

Expert Systems

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Expert System

An expert system is a class of computer programs developed by researchers in artificial intelligence during the 1970s and applied commercially throughout the 1980s. In essence, they are programs made up of a set of rules that analyze information (usually supplied by the user of the system) about a specific class of problems, as well as provide analysis of the problem(s), and, depending upon their design, recommend a course of user action in order to implement corrections.

- Wikipedia

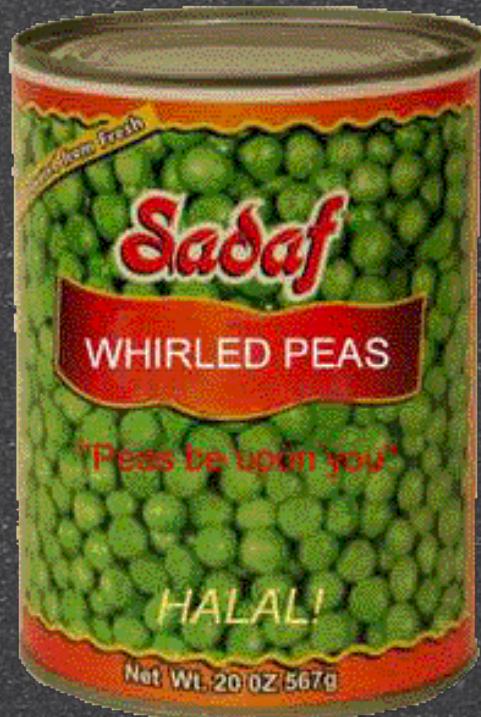
When to use?

- need for solution justifies cost
- human expertise not always available
- problem can be solved w/ symbolic reasoning
- domain well structured / no commonsense
- traditional computing methods fail
- cooperative articulate experts available
- proper size and scope of problem

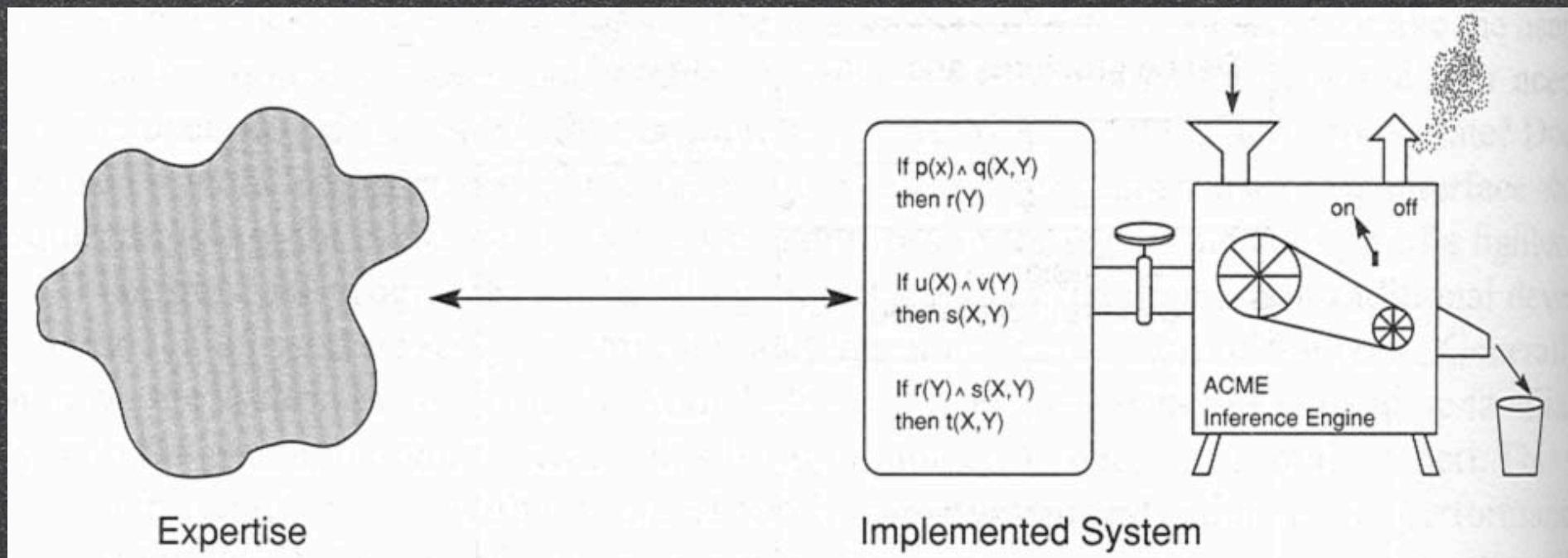
to learn from an expert

- Ask about specific situations to learn the expert's general knowledge
- Ask about situation pairs that look identical but are handled differently

“Peas distinguish...”



