Expert systems

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Abstract: Paper presents the key issues relating to the construction of expert systems, their types and uses.

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1 Introduction

Expert systems are one element of artificial intelligence, which includes the areas such as:

- game theory,
- robotics,
- learning machines,
- intelligent database,
- automatic programming etc.

Based on these elements can be said that artificial intelligence [9] is a very large IT department. A general definition is that this is an area dealing with the construction of algorithms and intelligent machines, which during the operation show some ability to take certain steps to adapt to different ways of learning machines, intelligent, etc. are those whose responses are consistent with the replies from the expert of the field problems. Such machines are intelligent expert systems, which represent only a part of such a wide range of artificial intelligence. Expert systems are computer programs designed to solve problems on a specialized, which quite often work better than experts in the field, because they are faster than humans and do not give signs of fatigue.

The first expert systems that have arisen are:

- DENDRAL – recognize a molecule of organic compounds based on spectroscopic analysis of the spectra,
- PROSPECTOR – assisted by the work of geological,
- MYCIN – analyzed the bacterial disease of blood and offered appropriate treatment,
- MACSYMA – was used to solve mathematical problems and integration.

2 Construction of expert systems

Expert systems [1] [2] are computer programs consisting of the following elements (Figure 2.1):

- knowledge base,
- database,
- requesting machine,
- explain the procedures (system explanatory),
- inference procedures
- control procedures for dialogue,
- procedures for updating the knowledge base.

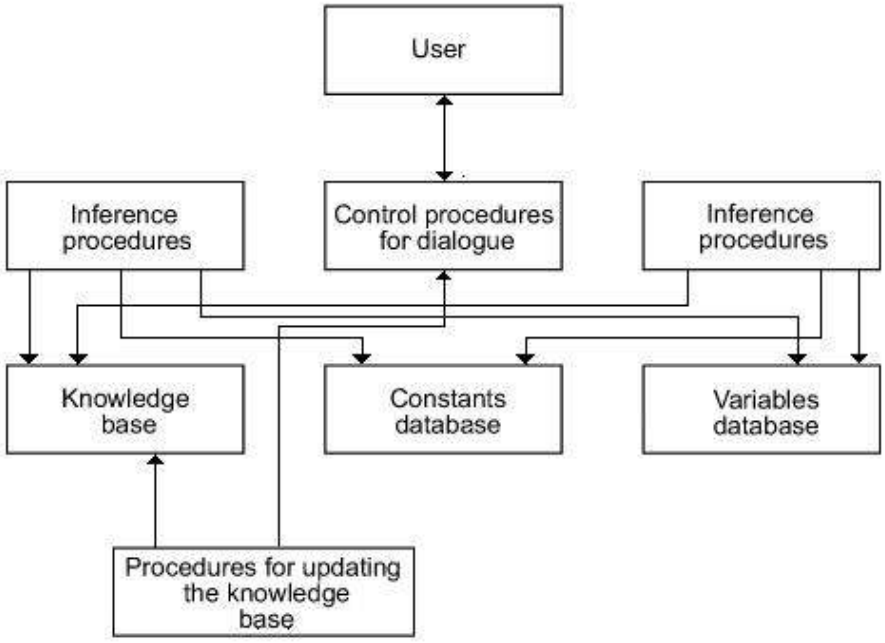

Figure 2.1 Construction of expert system

2.1 Knowledge base

The main mechanism of expert system is a knowledge base, which contains information provided by experts in the field problems. On a knowledge base consisting of sets of rules and facts. The rules are illustrated with the use of terms such as for example:

IF condition IS conclusion
IF condifition_1 AND condition_2 OR …… AND condition_n IS conclusion_1

In the condition are circumstance under which they are asked questions about features. If the rule is satisfied following its activation, which involves adding further proposals to the knowledge base and perform certain actions. The facts,

however, are represented as follows: (object → attribute = value) and are in the form of indicative sentences describe reality in a given field of knowledge. An example might be the following sentence:

The Fiat Siena has a luggage capacity of 200 liters

In this fact we are dealing with an object - a car. In addition, the knowledge base may contain other objects (types of cars) such as cars, vans, trucks, etc. Besides, "our" object has two attributes: name and boot capacity. Objects found in the knowledge base can be linked between different compounds. Examples are vehicles that have characteristics common to all cars as the make, model, capacity, engine type, gearbox type, etc. This gives the possibility to create relations of inheritance of characteristics from other objects. Thanks to the standard features you can take from other objects (in this case the car) and other characteristics specific to the vehicles defined separately. We distinguish the following types of knowledge base:

