

# Hybrid Intelligent Systems

## Lecture 9

ESWin – toolkit for development of hybrid expert systems

# ESWin

(Copyright Insycom Ltd., A.Gavrilov, 1999-2005)

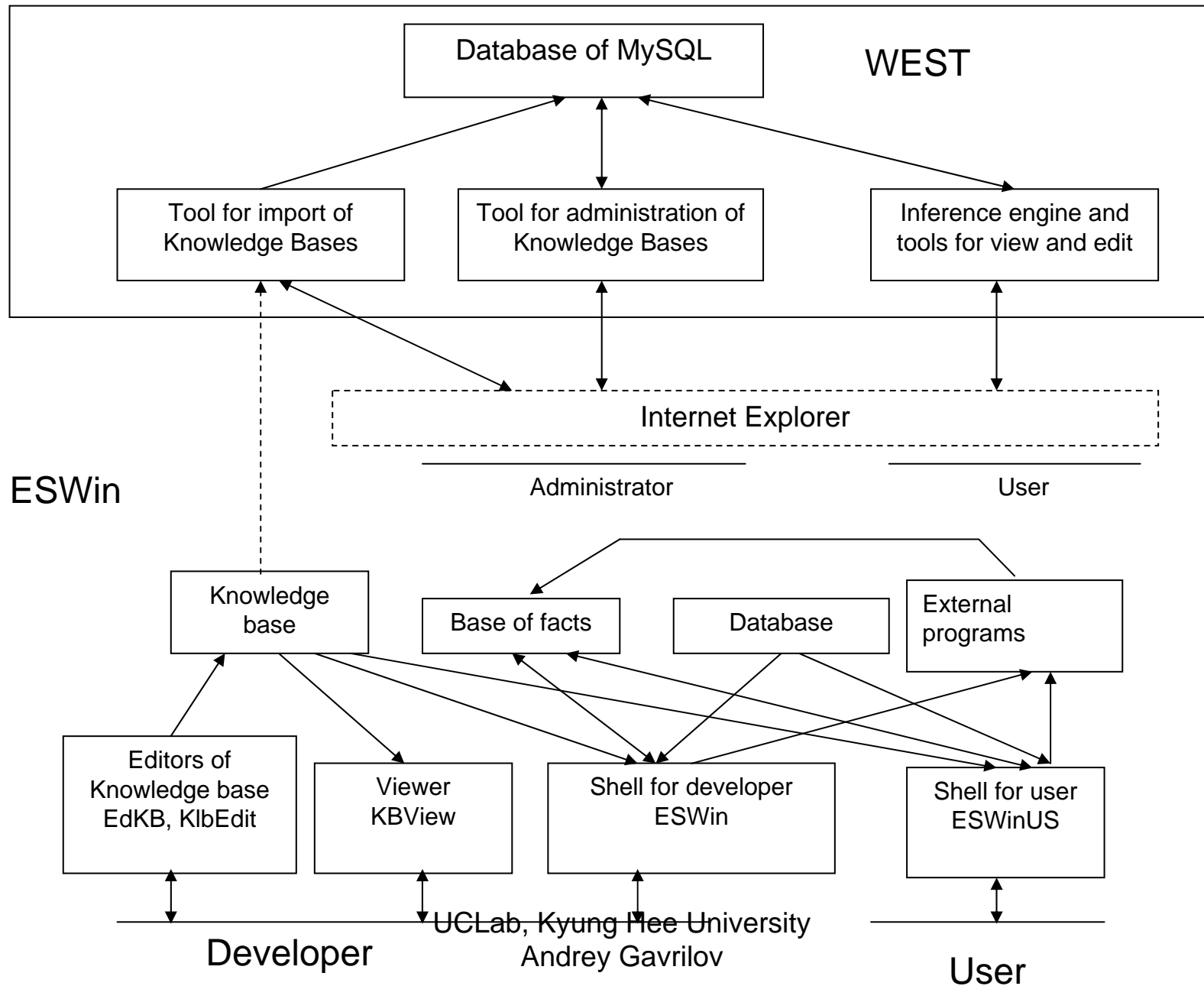
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- Consists of:
  - Language for description of knowledge base
  - Expert shell for developer
  - Expert shell for end user
  - Two kinds of editors of Knowledge Base (KB)
  - Program utility for view and diagnostics of KB
  - Program utility for improvement of structure of KB
- Solving of task by backward fuzzy inference
- Aims to using for development of expert systems for diagnostics, identification, support of making of decisions
- Used in several Universities of Russia for teaching of AI and related courses
- Downloaded (demo) by several foreign users for study
- Demo of ESWin is used in KHU in course “Technologies of Expert Systems”