capturing rules

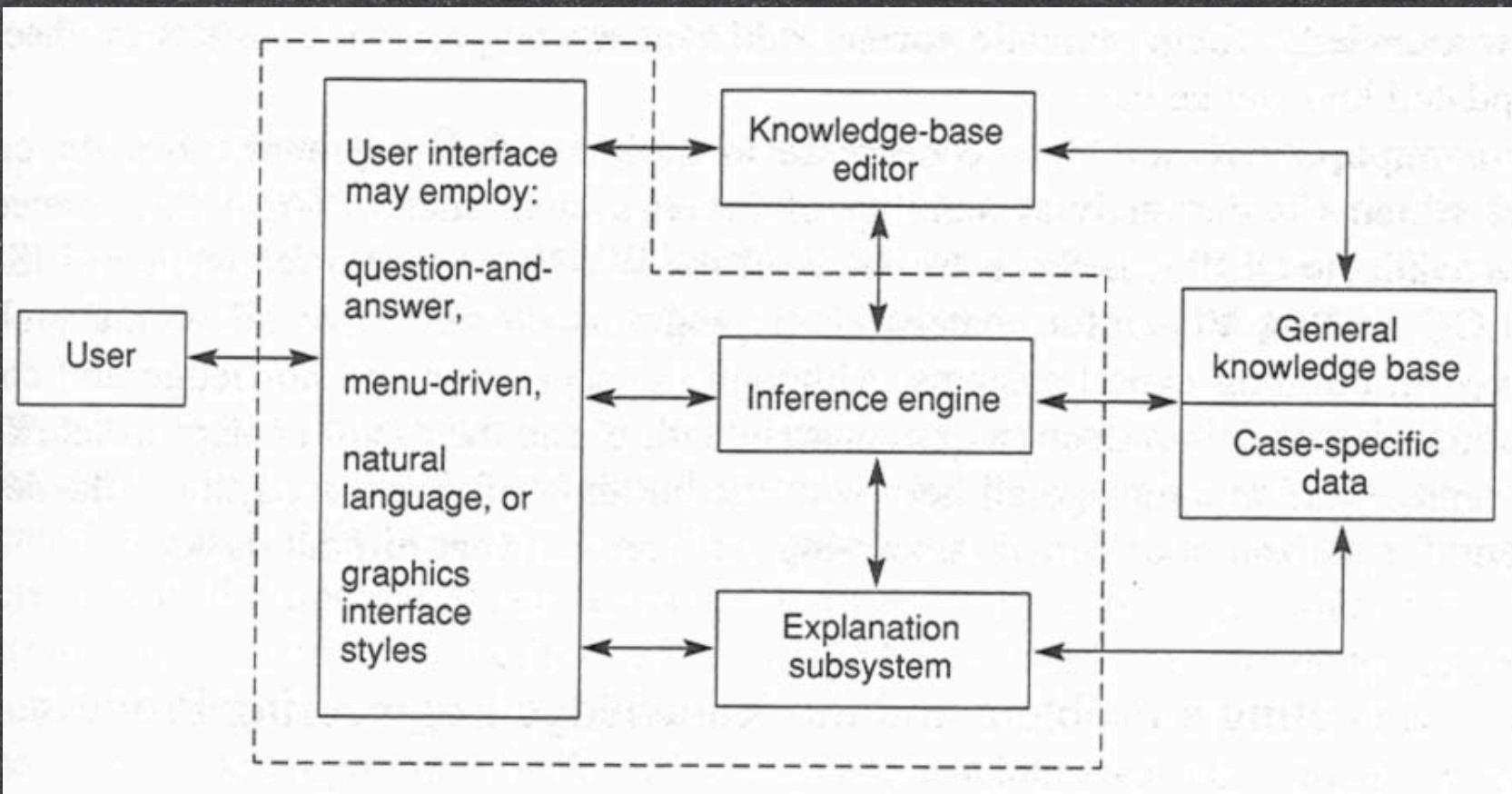


[Lugar 2002]

Knowledge Engineering

- knowledge representation
 - independent of problem domain
 - Ex: rules
- inference technique
 - dependent on knowledge structure
 - Ex: forwards, backwards chaining

Block Diagram [Lugar 2002]



Expert System

- Knowledge Base (Facts)
- Rules (if.. then..)
- Inference Engine
(how rules are applied to facts)

Inference Rules

Z1 IF ?x has hair
THEN ?x is a mammal

Forward v. Backward

- Forward

- fact driven
- finds new ideas

- Backward

- hypothesis driven
- usually used for diagnosis

Expert System Example

Zookeeper: toy deduction system
to identify animals.

[Winston 1991]

Mammal or Bird?

Z1 IF ?x has hair
THEN ?x is a mammal

Z2 IF ?x gives milk
THEN ?x is a mammal

Z3 IF ?x has feathers
THEN ?x is a bird

Z4 IF ?x flies
 ?x lays eggs
THEN ?x is a bird

What kind of mammal?

Z5 IF ?x is a mammal
 ?x eats meat
THEN ?x is a carnivore

Z6 IF ?x is a mammal
 ?x has pointed teeth
 ?x has claws
 ?x has forward-eyes
THEN ?x is a carnivore

What kind of mammal?

