

Demonstration Rule Based Expert System

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THERMOSTAT:

A demonstration Rule Based Expert System

To illustrate some of the ideas discussed above, we next consider a simple rule based expert system. The LEONARDO Expert system shell was selected as the tool to build a decision support system called THERMOSTAT.

The system provides advice on how to select the thermostat setting based on the season of the year, the day of the week and the time of day. Note that this example reflects seasons in Australia, where January, February and December are summer months.

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Knowledge Base

/* THERMOSTAT: A demonstration Rule-Base Expert System

Rule: 1

If the day is Monday

Or the day is Tuesday

Or the day is Wednesday

Or the day is Thursday

Or the day is Friday

Then today is a workday

Rule: 2

If the day is Saturday

Or the day is Sunday

Then today is the weekend

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Rule: 3

If today is a workday

And the time is ‘between 9 am and 5 pm’

Then operation is ‘during business hours’

Rule: 4

If today is a workday

And the time is ‘before 9 am’

Then operation is ‘not during business hours’

Rule:5

If today is a workday

And the time is ‘after 5 am’

Then operation is ‘not during business hours’

Rule: 6

If today is the weekend

Then operation is ‘not during business hours’

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Rule: 7

**If the month is January
Or the month is February
Or the month is December
Then the season is summer**

Rule: 8

**If the month is March
Or the month is April
Or the month is May
Then the season is autumn**

Rule: 9

**If the month is June
Or the month is July
Or the month is August
Then the season is winter**

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Rule: 10

**If the month is September
Or the month is October
Or the month is November
Then the season is spring**

Rule: 11

**If the season is spring
And operation is 'during business hours'
Then thermostat_setting is '20 degrees'**

Rule: 12

**If the season is spring
And operation is 'not during business hours'
Then thermostat_setting is '15 degrees'**

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Rule: 13

If the season is summer

And operation is 'during business hours'

Then thermostat_setting is '24 degrees'

Rule: 14

If the season is summer

And operation is 'not during business hours'

Then thermostat_setting is '27 degrees'

Rule: 15

If the season is autumn

And operation is 'during business hours'

Then thermostat_setting is '20 degrees'

Rule: 16

If the season is autumn

And operation is 'not during business hours'

Then thermostat_setting is '16 degrees'

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Rule: 17

If the season is winter

And operation is 'during business hours'

Then thermostat_setting is '18 degrees'

Rule: 18

If the season is winter

And operation is 'not during business hours'

Then thermostat_setting is '14 degrees'

/* The SEK directive sets up the goal of the rule set

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Objects

THERMOSTAT uses seven linguistic objects: Month, day, time, today, operation, season and the thermostat setting.

Each object can take one of the allowed values (for example, object month can take the value of January, February, March, April, May, June, July, August, September, October, November or December).

An object and its value constitute a fact (for instance, the month is January, the day is Monday, the time is ‘after 5 pm’). All facts are placed in the database.

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Object	Allowed Values	Object	Allowed Values
Month	January, February, March, April, May, June, July, August, September, October, November, December	Day	Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday
Season	Summer, Autumn, Winter, Spring	Operation	During business hours, not during business hours

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Options

The final goal of the rule based expert system is to produce a solution to the problem based on input data. In THERMOSTAT, the solution is a temperature selected from the list of eight options:

Thermostat_setting is '20 degrees'
Thermostat_setting is '15 degrees'
Thermostat_setting is '24 degrees'
Thermostat_setting is '27 degrees'
Thermostat_setting is '20 degrees'
Thermostat_setting is '16 degrees'
Thermostat_setting is '18 degrees'
Thermostat_setting is '14 degrees'

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Dialogues

In the dialogue shown below, the expert system asks the user to input data necessary to solve the problem (the season of the year, the day of the week and the time of the day). Based on the answers supplied by the user (answers are indicated by arrows), the expert system applies rules from its knowledge base to infer that the season is winter (august is winter in Australia), the day is a workday and the operation is during business hours. Rule 17 then selects one of the allowed values of the thermostat_setting.