# Expert shell supports:

- Knowledge representation by
  - Rules
  - Frames,
  - Linguistic variables
- Solving of tasks by backward fuzzy inference
- Nonmonotonic reasoning
- Usage of facts from databases by SQL-query
- Usage of graphics for comments to questions or as results of rule's execution
- Execution of external programs during inference

# Structure of ESWin and its ability of connection with WEST



# Expert shell for Internet WEST

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- Component WEST 1.0 may be used as independent product and consists of:
  - Backward fuzzy inference engine,
  - Tool for administration of Knowledge Base,
  - Tool for import of Knowledge Base from ESWin.
- Developed in MySQL and PHP
- Accessible for demonstration from <http://vt.cs.nstu.ru/~expsystem/>
- That's all about WEST here

# Sources of facts for inference in ESWin

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- Dialog with user
- Databases, SQL-query forming automatically during dialog
- External special programs been developed in case that capabilities of ESWin are not enough for solving of task
- For example, as external program may be any neural network or simulation program

# Knowledge base

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- Consists of:
  - TITLE = ‹name of Expert System›
  - COMPANY = ‹name of organization - owner of ES›
  - Frame with name Goal with names of tasks solved by expert system
  - Other frames describing of domain
  - Rules for solving of tasks
  - Descriptions of linguistic variables (if ones are used in expert system) in separate file

# Structure of frame

---

FRAME (⟨ type of the frame ⟩) = ⟨ a name of the frame ⟩

PARENT: ⟨ a name of the frame - parent ⟩

OWNER: <a name of the frame - owner>

⟨ A name of slot 1 ⟩ .....

....

⟨ A name of slot i ⟩ (⟨ type of slot ⟩) [⟨ a question of slot ⟩?]

{⟨ the comment of slot ⟩}: (⟨ value 1 ⟩; ⟨ value 2 ⟩; ...; ⟨ value m ⟩)

...

⟨ A name of slot n ⟩ .....

ENDF

Types of frames:

- Class
- Instance
- Template

Types of slots:

- Symbol
- Number
- LV – linguistic variable



# Examples of frames

---

Frame=Parameters

Parent:

Area: (Computer Science; Technology;  
Medicine)

Task: (CAD; CAM; Monitoring; Diagnostics)

EndF

---

Frame=Initial data

Parent:

Type of a body (symbol) [Choose type of a body]: (Sedan; Cabriolet;  
Unified; Hatchback; Minivan)

Type of a box of transfers (symbol) [Choose type of a box of transfers]:  
(Automatic; Manual)

Type of the engine (symbol) [Choose type of the engine]: (Diesel;  
Petrol)

Price (number) [how many money you are ready to spend?]:

EndF

# Structure of rules

RULE <number>  
<condition 1>  
<condition 2>  
...  
<condition m>

DO  
<conclusion 1>  
<conclusion 2>  
...  
<conclusion n>  
ENDR

Relations in conditions can be:

EQ or = Equal;  
GT or > It is more;  
LT or < It is less;  
NE or <> Not equal;  
IN Two frames are connected by the relation "part of" (there is a connection through slot OWNER).