Z7 IF ?x is a mammal
 ?x has hoofs
THEN ?x is an ungulate

Z8 IF ?x is a mammal
 ?x chews cud
THEN ?x is an ungulate

Identifying carnivores

Z9 IF ?x is a carnivore
 ?x has tawny color
 ?x has dark spots
THEN ?x is a cheetah

Z10 IF ?x is a carnivore
 ?x has tawny color
 ?x has black stripes
THEN ?x is a tiger

Identifying undulates

Z11 IF ?x is an undulate
 ?x has long legs
 ?x has long neck
 ?x has tawny color
 ?x has dark spots
THEN ?x is a giraffe

Z12 IF ?x is an undulate
 ?x has white color
 ?x has black stripes
THEN ?x is a zebra

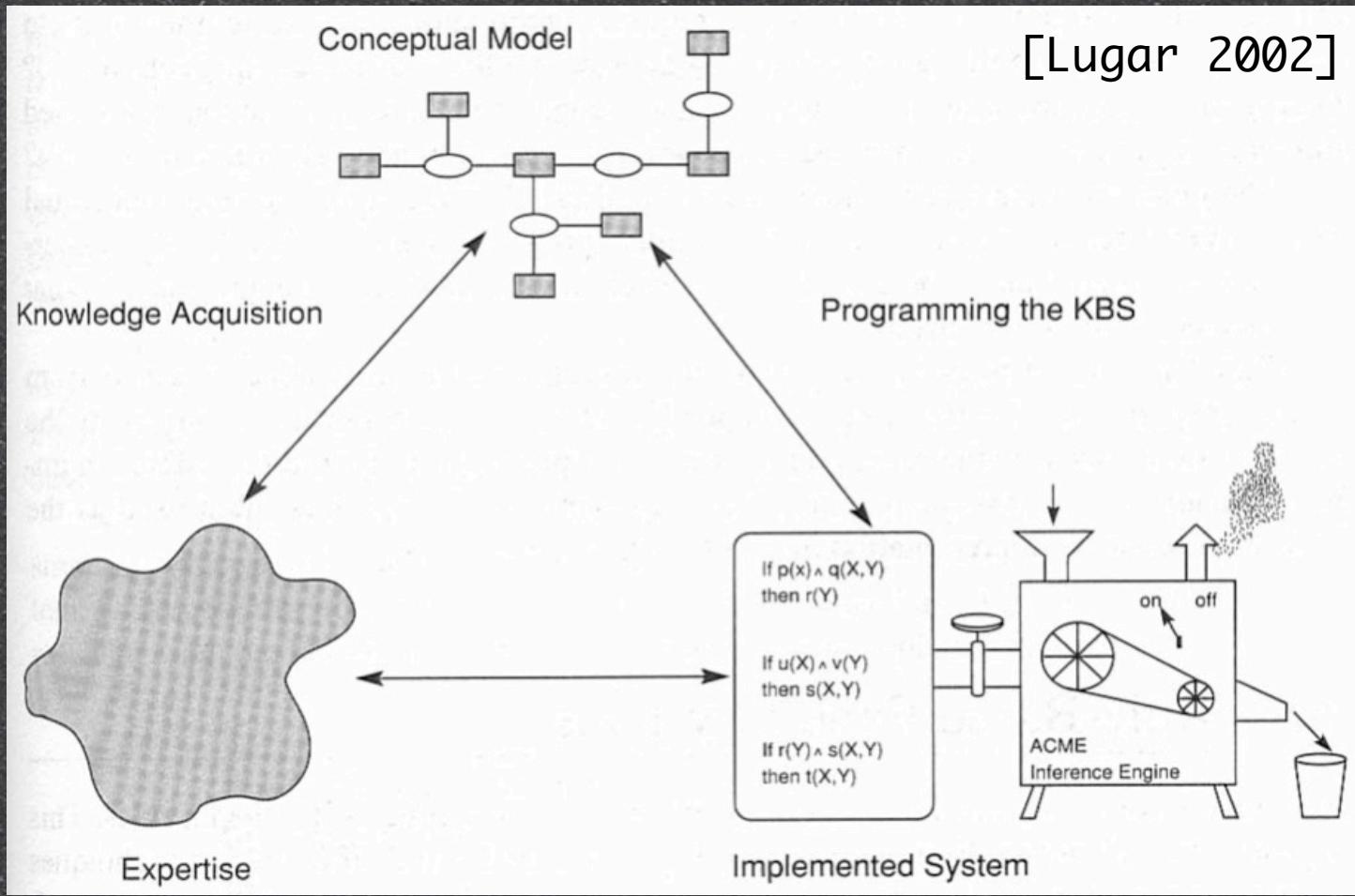
Identifying birds

Z13 IF ?x is a bird
 ?x does not fly
 ?x has long legs
 ?x has long neck
 ?x is black & white
THEN ?x is an ostrich

