Expert systems (ES) and their application

- 40 years history.
- Modular scheme of expert system:

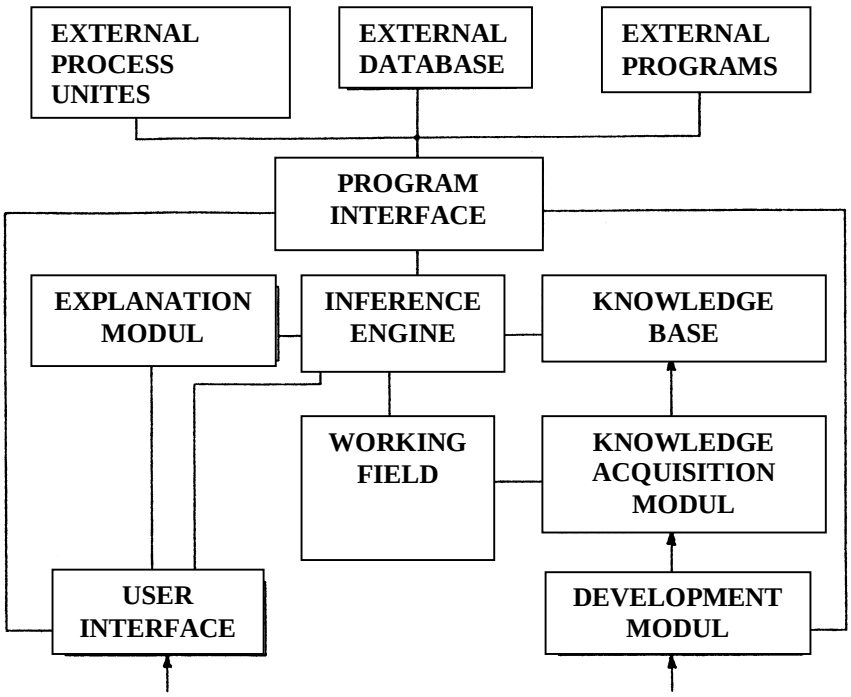


Fig.4.

Classical modeling: Similarity of various processes and systems represented especially by mathematical models is a similarity of behavior of **numerical structures**. *Knowledge based modeling:* Similarity in manipulations and in processing of knowledge, data and external objects within **Problem Solving**.

5.1 Basic functional modules

5.1.1 Knowledge base

Knowledge versus data. (John is heavy) versus (John-weight: 180).

Knowledge contain:

- Semantic specifications, („Be careful, please!“)
- Methods how to work with knowledge (with data, with facts, …). (Add your income to …. „How to add“, „What is income“, …).
- Context. („First sentence in this page depends on the interpretation.“)

Types of knowledge:

- Causal knowledge,
- Conceptual knowledge,
- Covers,
- Classes,
- Explanations,
- Restrictions,
- Preferences,
- Strategies,
- Targets (goals, objectives),
- Control,
- Proofs,
- Inferences,
- Examples,
- Terminology,
- Equation models,
- Relations,
- Procedures,
- Facts, …

Kinds of knowledge

- Procedural knowledge,
- Declarative knowledge,
- Hybrid knowledge.

Representation of knowledge

- Rules,
- Frames,
- Formal logic,
- Objects,
- Hybrid representation.

5.1.1.1 Knowledge representation

Rules

Methods of knowledge acquisition: repertory grid, …, protocol analysis,

Languages: Lisp, Prolog.

Expert systems: ETS, Expert system Builder, NEST, …

Types of knowledge: causal knowledge, restrictions, explanations, strategies, control, inferences, equation models, procedures.