Relations in the conclusions can be:

EQ or = Equal (creation of the fact - slot in a frame-instance);  
IN Including in the frame-owner (creation of connection - slot OWNER in the frame-instance);  
DL Remove of slot in a frame-instance;  
EX Execute of the external program;  
FR Output of a frame-instance;  
GO Execute of the rule;  
MS Output of the message to the screen;  
GR Output to the screen of a graphic file (formats

\* UGLab, Kyung Hee University  
.gif, .bmp, .avi or .htm).  
Andrey Gavrilov

# Examples of rules

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Rule 1

=(Initial data.Type of a body; Unified) 100

=(Initial data.Type of the engine; Diesel) 100

=(Initial data.Type of a box of transfers; Automatic) 100

<(Initial data.price; 1000) 100

Do

= (Goal.To buy the car; Under your choice approaches Toyota Caldina 1988) 100

EndR

---

Rule 1

EQ(Parameters.Area; Medicine)

EQ(Parameters.Task; Diagnostics)

Do

EQ(Knowledge representation method; Fuzzy Rules) 90

EQ(Knowledge representation method; Frames) 95

EQ(Tool for Developer; ESWin) 95

EndR

# Linguistic variables

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- Parameters describing of linguistic variable:
  - Name
  - Set of symbolic values
  - For every symbolic values
    - Minimal numeric value
    - Maximal numeric value
    - Number of values of membership function
    - Set of values of membership function

# Example of usage of linguistic variable

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Frame=You

Parent:

Employment: (Unemployment; Engineer; Businessman)

Age (lingvar) [How are You old ?]: (young; old)

EndF

Frame=She

Parent: Women

Age (lingvar) [How is her age?]: (young; middle age)

EndF

Rule 1

EQ(You.Age; young)

EQ(She.Age; young)

EQ(You.Employment; Businessman)

Do

EQ(Your chance of success is; Good)

100

EndR

# Example 1 of KB in ESWin (fragment)

---

TITLE=Demo Expert System for Creating of ES  
COMPANY=CopyRight 2000 Insycom Ltd.

Frame=Goal

Parent:

Knowledge representation method: ()

Tool for Developer: ()

EndF

Frame=Parameters

Parent:

Area: (Computer Science; Technology; Medicine)

Task: (CAD; CAM; Monitoring; Diagnostics)

EndF

Rule 1

EQ(Parameters.Area; Medicine)

EQ(Parameters.Task; Diagnostics)

Do

EQ(Knowledge representation method; Rules with Fuzzy) 90

EQ(Knowledge representation method; Frames) 95

EQ(Tool for Developer; ESWin) 95

EndR

Rule 2

EQ(Parameters.Area; Computer Science)

EQ(Parameters.Task; Monitoring)

Do

EQ(Knowledge representation method; Rules) 100

EQ(Tool for Developer; C++) 100

EndR

Rule 3

EQ(Parameters.Area; Technology)

EQ(Parameters.Task; Monitoring)

Do

EQ(Knowledge representation method; Rules with Fuzzy) 80

EQ(Tool for Developer; ESWin) 80

EQ(Tool for Developer; C++) 70

EndR

Rule 4

EQ(Parameters.Area; Technology)

EQ(Parameters.Task; CAD)

Do

EQ(Knowledge representation method; Frames) 100

EQ(Tool for Developer; Lisp) 95

EQ(Tool for Developer; ESWin) 70

EndR

Rule 5

EQ(Parameters.Area; Technology)

EQ(Parameters.Task; CAM)

Do

EQ(Tool for Developer; ESWin) 90

EndR

# Example 2 of KB in Eswin (fragment)

---

TITLE=Test of use "any"  
COMPANY=Insycom Ltd.

Frame=Goal

Parent:

Test: ()

EndF

Frame=Features

Parent:

Area: (Office; CAD; Games)

EndF

Frame=Components

Parent:

Processor: (above 3 GHz; to 3 GHz; to 1.5 GHz)

Monitor: (17"; 21")

EndF

Rule 1

EQ(Features.Area; Games)

Do

EQ(Components.Processor; above 3 GHz) 100

EQ(Components.Monitor; 17") 100

EndR

Rule 2

EQ(Features.Area; Office)

Do

EQ(Components.Processor; to 1.5 GHz) 100

EndR

Rule 3

EQ(Features.Area; CAD)

Do

EQ(Components.Monitor; 21") 100

EndR

Rule 4

EQ(Components.Processor; any)

EQ(Components.Monitor; any)

Do

EQ(Test; Components are selected) 100

FR(Action; Components) 100

EndR

# Example 3 of KB in Eswin (fragment)

---

TITLE=Example of application with any features

COMPANY= "Insycom Ltd."