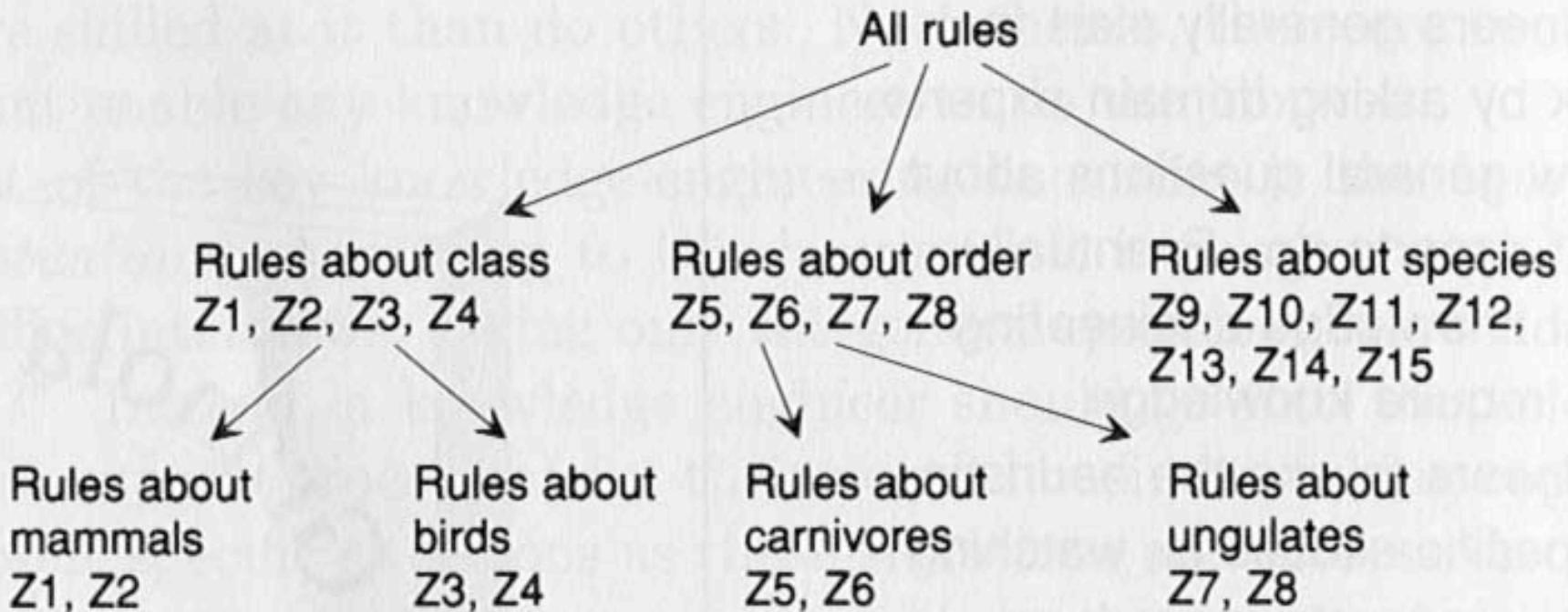
Z14 IF ?x is a bird
 ?x does not fly
 ?x swims
 ?x is black & white
THEN ?x is a penguin

Z15 IF ?x is a bird
 ?x is a good flyer
 THEN ?x is an albatross

really capturing rules



An Expert Model



Knowledge Base

- Stretch has hair
- Stretch chews cud
- Stretch has long legs
- Stretch has a long neck
- Stretch has tawny color
- Stretch has dark spots

Forward Chaining

- Until no new assertions or identified
 - for each rule
 - try to find antecedents in KB
 - if all supported,
add consequent to KB

Forward Chaining

- Z1 IF ?x has hair
THEN ?x is a mammal
- Stretch has hair
 - Stretch chews cud
 - Stretch has long legs
 - Stretch has a long neck
 - Stretch has tawny color
 - Stretch has dark spots

Forward Chaining

- Z1 IF ?x has hair
THEN ?x is a mammal
- Stretch has hair
 - Stretch chews cud
 - Stretch has long legs
 - Stretch has a long neck
 - Stretch has tawny color
 - Stretch has dark spots
 - Stretch is a mammal

Forward Chaining

Z2 IF ?x gives milk
THEN ?x is a mammal

- Stretch has hair
- Stretch chews cud
- Stretch has long legs
- Stretch has a long neck
- Stretch has tawny color
- Stretch has dark spots
- Stretch is a mammal

Forward Chaining

Z3 IF ?x has feathers
THEN ?x is a bird

- Stretch has hair
- Stretch chews cud
- Stretch has long legs
- Stretch has a long neck
- Stretch has tawny color
- Stretch has dark spots
- Stretch is a mammal

Forward Chaining

Z8 IF ?x is a mammal
 ?x chews cud
THEN ?x is an ungulate

- Stretch has hair
- Stretch chews cud
- Stretch has long legs
- Stretch has a long neck
- Stretch has tawny color
- Stretch has dark spots
- Stretch is a mammal

Forward Chaining

Z8 IF ?x is a mammal
 ?x chews cud
THEN ?x is an ungulate

- Stretch has hair
- Stretch chews cud
- Stretch has long legs
- Stretch has a long neck
- Stretch has tawny color
- Stretch has dark spots
- Stretch is a mammal
- Stretch is an undulate

Forward Chaining

Z1 IF ?x has hair
THEN ?x is a mammal

...