- *database of texts* – as an example can serve as dictionaries, with selected data from the problematic areas, the information is stored in a piecemeal manner,
- *database* – stores data in an orderly manner,
- *modelbase* – holds various mathematical models of the selected area of problem,
- *rulebase* – has information on any links in a specific area problematic,
- *common sense knowledge base* – contains meta knowledge or knowledge of how the process information, has rules that allow you to decide. Knowledge can be represented in two ways: symbolically and not symbolically. A symbolic representation of knowledge is divided into:
- *procedural*, based on her procedures, which represent the performance of knowledge from the problem,
- *declarative*, which is to define the facts, rules and statements related to the field problem.

The advantage of the first variant is quite high efficiency in the case of the second easy description and formalization. The symbolic knowledge representation methods include:

- using record statements,
- using a regulated system,
- using computational models,
- using the account statements and predicates,
- using semantic networks.

However, not symbolically methods of knowledge representation based on observations and experiences with the surrounding world, as exemplified by the neural network to simulate the properties of knowledge representation and processing. Another example is genetic algorithms, which in successive generations communicate information about the species.

The process of creating a knowledge base consists of the following steps:

- identification of the problem to be solved,

- choice of knowledge representation,
- creation of structures holding the knowledge,
- implementation rules,
- testing rules.

For the entire process of creating a knowledge base corresponds to the knowledge engineer. During the first stage must determine the problem and its scope, which will be governed by the system. In the next phase is carried out analysis of the problem, resulting in a description of the flow of data, different approaches to the problem. At this stage, collected the necessary information and data. While creating awareness of the organizations is to translate the results of the previous phase of the formal language, which should be designed by an engineer's knowledge. During the implementation of rules created a system which is then tested in terms of provision of correct answers.

2.2 Inference engine

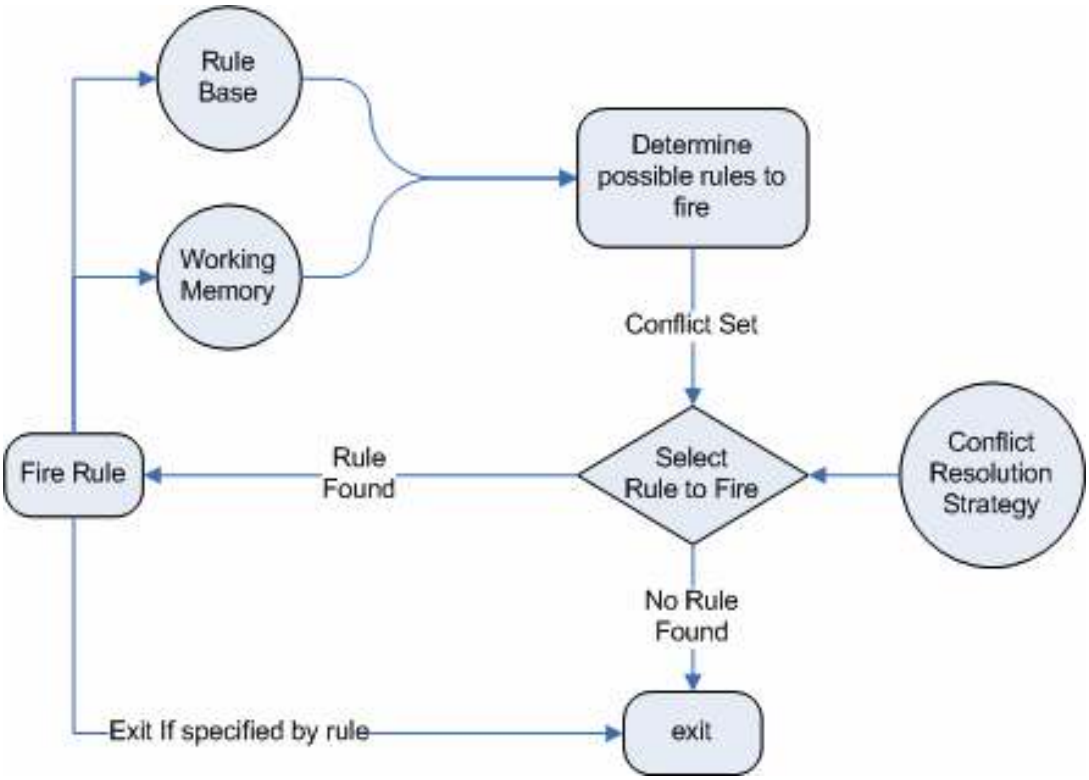

Figure 2.2 Inference algorithm - "forward chaining" [8]