Frame=Goal

Charge of Salary:  
EndF

Frame=Profit

Fund for Salary [How much money may be directed  
for salary?](number):  
EndF

Frame=Men

Position [Position of employee?]:  
\*Name [Name of employee?]:  
EndF

Frame=Name

parent: Men  
\*How many [How many to charge (\$)?: (number) :  
EndF

Frame=Salary

SumSalary (number): (0)  
EndF

Rule 1

<(Profit.Fund for Salary; 500)

Do

=(Charge of Salary; There is no sense)

EndR

Rule 2

>(Profit.Fund for Salary; 499)

=(Men.Name; any)

Do

=(Charge of Salary; is successfull)

=(Salary.SumSalary;

#Salary.SumSalary+Name.How much)

FR(Frame; Salary)

EndR



# Expert shell ESWin for developers

The screenshot displays the ESWin expert shell interface. The main window title is "Expert System: Choice of a complete sets for power supply , CopyRight Insicom Ltd. , phone: +7 3832 46-02-19 , email: avg@vt.cs.nstu.ru". The menu bar includes "File", "Task", "Help", and "Quit". The toolbar contains icons for file operations and help. The main text area shows the following content:

```
Frame=data
Parent:
Capacity [What required target capacity (Wt)?] (number):
Stability [What required stability of a target voltage?]: (Average: High)
Profitability: [(the Minimum of material inputs; the Minimal size and weight of a source)]
EndF

Frame=Goal
Parent:
The choice of a complete set: {}
EndF

Frame=Characteristics
Parent:
Weight: {}
Frequency: {}
EndF

Rule 1
<(data.Capacity: 100)
=(data.Stability: Average)
=(data.Profitability: the Minimum of material inputs)
Do
  (Characteristics.Stability: High) 100

Goal: the choice of a complete set

GOAL >> the choice of a complete set
DECISION:
```

A dialog box titled "SELECT OF VALUE" is open, displaying the question "What required stability of a target voltage?". The dialog box contains a list of options: "data, stability", "average", and "high". The "average" option is currently selected. At the bottom of the dialog box, there are four buttons: "OK", "Comment", "Cancel", and "Interrupt".

The Windows taskbar at the bottom shows the "Пуск" (Start) button, several open applications including "ABBYY Lingvo", "Internet Explorer", and "Intelligent Sys...", and the system tray with the time "10:40".

# Expert shell ESWin for developers (2)

The screenshot displays the ESWin expert shell interface. The main window title is "Expert System: Choice of a complete sets for power supply , CopyRight Insicom Ltd. , phone: +7 3832 46-02-19, email: avg@vt.cs.nstu.ru". The menu bar includes "File", "Task", "Help", and "Quit". The toolbar contains icons for file operations and help. The main text area shows the following content:

```
TITLE= Choice of a complete sets for power supply
COMPANY=CopyRight Insicom Ltd. , phone: +7 3832 46-02-19, email: avg@vt.cs.nstu.ru

Frame=data
Parent:
Capacity [What required target capacity (Wt)
Stability [What required stability of a target vo
Profitability: (the Minimum of material inputs; t
EndF

Frame=Goal
Parent:
The choice of a complete set: {}
EndF

Frame=Characteristics
Parent:
Weight: {}
Frequency: {}
EndF

Rule 1
<(data.Capacity: 100)
=(data.Stability: Average)
=(data.Profitability: the Minimum of material in
Do
(characteristics.weight: up to 3kg) 100
(characteristics.frequency: 50-60khz) 100

Goal: the choice of a complete set

GOAL >> the choice of a complete set
DECISION:
characteristics.weight = up to 3kg with confide
characteristics.frequency = 50-60khz with cor
```