Z10 IF ?x is a carnivore
 ?x has tawny color
 ?x has blk stripes
THEN ?x is a tiger

- Stretch has hair
- Stretch chews cud
- Stretch has long legs
- Stretch has a long neck
- Stretch has tawny color
- Stretch has dark spots
- Stretch is a mammal
- Stretch is an undulate

Forward Chaining

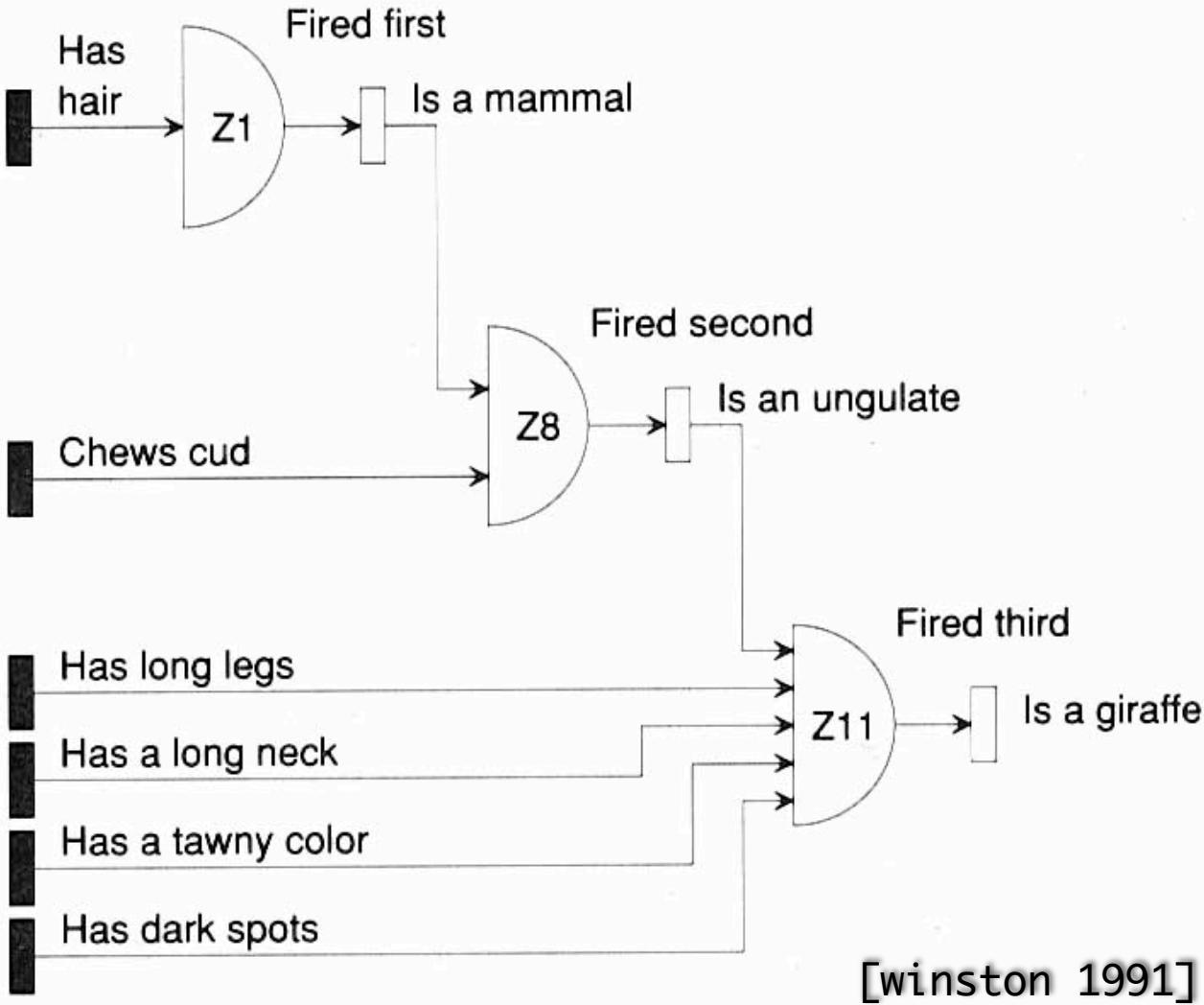
Z11 IF ?x is an undulate
 ?x has long legs
 ?x has long neck
 ?x has tawny color
 ?x has dark spots
THEN ?x is a giraffe

- Stretch has hair
- Stretch chews cud
- Stretch has long legs
- Stretch has a long neck
- Stretch has tawny color
- Stretch has dark spots
- Stretch is a mammal
- Stretch is an undulate

Forward Chaining

Z11 IF ?x is an undulate
 ?x has long legs
 ?x has long neck
 ?x has tawny color
 ?x has dark spots
THEN ?x is a giraffe

- Stretch has hair
- Stretch chews cud
- Stretch has long legs
- Stretch has a long neck
- Stretch has tawny color
- Stretch has dark spots
- Stretch is a mammal
- Stretch is an undulate
- Stretch is a giraffe



[winston 1991]

inductive reasoning

- Reasoning from observation to generalization
- Premises support the conclusion but do not ensure it
- Europeans thought all swans were white until they got to Australia
- Stretch may not actually be a giraffe!