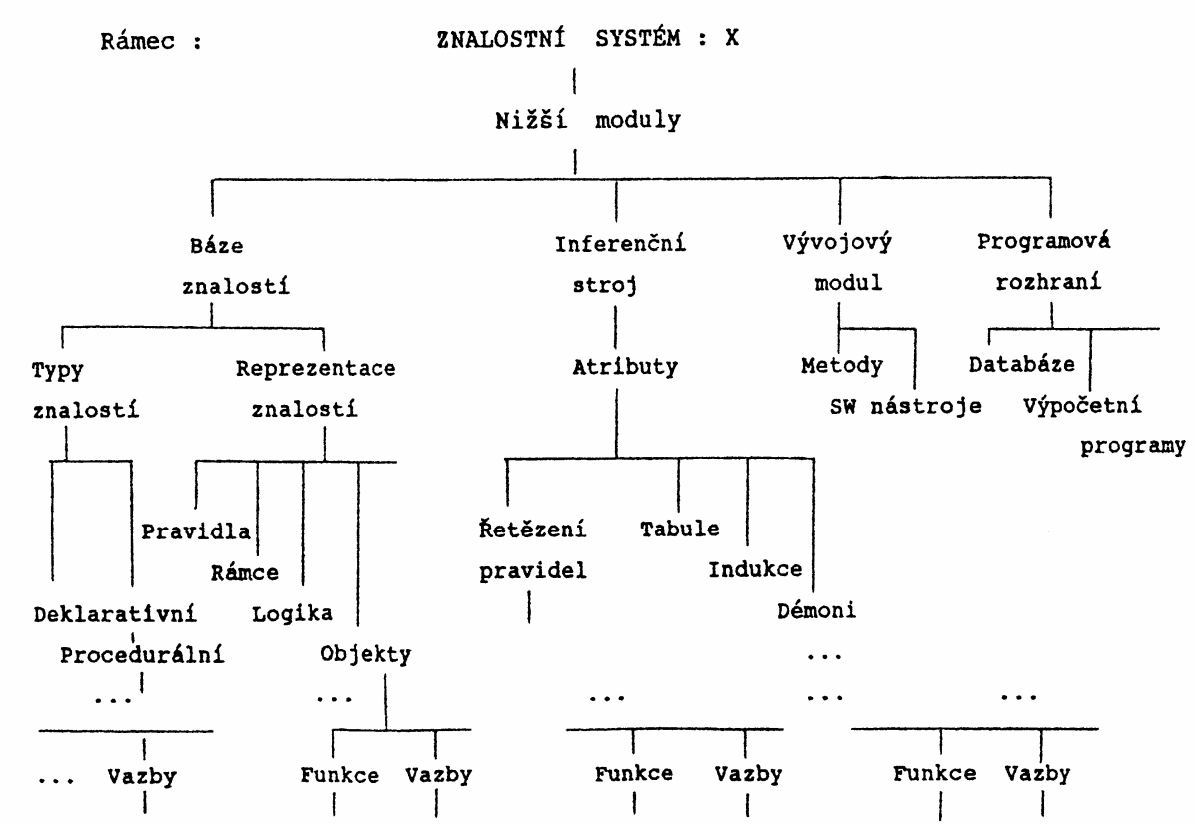
Frames

Methods of knowledge acquisition: graphs, tables, …,

Languages: Lisp, C++, Cattia,

Expert systems: G2, NEST, Kee,

Types of knowledge: classes, coverings, relations, facts, terminology.



Obr.21.4.

Formal logic

Methods of knowledge acquisition: special methods for transfer of natural language into formulas of FOL.

Languages: Lisp, Prolog,

Expert systems: Programmed in Prolog.

Types of knowledge: causal knowledge, restrictions, explanations, strategies, control, inferences, equation models, procedures.