A "Data of facts" dialog box is open, showing the following text:

```
Frame=data (13.10.2005,10:34:38)
capacity(number):(500) 100 (13.10.2005,10:34:56)
stability:(average) 100 (13.10.2005,10:34:38)
profitability:(the minimum of material inputs) 100 (13.10.2005,10:34:38)
EndF
Frame=characteristics (13.10.2005,10:34:38)
weight:(up to 3kg) 100 (13.10.2005,10:35:16)
frequency:(50-60khz) 100 (13.10.2005,10:34:38)
EndF
```

The dialog box has buttons for "Save in RTF-file", "Print", "Delete selected", "Delete all", and "Close". The Windows taskbar at the bottom shows the "пуск" button and several open applications: "C:\DOCUME...", "ABBYY Lingvo", "Internet E...", "Intelligent Sys...", "Eswined2", and "RU". The system clock shows "10:35".

# Editor of knowledge base

Expert System: Demo Expert System for Creating of ES . CopyRight 2000 Insycom Ltd.

File Task Help Quit

knowledge representation

TITLE=Demo Expert System for Creating of ES  
COMPANY=CopyRight 2000 Insycom Ltd.

Frame=Goal  
Parent:  
Knowledge representation method: ()  
Tool for Developer: ()  
EndF

Frame=Parameters  
Parent:  
Area: (Computer Science; Technology; Medicine)  
Task: (CAD; CAM; Monitoring; Diagnostics)  
EndF

Rule 1  
EQ(Parameters.Area; Medicine)  
EQ(Parameters.Task; Diagnostics)  
Do  
EQ(Knowledge representation method; Rules with Fuzzy) 90  
EQ(Knowledge representation method; Frames) 95  
EQ(Tool for Developer; ESWin) 95  
EndR

Rule 2  
EQ(Parameters.Area; Computer Science)

Цель: knowledge representation method

GOAL >> knowledge representation method  
DECISION:  
knowledge representation method = rules with fuzzy with confidence 90 %  
knowledge representation method = frames with confidence 95 %  
tool for developer = eswin with confidence 95 %  
(Rule 1)

Data of facts

Frame=parameters (13.04.2003,9:35:34)  
area:(medicine) 100 (13.04.2003,9:35:33)  
task:(diagnostics) 100 (13.04.2003,9:35:27)  
EndF  
Frame=Goal (13.04.2003,9:35:34)  
knowledge representation method:(rules with fuzzy) 90 (13.04.2003,9:35:34)  
knowledge representation method:(frames) 95 (13.04.2003,9:35:27)  
tool for developer:(eswin) 95 (13.04.2003,9:35:27)  
EndF

Save in RTF-file Print Delete selected Delete all

Andrey Gavrilov

# Editor of KB (editing of linguistic variables)

The screenshot displays a software interface for editing a knowledge base. The main window, titled "Build or edit of knowledge base", contains a menu bar and a list of frames on the left. The "Linguistic variables" dialog box is open, showing a list of variables with "old" selected. The "Symbol values" list includes "young", "old", and "middle". The "Range of numerical values" is set from 1 to 80, and the "Number of values" is 10. The "Edit of description of linguistic variables" dialog box is also open, showing a graph of a bell-shaped curve for the "old" variable. The graph has a peak at "middle" and a value of 3. The "Scale of ling. var." is 10, with "Min" at 1 and "Max" at 80. The "Function of ajunction" list includes values 6, 14, 32, 63, 91, 99, 99, 97, 55, and 20. The "Forming of values" button is highlighted, and the text "set on and off of draw by right button of mouse" is visible below it.

**Build or edit of knowledge base**  
KnowledgeBase Frames Rules Linguistic variables About program Help Exit

TITLE=Demo Expert System "How to contact with girl"  
COMPANY=CopyRight 2001 Insycom Ltd.

