goal, then attempts to prove it by searching for support information.
  - Concern with proving some hypothesis or recommendation.
  - If the number of goals < than the amount of data.

Backward Chaining

- The principal objective – is to prove some goal or hypothesis.
- Begins by collecting a set of rules that contain the goal in their THEN part – goal rules.
- Goal rules, will fire only if its premises are true.
- The premises of the goal rule may themselves be supported by other rules.
- Premise primitive – premise that is not supported by any of the system's rules.

Backward Chaining



Backward Chaining

- The system ask use a question and the answer is placed in the working memory.
- Will cause the firing of rules – add their conclusions to the working memory.
- Process continues until all the goals and sub goals have been searched.

Backward Chaining

R1	IF	physician knows patient has meningitis
	OR	we suspect meningitis
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Premise primitive
Ask question

Q: Tests were run?

Begins with THEN part
(IF a AND b THEN c)

↓

may be supported
by other rules
(IF q OR w THEN a)

↓

Premise primitive
(q)

↓

Ask question

↓

q?

Backward Chaining With Prolog

```
1) is_true(Conc):-
     if Cond then Conc,!,
     is_true(Cond),!,
     write('CONC: '),
     write(Conc),nl.

2) is_true(Cond):-
     fact(Cond),!.

3) is_true(Cond1 and Cond2):-
     !,
     is_true(Cond1),
     is_true(Cond2).

4) is_true(Cond1 or Cond2):-
     is_true(Cond1);
     !,
     is_true(Cond2).

5) is_true(Cond):-
     write('Q: '),
     write(Cond),
     write('? [yes/no]'),
     nl,
     write('ANS'),
     read(Ans),
     process(Ans,Cond).

% process user input/response
6) process(no,_):-
     fail.

7) process(yes,Cond):-
     assert(fact(Cond)).
```

Selecting Control Strategy

PROBLEM TYPE	INFERENCE	
	BACKWARD	FORWARD
Control	Low	High
Design	Low	High
Diagnosis	High	Low
Instruction	High	Low
Interpretation	Avg.	High
Monitoring	Low	High
Planning	Low	High
Prediction	Avg.	High
Prescription	Avg.	Avg.
Selection	High	Low
Simulation	Low	High

Advantages of Forward Chaining

- **It works well when the problem naturally begins by gathering information and then seeing what can be inferred from it.**

- **Can provide a considerable amount of information from only a small amount of data.**

Data		New Information
Raining	→ Grass is wet	→ can't mow grass
	→ Game cancelled	→ go to theater

- **An excellent approach for certain types of problem solving tasks, such as planning, monitoring, control, and interpretation.**

Disadvantages of Forward Chaining

- Have no means of recognizing that some evidence might be more important than others – the system will ask all possible questions, even though it may only need to ask a few questions to arrive at a conclusion.
- The system may also ask unrelated questions.