The Inference engine [8] also known as the inference machine a next element expert system. The machine uses a knowledge base for the applicant or the facts and rules to solve a problem with a specified area or place a proper diagnosis. Examines the engine of the applicant in a specific order rules while retaining the logic of statements. Maintaining adequate control over the order of the rules has an interpreter of the rules and statements that is contained in a knowledge base. We distinguish the following types of inference: "forward chaining", "backward chaining" and "mixed chaining". "Forward chaining" inference (Figure 2.2) lies in

the fact that the expert system based on the facts underlying the rules and generates more facts and rules until a solution to get a specific question.

Generally, the "forward chaining" inference consists of the following steps:

- based on the facts, creates a set of rules that can be activated,
- these rules are selected, in which all the conditions (condition) part of a conditional, among them one rule is selected for activation,
- in such a way that created a new fact.

All steps are repeated until the show that presented the hypothesis is true or not. Choices depend on the number of rules in terms of the conditional order of appearance in the knowledge base of information or whether the rule was already used during the inference. In turn, the second type of inference is reasoning backward (Figure 2.3) which consists of proving the veracity of the basic hypotheses based on the truth conditions (the conditions) in the conditional part of rules.

Where there is no certainty as to the veracity of the condition is treated as a condition of a new hypothesis. For a new hypothesis is performed the same function as the primary hypothesis. When you encountered a rule that all the conditions are correct that the inference resulting from this rule is true. Based on a inference to be taken is another rule that there was no pre-condition, etc. Demonstration of truth hypothesis is tantamount to showing the truth of all evidence.

Another type of inference is mixed inference, which is based on the use of so-called metarules which rules about rules. Based metarules managing the program selects the appropriate type of inference. Metarules contain a specific indication of correct choice of the application, which allows for automatic selection of the type inference.

2.3 Explanatory system

Generally speaking, the system explains that explains how the solution was obtained and provides various statistics on the subject.

The main task of explaining are the answers to the questions "how" and "why". Questions might include:

- *rules of operation* – questions about the content of the various rules in the rules that meet certain criteria, the questions may also relate to conduct a dialogue with the system, such as the rule used to obtain answers,
- *fixed and variable data* – what are the relationships between data, the proposed answers to the questions addressed by the user, explaining why the question comes to ask further questions to the user.

The reply given by the explanatory system is formed by making the texts in the system. In this way, the output obtained is the message understandable to man.

