Overview:

- Roles of people involved in a knowledge-based system
- How representation and reasoning systems interact with humans.
- Knowledge-based interaction and debugging tools
- Building representation and reasoning systems
Knowledge-based system architecture

- **Domain Expert**
- **Knowledge Engineer**
- **Knowledge Base**
- **Inference Engine**
- **User Interface**
- **User**
Roles for people in a KBS

- **Software engineers** build the inference engine and user interface.
- **Knowledge engineers** design, build, and debug the knowledge base in consultation with domain experts.
- **Domain experts** know about the domain, but nothing about particular cases or how the system works.
- **Users** have problems for the system, know about particular cases, but not about how the system works or the domain.
Users

How can users provide knowledge when

- they don’t know the internals of the system
- they aren’t experts in the domain
- they don’t know what information is relevant
- they don’t know the syntax of the system
- but they have essential information about the particular case of interest?
Querying the User

- The system can determine what information is relevant and ask the user for the particular information.
- A top-down derivation can determine what information is relevant. There are three types of goals:
  - Goals for which the user isn’t expected to know the answer, so the system never asks.
  - Goals for which the user should know the answer, and for which they have not already provided an answer.
  - Goals for which the user has already provided an answer.
Yes/No questions

- The simplest form of a question is a ground query.
- Ground queries require an answer of “yes” or “no”.
- The user is only asked a question if
  - the question is askable, and
  - the user hasn’t previously answered the question.
- When the user has answered a question, the answer needs to be recorded.
In the electrical domain:

- The designer of a house:
  - will know how switches and lights are connected by wires,
  - won’t know if the light switches are up or down.

- A new resident in a house:
  - won’t know how switches and lights are connected by wires,
  - will know (or can observe) if the light switches are up or down.
You probably don’t want to ask \( \text{?age(fred,0)}, \text{?age(fred,1)}, \text{?age(fred,2)}, \ldots \)

You probably want to ask for Fred’s age once, and succeed for queries for that age and fail for other queries.

This exploits the fact that age is a functional relation.

Relation \( r(X,Y) \) is functional if, for every \( X \) there exists a unique \( Y \) such that \( r(X,Y) \) is true.
Getting information from a user

- The user may not know the vocabulary that is expected by the knowledge engineer.
- Either:
  - The system designer provides a menu of items from which the user has to select the best fit.
  - The user can provide free-form answers. The system needs a large dictionary to map the responses into the internal forms expected by the system.
More General Questions

Example: For the subgoal $p(a, X, f(Z))$ the user can be asked:

\[
\text{for which } X, Z \text{ is } p(a, X, f(Z)) \text{ true?}
\]

- Should users be expected to give all instances which are true, or should they give the instances one at a time, with the system prompting for new instances?

Example: For which $S, C$ is $enrolled(S, C)$ true?

- Psychological issues are important.
Re-asking Questions

For the case when a user provides instances one at a time: When should the system repeat a question or not ask a question?

Example:

<table>
<thead>
<tr>
<th>Query</th>
<th>Ask?</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>?p(X)</td>
<td>yes</td>
<td>p(f(Z))</td>
</tr>
<tr>
<td>?p(f(c))</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>?p(a)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>?p(X)</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>?p(c)</td>
<td>no</td>
<td></td>
</tr>
</tbody>
</table>
When to ask the user

Don’t ask a question that is

• an instance of a positive answer that has already been given or
• or instance of a query to which the user has replied no.
Should the system ask the question as soon as it’s encountered, or should it delay the goal until more variables are bound?

**Example** consider query $p(X) \& q(X)$, where $p(X)$ is askable.

- If $p(X)$ succeeds for many instances of $X$ and $q(X)$ succeeds for few (or no) instances of $X$ it’s better to delay asking $p(X)$ and prove $q(X)$ first.
- If $p(X)$ succeeds for few instances of $X$ and $q(X)$ succeeds for many instances of $X$, don’t delay.
Asking the user is just one instance of using multiple information sources. There are many types of subgoals:

- those the system has rules about
- those the system has facts about
- those that the user should be able to answer
- those that a web site may be able to answer (e.g., flight arrival times)
- those that a database may be able to answer (e.g., someone’s phone number, or the meaning of a word)

Each information source has its own characteristics.
Assumptions

- Some subgoals you don’t know if they are true; they are assumptions or hypotheses.
- You want to collect the assumptions needed to prove the goal.
- Example: in the electrical domain, ok may be assumable.