Frame=Goal  
Parent:  
How to begin: ()  
Chances: ()  
EndF

Frame=You  
Parent:  
Employment: (Unemployment; Engineer; Businessman)  
Old (lv)[How are You old ?]: (young; old)  
EndF

Frame=She  
Parent: Women  
Old (lv): (young; middle old)  
EndF

Frame=Women  
Parent:  
Like flowers: (yes)

**Linguistic variables**

old

Symbol values:  
young  
old  
middle

Range of numerical values:  
From 1 to 80  
Number of values: 10

New Edit

**Edit of description of linguistic variables**

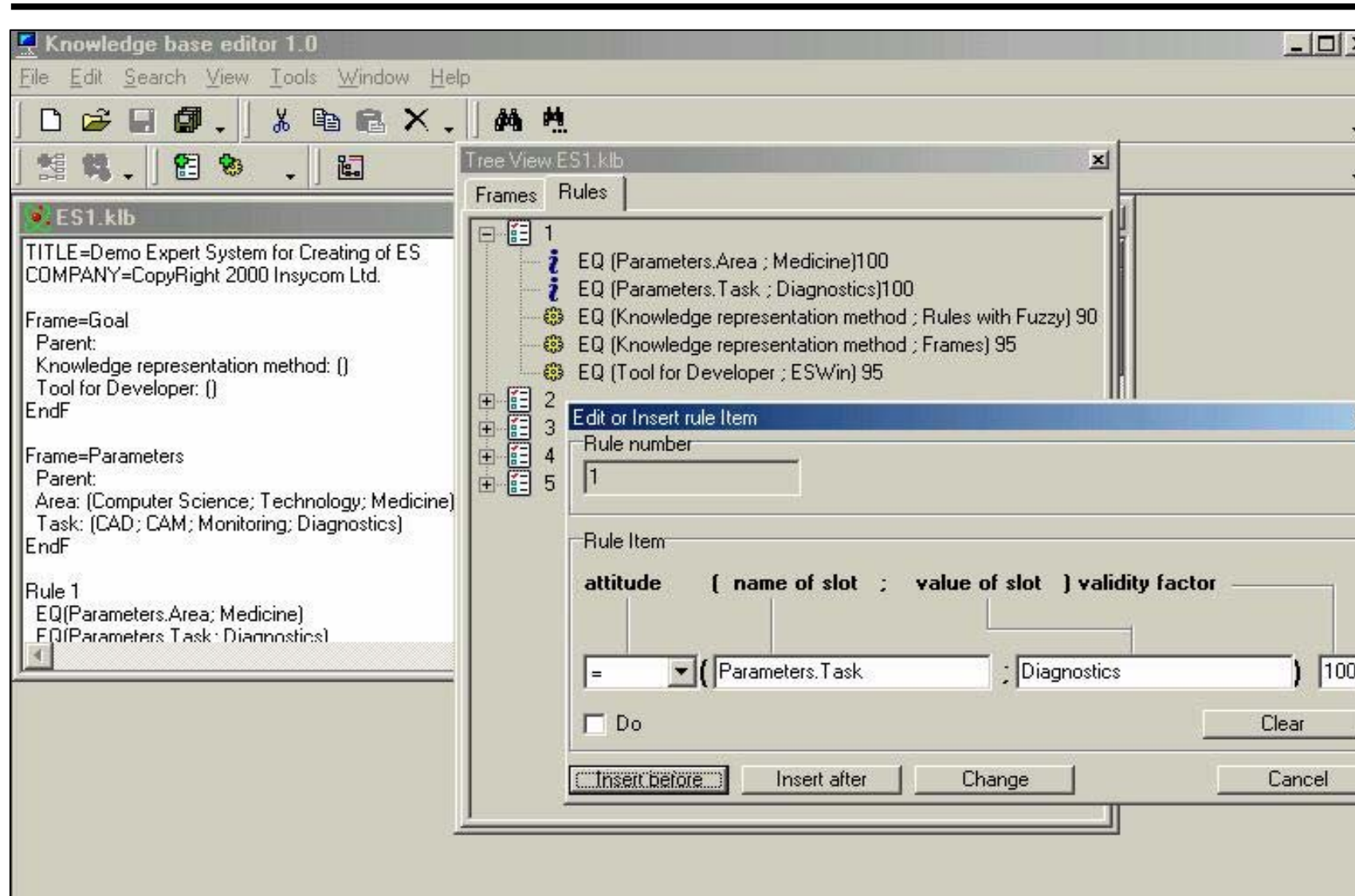
Name Value < > 3  
old middle

Scale of ling. var.  
Number of points 10  
Min 1  
Max 80  
Function of ajunction  
6  
14  
32  
63  
91  
99  
99  
97  
55  
20