What month is it?

☐ **August**

Rule: 9

If the month is June

Or the month is July

Or the month is August

Then the season is winter

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What day is it?

☐Friday

Rule: 1

If the day is Monday

Or the day is Tuesday

Or the day is Wednesday

Or the day is Thursday

Or the day is Friday

Then today is a workday

What time is it?

☐between 9 am and 5 pm

Rule: 3

If today is a workday

And the time is ‘between 9 am and 5 pm’

Then operation is ‘during business hours’

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Rule: 17

If the season is winter

And operation is 'during business hours'

Then thermostat_setting is '18 degrees'

Inference Engine

The standard inference technique in Leonardo is backward chaining with opportunistic forward chaining. It provides the most efficient use of the available information. However, Leonardo also provides an opportunity to turn off backward or forward chaining, and thus to study both inference techniques separately.

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Forward chaining is the data driven reasoning and thus we need first to provide some data. Assume that

The month is August

‘month’ instantiated by user input to August

The day is Friday

‘day’ instantiated by user input to Friday

The time is ‘between 9am and 5 pm’

‘time’ instantiated by user input to ‘between 9 am and 5 pm’

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The following process will then happen:

Rule: 1 fires ‘today’ instantiated by Rule: 1 to ‘workday’

Rule: 3 fires ‘operation’ instantiated by rule: 3 to ‘during business hours’

Rule: 9 fires ‘season’ instantiated by rule: 9 to ‘winter’

Rule: 17 fires ‘thermostat_setting’ instantiated by rule: 17 to ‘18 degrees’

No rules fire stop

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Backward chaining is goal driven reasoning, so we need first to establish a hypothetical solution (the goal). Let us, for example, set up the following goal:

‘Thermostat_setting’ is ‘18 degrees’

Pass 1

Trying Rule: 17	Need to find object ‘season’
Rule: 17 stacked	Object ‘season’ sought as ‘winter’

Pass 2

Trying Rule: 9	Need to find object ‘month’
Rule: 9 stacked	Object ‘month’ sought as ‘June’

Ask month

<input type="checkbox"/> August	‘month’ instantiated by user input to August
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Trying Rule: 9 **‘Season’ instantiated by rule: 9 to ‘winter’**

Pass 3
Trying Rule: 17 **Need to find object ‘operation’**
Rule: 17 stacked **Object ‘operation’ sought as ‘during business hours’**

Pass 4
Trying Rule: 3 **Need to find object ‘today’**
Rule: 3 stacked **Object ‘today’ sought as ‘workday’**

Pass 5
Trying Rule: 1 **Need to find object ‘day’**
Rule: 1 stacked **Object ‘day’ sought as ‘monday’**

Ask day
☐ **Friday** **‘Day’ instantiated by user input to Friday**

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Trying Rule: 1 ‘today’ instantiated by rule: 1 to ‘workday’

Pass 6

Trying Rule: 3 Need to find object ‘time’

Rule: 3 stacked Object ‘time’ sought as ‘between 9 am and 5 pm’

Ask time

Between 9 am and 5 pm ‘time’ instantiated to between 9 am and 5 pm’

Trying rule: 3 ‘operation’ instantiated to ‘during business hours’

Pass 7

Trying Rule: 17 ‘Thermostat_setting’ instantiated to ‘18 degress’

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Rule: 17

**If the season is winter
And operation is 'during business hours'
Then thermostat_setting is '18 degrees'**

Rule: 9

**If the month is June
Or the month is July
Or the month is August
Then the season is winter**

Rule: 1

**If the day is Monday
Or the day is Tuesday
Or the day is Wednesday
Or the day is Thursday
Or the day is Friday
Then today is a workday**

Rule: 3

**If today is a workday
And the time is 'between 9 am and 5 pm'
Then operation is 'during business hours'**