(deductive reasoning)

- Conclusion is of less or equal generality
- All men are mortal
- Socrates is a man
- Therefore, Socrates is mortal

Backwards Chaining

- ➊ Until all hypotheses have been tried or animal is identified
 - ➋ for each hypothesis
 - ➌ for each rule w/ matching consequent
 - ➍ try to support its antecedents by matching assertions in KB or creating a new hypothesis
 - ➎ if all antecedents supported, announce hypothesis is true

Backwards Chaining

- KB: Swift has forward eyes
has claws
has pointed teeth
has hair
has tawny color
has dark spots
- Hypothesis: Swift is a cheetah

Backwards Chaining

Hypothesis: Swifty is a cheetah

Z9 IF ?x is a carnivore
 ?x has tawny color
 ?x has dark spots
THEN ?x is a cheetah

Hypothesis: Swifty is a carnivore

Backwards Chaining

Hypothesis: Swifty is a carnivore

Z5 IF ?x is a mammal

?x eats meat

THEN ?x is a carnivore

Hypothesis: Swifty is a mammal

Backwards Chaining

Hypothesis: Swifty is a mammal

Z1 IF ?x has hair
THEN ?x is a mammal

Swifty has hair - so is a mammal

Backwards Chaining

Hypothesis: Swifty is a carnivore

Z5 IF ?x is a mammal √
 ?x eats meat
THEN ?x is a carnivore

don't know if Swifty eats meat.

Backwards Chaining

Hypothesis: Swifty is a carnivore

Z6 IF ?x is a mammal
 ?x has pointed teeth
 ?x has claws
 ?x has forward-eyes
 THEN ?x is a carnivore