Start of forming of new values Clear value  
Forming of values Delete of all values Exit

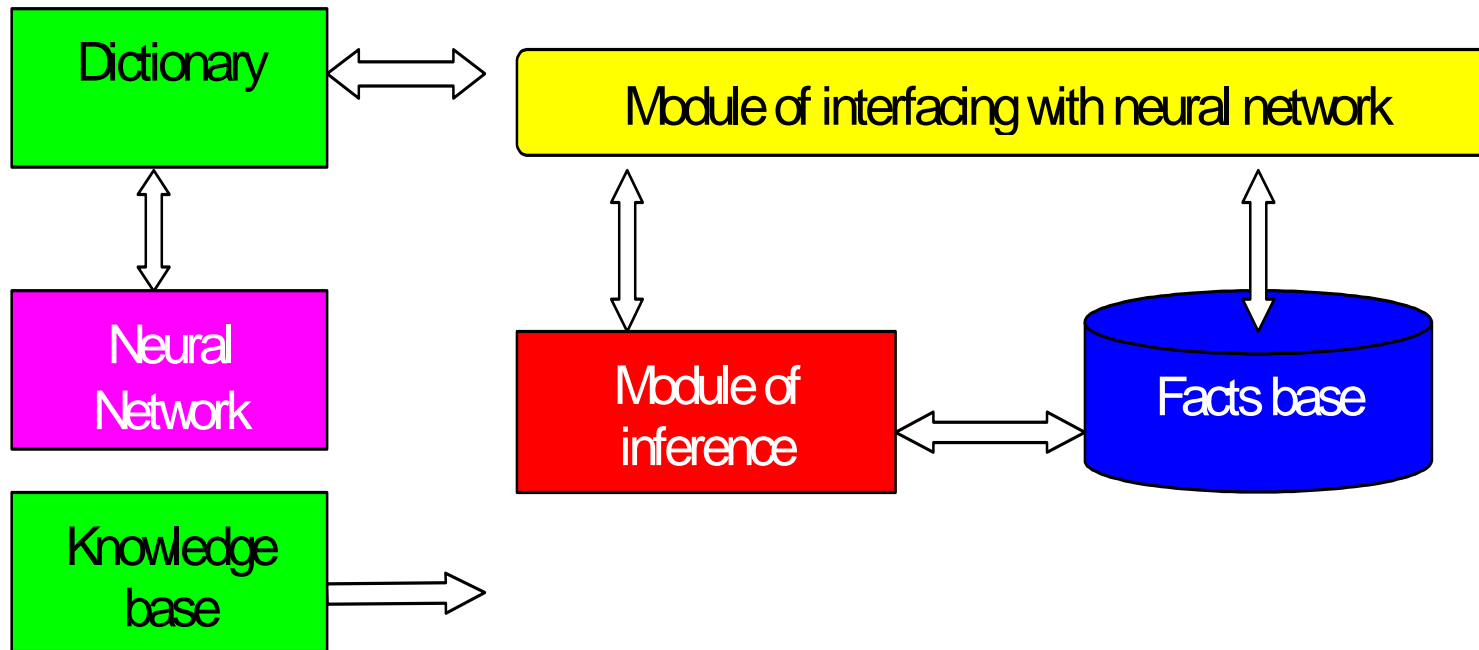
set on and off of draw by right button of mouse

# Other editor of KB



# In present time the version of ESWin is developed for creating hybrid expert systems with neural networks

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# Example of description of protocol between Expert Shell and Neural Network in XML

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```
<MODULE source=ES time=GetLocalTime()>
  <REQUEST target=NN source=ES dataType="frame">
    <DATA>