Objects

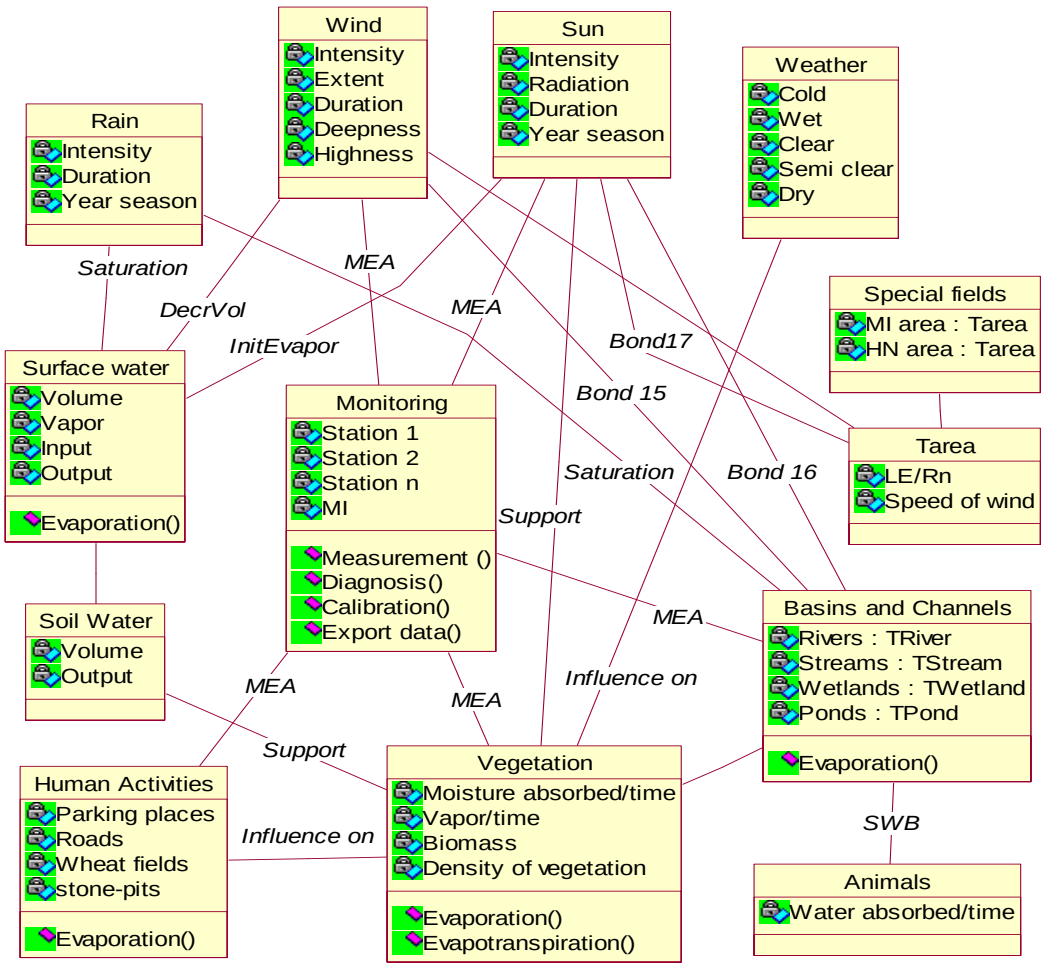
Methods of knowledge acquisition: Object Modeling Technique (OMT]

Languages: Java, C++,

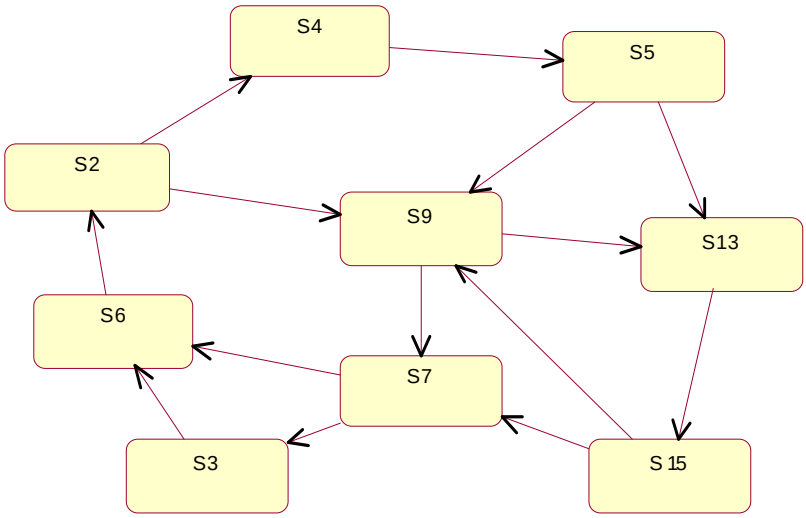
Expert systems: Programmed in Java (recently in Smalltalk).

Types of knowledge: causal knowledge, restrictions, explanations, strategies, control, inferences, equation models, procedures.

Example of a class model:



Example of state model:



S1	***Low local humidity***
S2	***Medium local humidity***
S3	***High local humidity***
S4	***Local fog***
S5	***Regional fog (covering an area greater than 20 km2)***
S6	***High volume of water absorbed in the soil***
S7	***Local floods***
S8	***Violation of the small water cycle (SWC)***
Weather	
S9	***Rain***
S10	***Snow***
S11	***Long time local dry atmosphere, (arid soil)***
S12	***Semi-clear weather***
S13	***Very cloudy weather and overcast***
S14	***Strong wind***
S15	***Storm***
Evaporation	
S16	***High evaporation (nearly no water goes back into the ecosystem)***
S17	***Medium evaporation – (some of the evaporated water returns back)***
S18	***Low evaporation***
S19	***Diminished evapotranspiration***

Hybrid representation

The most of large expert systems nowadays allows to use a few type of knowledge representation together. It is very useful in cases of heterogeneous working fields. Very often is mixed inference style of expert system with solvers. (In such cases the algorithms are arguments of rules or of object structures. Similarly the frames may be used as arguments of rules.