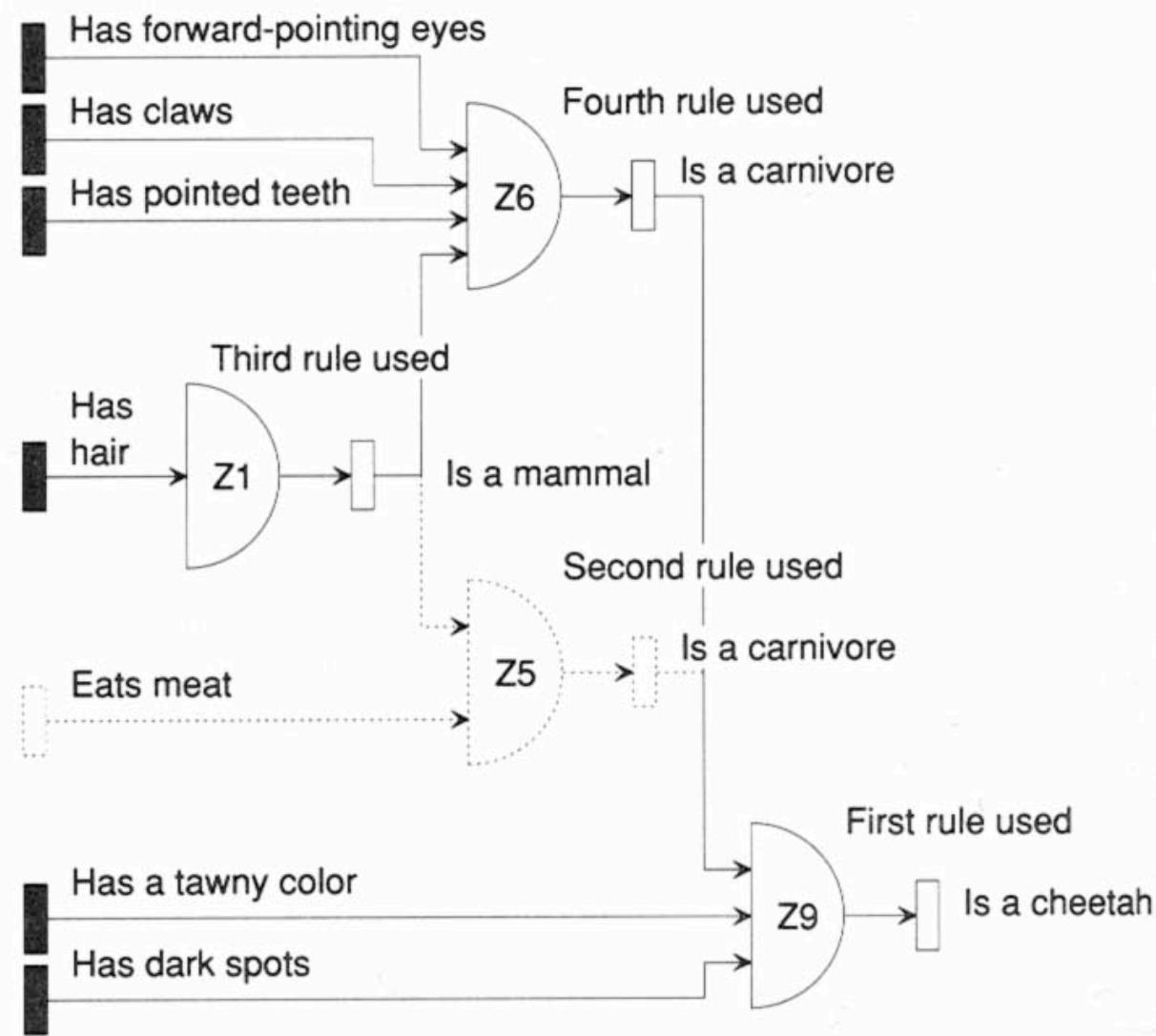
All match - Swifty is a carnivore

Backwards Chaining

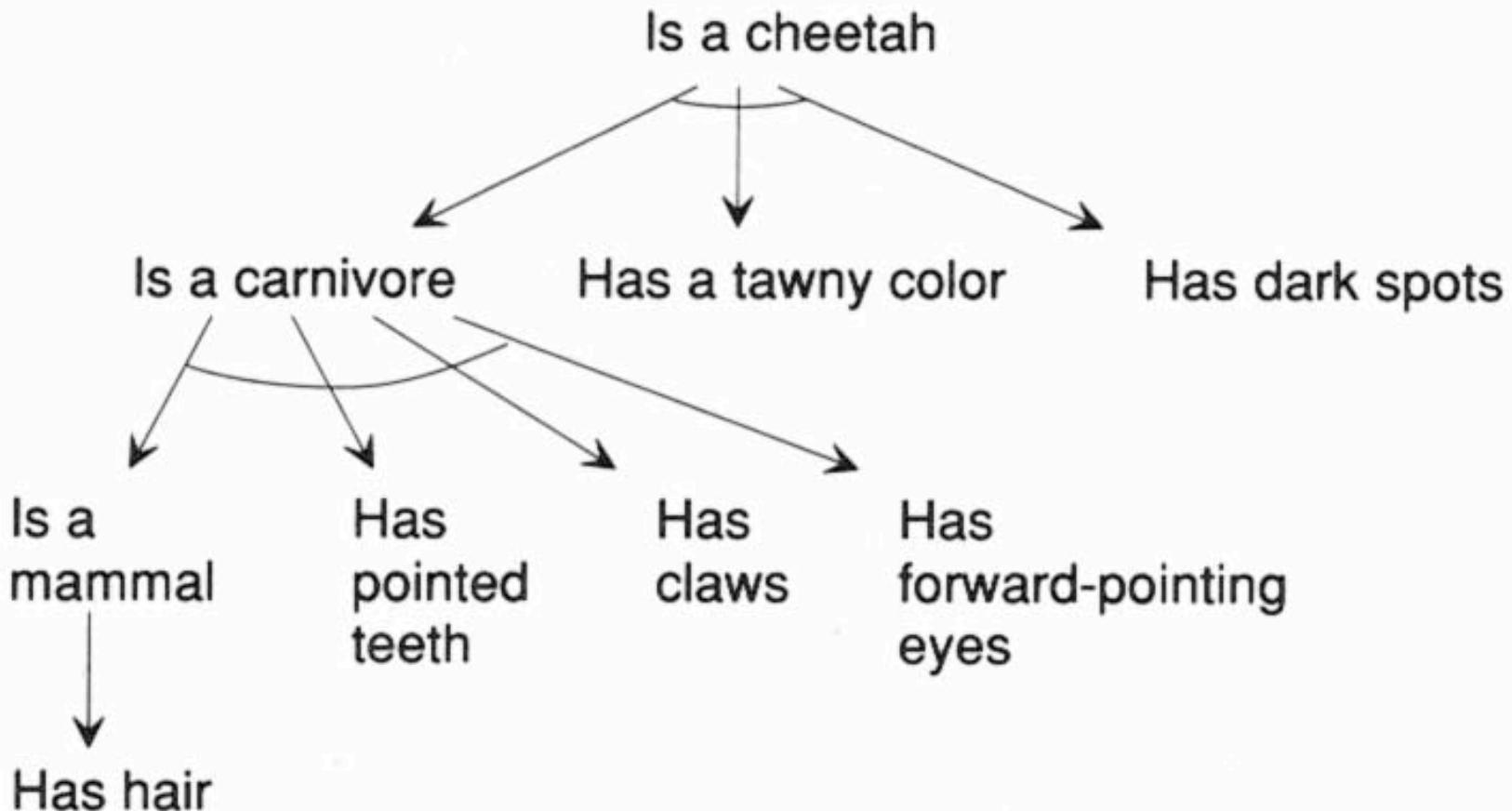
Hypothesis: Swifty is a cheetah

Z9 IF ?x is a carnivore
 ?x has tawny color
 ?x has dark spots
THEN ?x is a cheetah

All match - Swifty is a cheetah



[winston 1991]



Forward or Backward Chaining?

many rule systems can chain
in either direction.

which is better?

