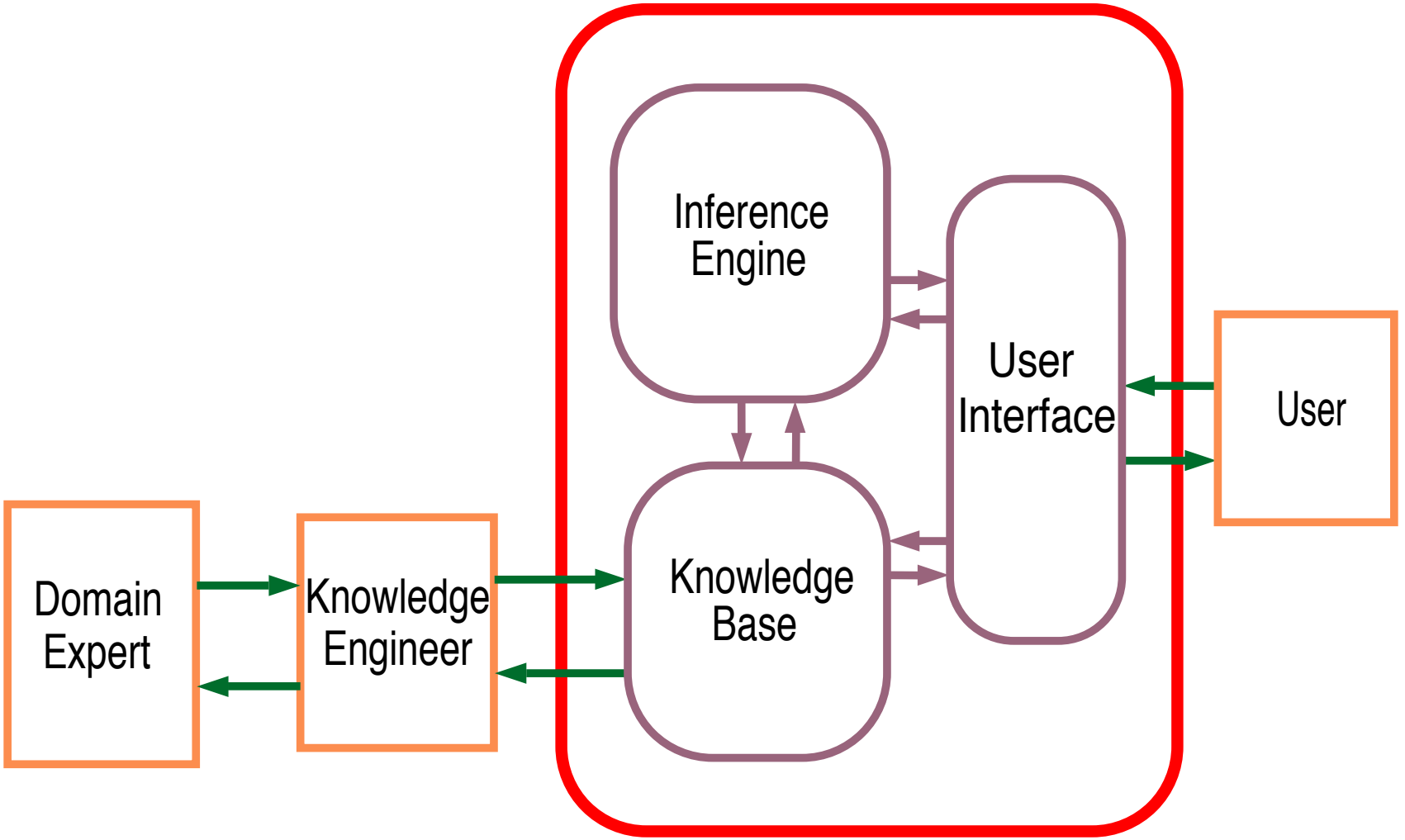
Knowledge Engineering

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



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.

Electrical Domain

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.

Functional Relations

- You probably don't want to ask $?age(fred, 0)$, $?age(fred, 1)$, $?age(fred, 2)$, ...
- 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:

for which X, Z is $p(a, X, f(Z))$ 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:

Query	Ask?	Response
$?p(X)$	yes	$p(f(Z))$
$?p(f(c))$	no	
$?p(a)$	yes	yes
$?p(X)$	yes	no
$?p(c)$	no	

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.*

Delaying Asking the User

- 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.

Multiple Information Sources

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.