5.1.2. Inference engine

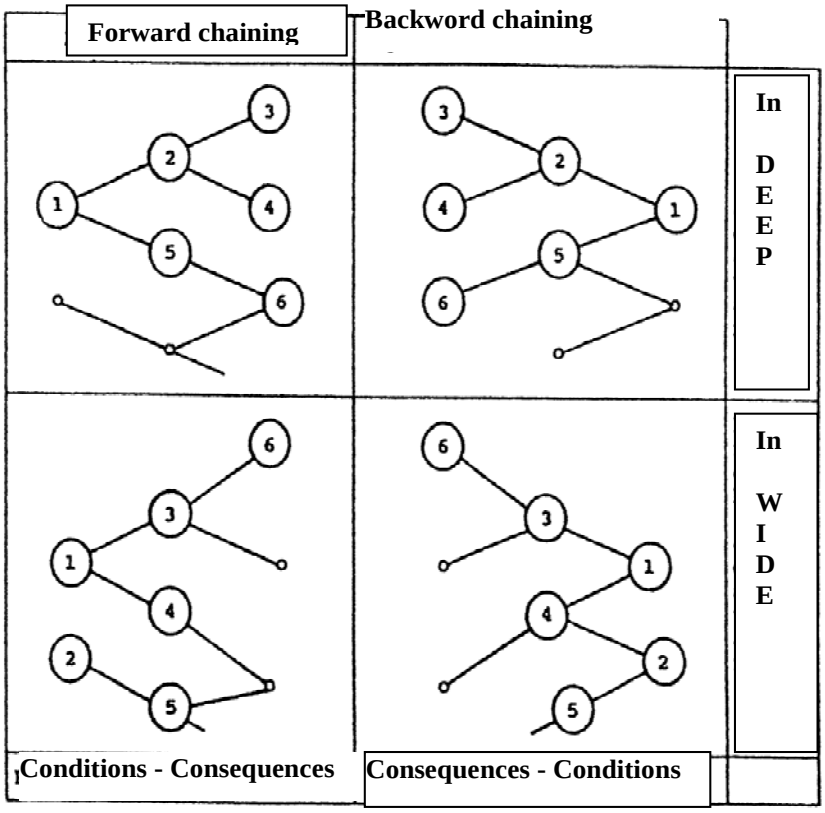
Inference engine manages:

- Run of the ES in data-base (e.g., determines the start and the end of manipulations with knowledge extracted form data base). In case that the knowledge base consists of complicated rules, inference engine decides which rule will be processed as the first, how will be interpreted the result of rule, which will be the second rule, etc.).
- The style of processing of knowledge in the data base (e.g., forward chaining, backward chaining, the approach in the depth, …).
- The deployment of special tools (induction, blackboard, mathematical operations, …).

The criterion of the work of inference engine is the correctness and efficiency of the processing of knowledge in solving the given task.

Some components and attributes of inference engine:

- Chaining of rules



- *Blackboard.*
- *Logical inference.*
- *Computations.*
- *Inductive tools* (modal logic, statistics, heuristics, methods of generalization, …).
- *Demons.*

5.2. Application and examples of the deployment of expert systems

Shell of ES – empty ES (without filled knowledge base, without modified inference engine, without customization).

Application of ES – dedicated ES (prepared for the problem solving form a certain field – e.g., for the design of building machines – example ES SALT).

In Table 1.5 are introduced expert systems with their authors, with distributing firm, with the field of use, and with the degree of difficultness (G) of their deployment (G=5 – very difficult, G = 1 easy to use).

Tab. 1.5.