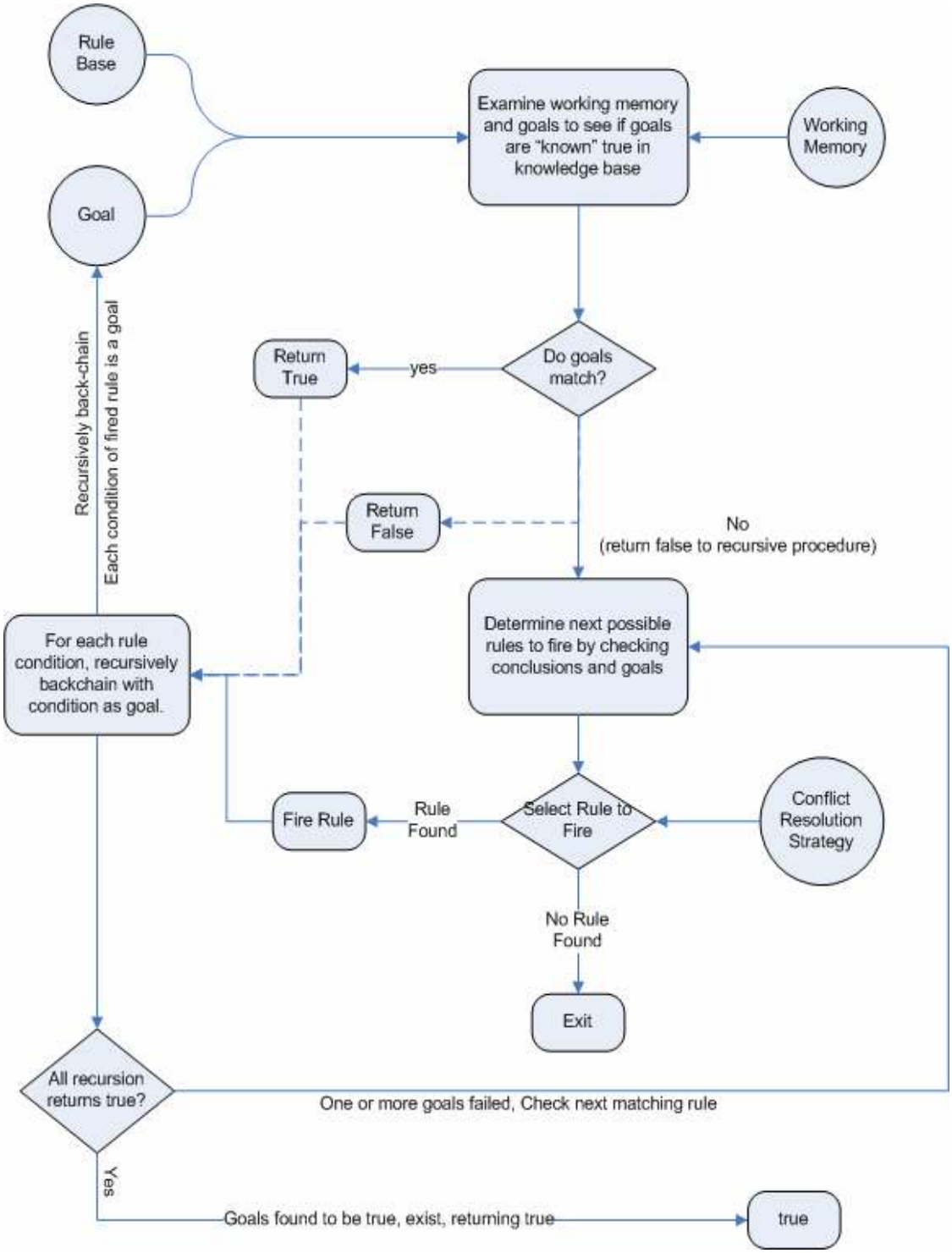

Figure 2.3 Inference algorithm - "backward chaining" [8]

2.4 Control procedures for dialogue

In order to allow a conversation with an expert system using language comprehensible to the human expert system must have a dictionary provided with a considerable amount of words. A large number of words entails comprehension of

answers by the system. Advanced systems offer an additional choice of using language, which will communicate with the user. Creating a response to the question whether the system uses ready-made phrases which belong to the relevant rules of combining the words from the dictionary.

2.5 Procedures for updating the knowledge base

Unfortunately, not always successfully build a knowledge base and then the errors can be observed during operation of the system, which entails changes in the structure and update the knowledge base. Remedy knowledge base can cause other errors. In order to prevent this situation be used to automatically test and control semantic correctness.

Followed by matching appropriate rules, which will repair your system. The rule is tested in many different variants, of which the best is implemented. After entering the appropriate variant of a rule system is tested in the same situation in which the error was detected to determine whether in fact the problem is resolved. The whole process of correction is subject to supervision by the knowledge engineer, who ultimately approved the new changes.

In addition to the change in the structure of the knowledge base is possible to update the contents of the knowledge base, which allows for changes in the collection of rules by editing the existing rules and adding new ones. Revision of the rules shall be made in case of irregularities in the rule, etc. The contents of the new rule is defined in cooperation with the user. The new policy will be tested before being introduced to knowledge base.

3 Types and application of expert systems

Expert systems can be divided according to different criteria [3], i.e.:

- solution presentation,
- development strategy,
- performed tasks.

Expert systems due to the presentation of solutions can be divided into:

- *advice under the control of people* – the result of a solution is evaluated by users in terms of quality, the user has the ability to approval by either waiting for another better,
- *advice without the supervision of the people* – the result of a solution is validated by the system without human intervention,
- *criticizing* – is made to analyze and evaluate solutions obtained.

By contrast, taking into account expert systems, depending on the strategy of creating distinguish:

- *dedicated systems*– implemented from scratch,
- *skeletal systems* – they are ready-made systems with a blank knowledge base to be completed.

The last group is the division of expert systems in view of the executed tasks:

- *predictive systems* – predict the future based on current information, such as weather,

- *completion systems* – dealing with objects with the settings and restrictions, such as configuring software,
- *planning systems* – the same take specific actions to achieve the goal,
- *diagnostic systems*– under the influence of observation to detect various defects, such as electronic circuits,
- *systems of interpretation* - based on the observations make the interpretation of certain situations, such as speech recognition,
- *monitoring systems* - make observations with regard to any restrictions, such as traffic lights on the road,
- *improving systems* - the system shows how to proceed when the object is functioning poorly,
- *repair systems* - make a record activities in the elimination of damaged buildings defects,
- *instruct systems* - systems designed for education,
- *control systems* - which contain the features of predictive systems, interpretation, repair, monitor.