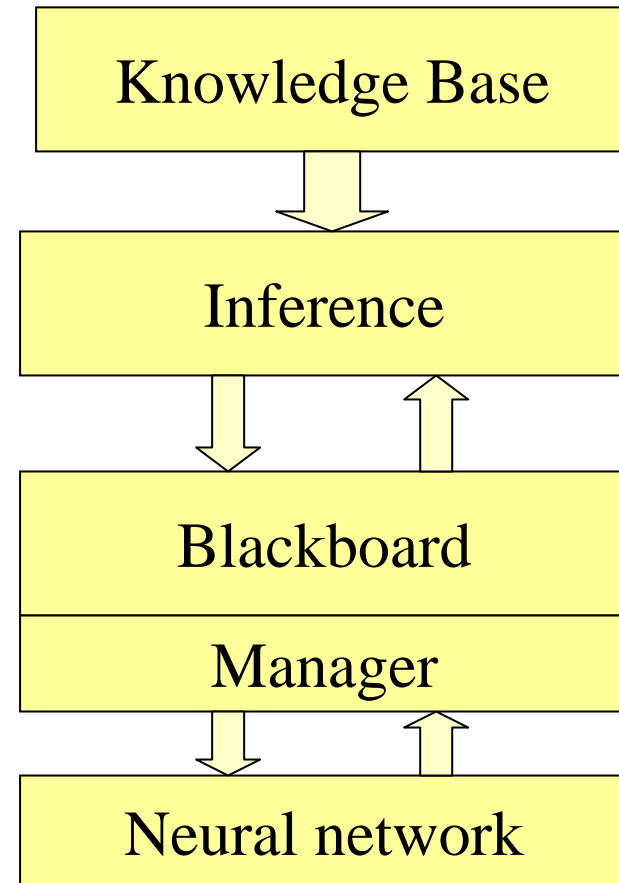
      <METHOD type="AskFactt">
        < FRAME name="Distance">
          <SLOT name="toObject" type="Number"></SLOT>
        </FRAME>
      < /METHOD >

    </DATA>
  </REQUEST>
</MODULE>
```

# An architecture of “two-hemisphere” expert system (Gavrilov A.V., 1989)

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- Level of store of knowledge
- Level of processing of data and knowledge
- Level of store of data
- Level of processing of signals and events





# Possible functions of Neural Network

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- Preprocessing of signals and data, received from external hardware, classification and clustering,
- Forming linguistic variables from examples,
- Generation of hypothesis based on facts from blackboard,
- Forming of associative links between facts for fast solving of task without inference

# Future developments

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- Development of collection of neural networks as modules of ESWin
- Introducing into inference the processing of temporal relations and entities “event”, “time”, “duration” to build of Real Time Expert Systems
- Implementation of inference engine as independent component for including in Real Time Systems
- Testing of proposed architecture on real tasks:
  - System for diagnostic and sorting of genuine leather
  - Control system of mobile robot (program model and real robot)

# Opportunity of usage of ESWin in CAMUS

- Development of inference engine compatible with ESWin
- This one will allow to use ESWin for suitable building and debugging of knowledge bases for scenarios

# Publications:

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- Gavrilov A.V., Novickaja J.V. The Toolkit for development of Hybrid Expert Systems. - 5-th Int. Symp. "KORUS-2001", Tomsk: TPU, 2001. - Proceedings. - Vol.1. - P. 73-75.
- Gavrilov A.V., Novitskaya J.V. The Architecture of the Hybrid Expert System. - / The 6-th Russian-Korean International Symposium on Science and Technology. KORUS-2002, Materials. - Novosibirsk, 2002. - Vol. 3.- P.70.
- Gavrilov A.V. Hybrid Intelligent Systems. – Novosibirsk, NSTU, 2003. – 162 p. (in Russian)
- Gavrilov A.V., Chistyakov N.A. An architecture of the toolkit for development of hybrid expert systems. // Proc. Of the Second IASTED Int. Multi-Conference ACIT-2005, Automation, Control and Applications, Novosibirsk, 2005. – Pp. 116-120.

Thanks