How rules & facts relate

- all facts already known?
 - forward chaining
- hypotheses lead to many questions?
 - high degree of fan in
 - forwards chaining

How rules & facts relate

- no facts gathered?
 - backwards chaining
- set of facts lead to many conclusions?
 - high degree of fan out
 - backwards chaining

Mycin

- Expert system to diagnose blood diseases
- Written in Lisp by Shortliffe
(under Buchanan, 1974)
- about 500 rules, 100 diseases
- Backward chaining
- Outperformed real doctors
- Never actually used in practice

Mycin

M: Has the patient had neurosurgery?

U: Why?

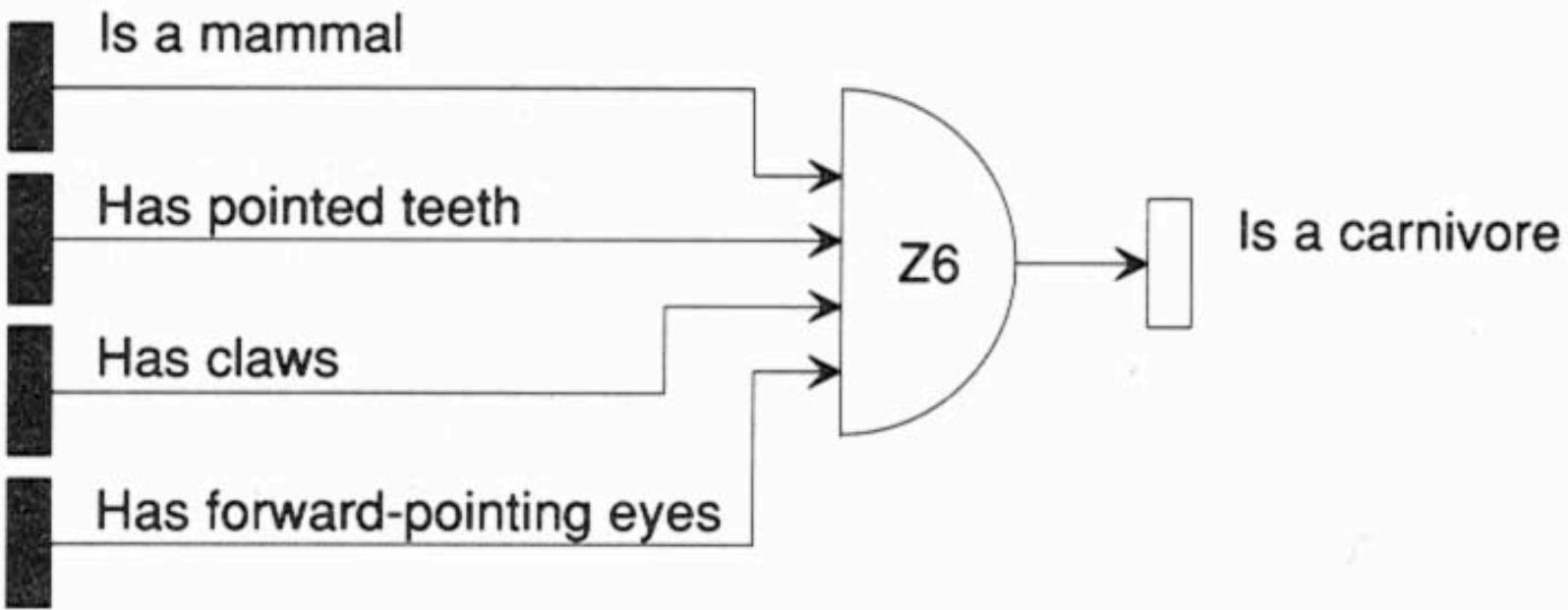
M: This will aid in determining the organisms that might be causing the infection. It has already been established that: the culture is meningitis; organisms were not seen of the pending culture. Therefore if the patient had neurosurgery then there is evidence that the organisms that might be causing the infection are staphylococcus-coag-pos (0.75) and staphylococcus-coag-neg (0.5).
Has the patient had neurosurgery?

U: No.

[Cawsey 1998]

How?

Why?



Zookeeper

Z: Does Swifty have claws?

U: Why?

Z: This will aid in determining whether Swifty is a carnivore. It has already been established that: Swifty is a mammal; Swifty had pointed teeth. Therefore if Swifty has claws then there is evidence that Swifty is a carnivore. Does Swifty have claws?

U: Yes.

Expert Systems as Idiot Savants

- Rule based systems solve many problems
- They answer questions about how and why
- They do not reason on multiple levels
- They do not use different perspectives
- They do not use constraint-exposing models
- They do not know reasoning behind the rules
- They do not know when to break their rules

Imagine if...

- rule consequent could ADD or DELETE rules in the expert system!
- this is called a reaction system
- we'll see this when we talk about planning...