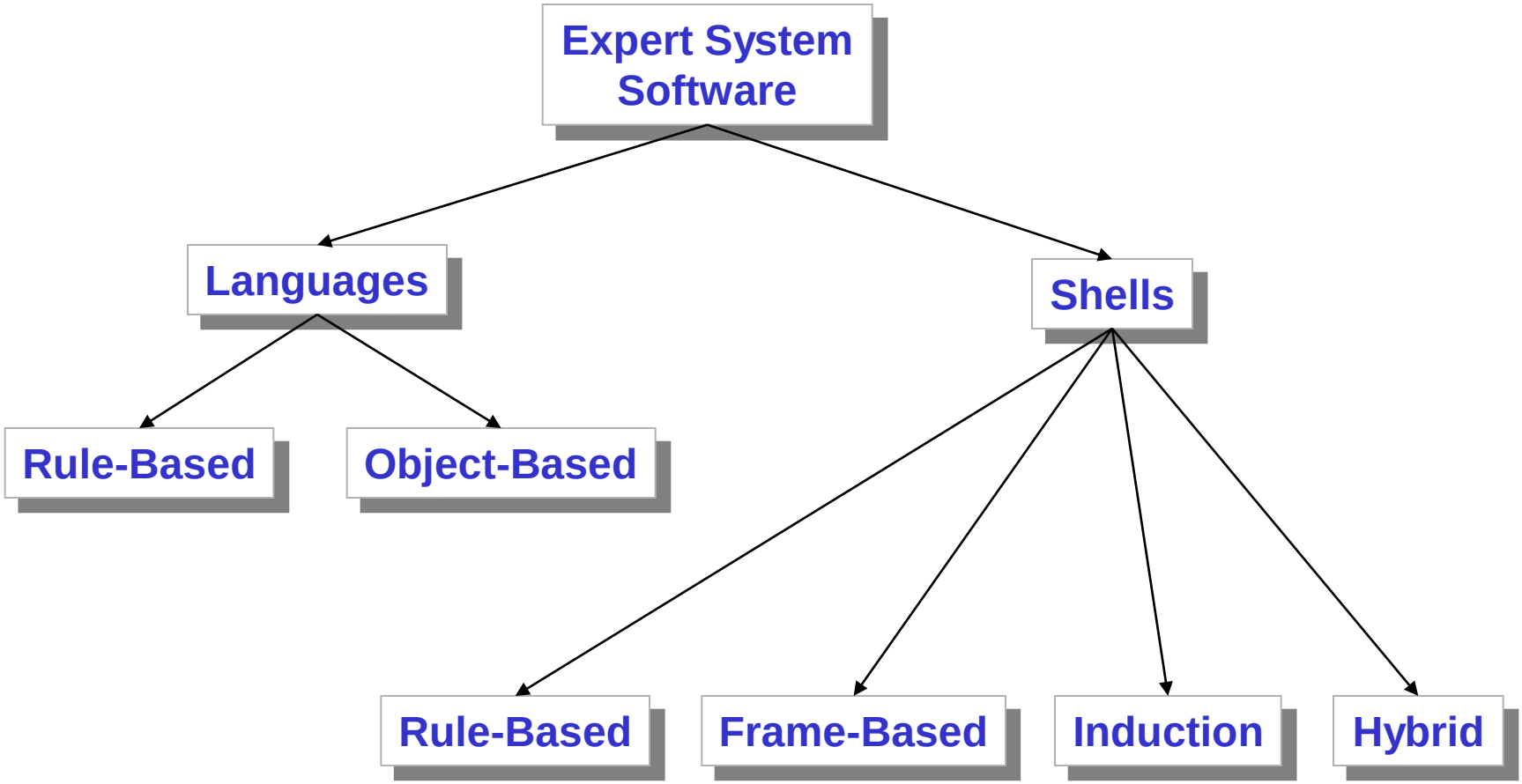
Advantages of Backward Chaining

- Works well when the problem naturally begins with hypothesis.
- Remains focused on a given goal – produces a series of questions on related topics.
- Excellent approach for certain types of problem solving tasks, such as diagnostics, prescription and debugging.

Disadvantages of Backward Chaining

- It will continue to follow a given line of reasoning even if it should drop it and switch to a different one.

ES Software


Expert System Software
Languages
Shells
Rule-Based
Object-Based
Rule-Based
Frame-Based
Induction
Hybrid

Selecting ES Software

- **Considerations:**
  - **General**
    - Cost, hardware, license, training / support
  - **Developer interface**
    - Coding knowledge, inexact reasoning, rule sets, external program access, debugging utilities
  - **User interface**
    - Questions, explanations, graphics, hypertext, multimedia elements, web access

Prototype Development

- Most ES projects begin the development by building a small prototype system.
- Prototype is a model of the final system.
- Serve the purposes:
  - Validates the ES approach
  - Confirms the choice of the knowledge representation technique and control strategies.
  - Provides a vehicle for knowledge acquisition.

Interface Design

- User views the program through the system's interface.
- The acceptance of a system will depend on how well the interface accommodates the needs of the user.
- Developers should pay attention to every aspect in interface design, including the introductory display, the questions asked, the screen directions, the explanation and the conclusion display.

Interface Design

- **Introductory display**
  - Is used to tell user about the overall purpose of the system
  - Provide insight into what the system will do, how the system will perform the task etc.

- **Questions**
  - Most of the interaction takes place in a form of Q & A session, therefore the questions asked must be clear enough to user
  - Most shells ask questions automatically generated from the found primitives in the rules. In fact most of them permit developers to tailor the questions to avoid ambiguity problems.

Interface Design

Screen directions

- Clear directions on what options available on the current screen and how to use them will be very helpful.

- E.g :
  - *Please press ENTER to continue the session*
  - … Question … *Select as many as apply*
  - *To exit the system press F10. If you would like to restart the session press F3.*

Conclusion display

- Is used to present to the user the system's findings
- In addition to the final recommendation, user should also receive some reasons why the recommendation was made. Most of the system provide this ability through the use of HOW button.

Interface Design

- **Keys to effective design:**
  - Consistency
  - Clarity
  - Control

- **Consistency – consistent screen format**
  - Various types of materials are presented on screen such as title, questions, answers, explanation & control functions.
  - When presenting these materials, make sure that similar material is place in the same location.

Interface Design

- **Clarity – clarity of presented materials**
  - **Screens are used to:**
    - **Ask questions**
    - **Provide explanation on the system's reasoning**
    - **Display intermediate of final results**

- **These materials should be presented in a clear manner for two reasons:**
  - **To ensure the user will be receptive to the system**
  - **To enhance the reliability of exchanging information between the user and the system**

Interface Design

- **Asking clear questions**
  - To minimize errors in the user's response, which will lead to erroneous findings by the system
- **Providing clear explanation and result**
  - To avoid confusion
  - Don't present a lengthy discussion of a question or result
  - Don't include so many graphics to avoid screen becoming to "busy"
  - Provide only the necessary material

Interface Design

- **Control – screen control**
  - To ensure the user always feel in control when using the system
  - To convince the user that any mistake he/she might make couldn't lead to disastrous consequences.
  - Minimum requirement: easy to start, exit and access the system's explanation
  - Incorporate with the use of an interactive technique such as mouse, light pen, touch screen etc.

Interface Design

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Explanation Facility

- A trademark of a KBS/ES is its ability to explain WHY a question was asked and HOW a recommendation was derived.

- WHY
  - The system uses a forward chaining approach when trying to explain why it asked a question
  - Is used when a user wants to know why the system asks question.

Explanation Facility

- **HOW**
  - The system uses a backward chaining approach when trying to explain how it derived a conclusion
  - Is used when a user wants to know how the system derives a conclusion or recommendation.

- Explanation for both WHY and HOW questions must be clear and concise.