Row	The name of ES	Field of application and deployment	G	Ref.
1	ETS (Boose, J.H.)	The choice of optimal variants of the solution, procedures of the decision, the support of knowledge acquisition processes. Educational ES.	1	[5]
2	Expert System Builder (PAUL CASWELL, Bournemouth, Dorset, BH5 2ER, UK)	The choice of optimal variants of the solution, procedures of the decision, the support of knowledge acquisition processes.	1	[7]
3	XCON (DEC)	Designs of configuration of machines, of computer system, of complex machinery products.	4	[8]
4	G2 (Gensym Corp.)	Qualitative simulation, visualization, real-time control. Monitoring and supervising systems. Biotechnologies. Production of building materials.	5	[9]
5	NEST (P.Berka, High School for Economy, Prague)	Universal application. Knowledge Engineering Environment, models of control processes.	5	[10]
6	CLIPS (NASA)	Universal application, models of control processes, project management.	5	[1]
7	Vanguard (2009 Vanguard Software Corporation)	Decision processes, business rule-based systems, complex planning operations.	3	[11]

5.2.1 An example of consulting expert system for the support of human operator control

Modular scheme of ES is in Fig. 24.4. Modules are interconnected by means of Control module (not seen in 24.4.)

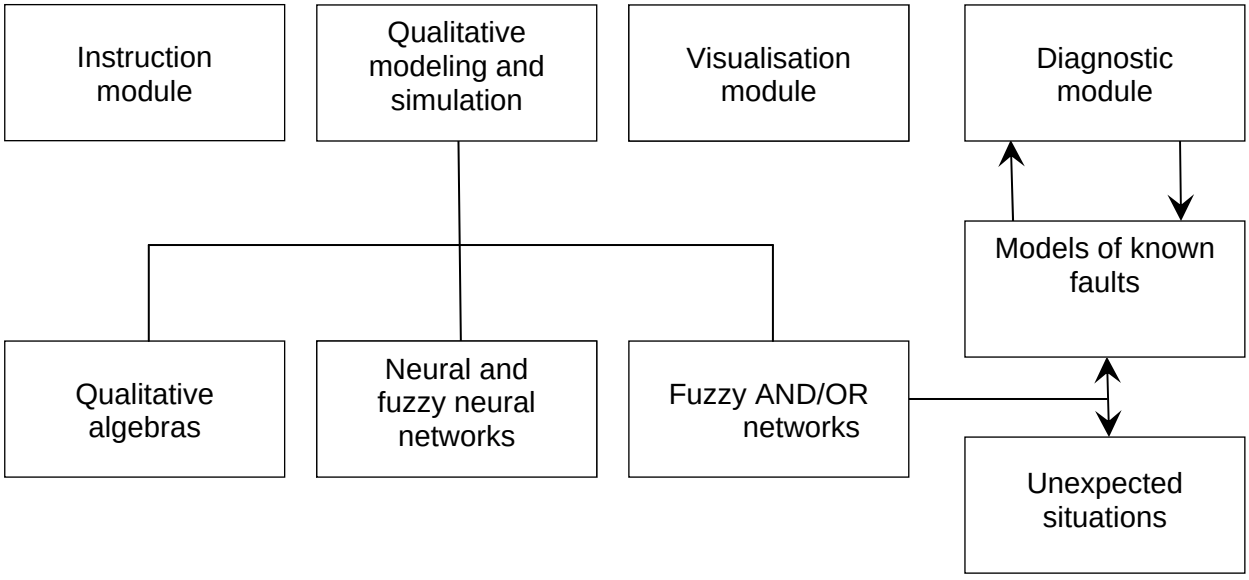


Fig. 24.4.

Instruction module

The goal of instruction module activities is to navigate human operator to correct control actions in case of blackout of control system or in untypical regimes of the system (e.g., in starting or ending phases of the system operation).

Module works as an expert system with tree knowledge base without uncertainties – see Fig.25.4.

Module communicates with operator by means of simple command windows – see Fig. 26.4.

Each window has two parts. Upper part contains an instruction that navigates operator to certain activity.

The execution of activity is checked by the question in lower part of the window. The operator reacts by one of the following responses: " YES", "NO", „I DO NOT KNOW.“

The question with one of possible responses is formalized as a rule:

〈 (IF (("The text of question“) AND (Response is "YES") 〉 ---->

----> 〈THEN (Transfer into further node of knowledge base "A pointer") 〉 .

Instruction module allows very quick extension and adaptation of knowledge base.

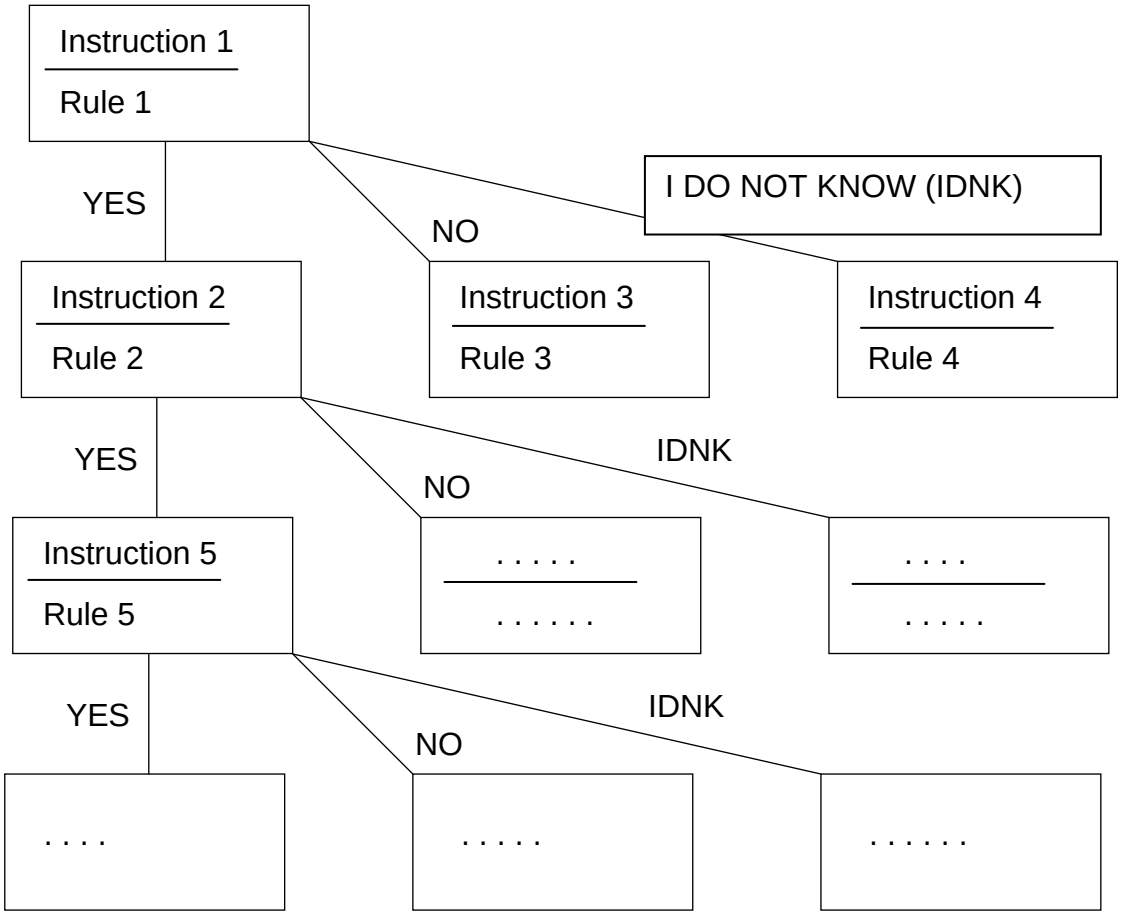


Fig. 25.4.

Instruction:
Prepare for execution of operation P 112 ! Check navigation of the machine to mode A1.
Execute opening manouvre ! Read coordinates !

Rule:
Are you in coordinates (52.35, 681.2) ?

YES | NO | IDNK

Fig. 26.4.

Module for qualitative modeling and simulation

Module supports a qualitative reasoning of the type „What will happen If I execute operation P 112 ?“ (What / IF ?).

Visualization module

There are many of visualization modules nowadays, e.g., „InTouch“, „Modicon“ „MonitorPro“, „Promotic 2000“.

Diagnostic module

This module contains means for the detection, allocation and interpretation of faults. Faults are formalized as fuzzy AND/OR networks or by means of neural networks (each fault is assigned to one trained neural network).

References

[1] Castillo, E. & Alvarez, E. : Introduction to Expert Systems: Uncertainty and Learning. Esevier Science Publishers, Essex, 1991.

[2] http://www.esbuilder.com/

[3] Baker, V.E. & O′Conor, D.E.: Expert System for Configuration at Digital: XCON and beyond. Communication of the ACM, Vol. 32, No. 3., 1989.

[4] G2 Reference Manual. GENSYM Corporation, Cambridge, USA, 1998.

[5] Berka P., Laš V., Svátek V.: NEST: Re-engineering the Compositional Approach to Rulebased Inference. Neural Network World, 5/04, 2004, 367-379.

[6] http://www.vanguardsw.com