Based on the above divisions can easily conclude that expert systems are used in many areas of life. Expert systems are being implemented in fields such as chemistry, physics, computer science, medicine, geology, electronics, industry, agriculture, economics, meteorology, etc. The largest number occurs in the U.S. and Japan. Approximately 35% of the system is applicable in the diagnosis and approximately 30% of the fully complex functions. Significant role played by expert systems and energy management. The management are to: perform audits, lending, financial planning, personnel management, tax planning, optimization of production, etc. In turn, assist in the energy forecasting and planning, troubleshooting, power system control, alarm processing, etc.

4 Distributed expert systems

The current economic market is full of many companies divided territorially. Dispersed firms promotes the continuing development of specialized hardware and software allowing for easy contact and information exchange. This course gives businesses the chance of a situation to take full advantage of their opportunities.

An important element of the corporations is knowledge and experience [4] that are acquired years. These valuable assets have qualified experts. Territorial division of the company makes that individual professionals are not present in all places at specific times. Difficult contact with experts forces employees to make their own decisions based on their own are often insufficient knowledge and experience. To solve these problems, use the appropriate solutions, such as expert system to build the architecture that fits into the company. Referring to the second section may provide general structure of expert system, which consists of the following elements:

- knowledge base,
- inference engine,
- database.

In addition, we can distinguish the editor's knowledge base and user interface allowing for interaction with the system. The separation of knowledge from the other components of the system allows for easy updating of knowledge which improves SE. Overall, the task of expert systems is knowledge acquisition and processing, in contrast to other systems, which tend to be aimed only at the data processing.

In Figure 4.1 are presented the basic relationships between the various components of the expert system. Direct access to the knowledge base is through the knowledge base editor or the system applicant. The structure of such a system can distinguish the following division into layers:

- UI layer,
- knowledge processing layer (inference engine, knowledge base editor, database),
- layer knowledge base.

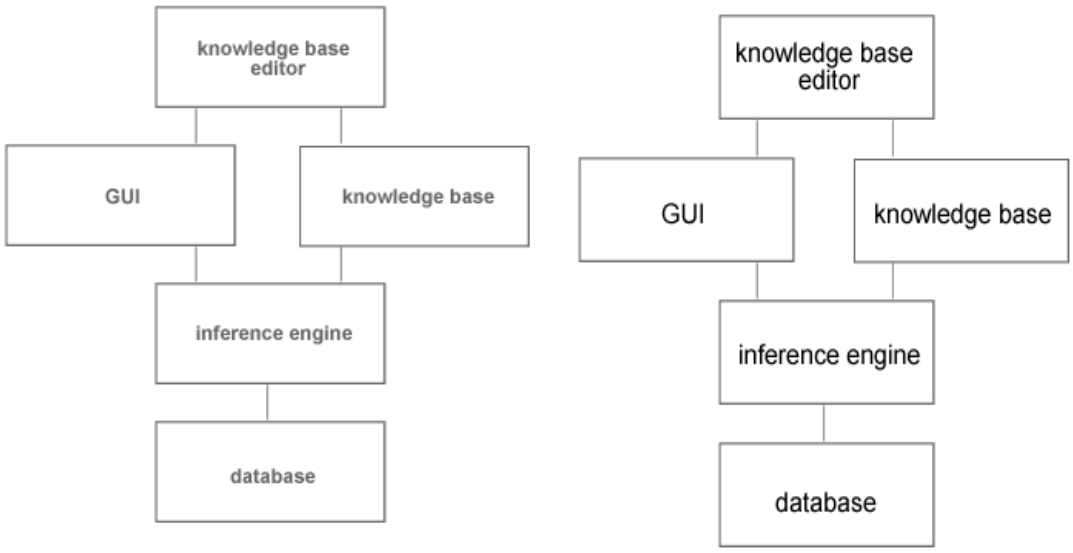

Figure 4.1 Expert system architecture

The general idea of distributed systems involves the location of at least two computers or similar devices. Communication takes place via a computer network wired or wireless. The main advantage of such systems is to achieve greater productivity with less cost compared with single systems and the internal dissipation of certain functions. Significant improvement of teamwork and greater reliability is another of the features that argue in favor of using such systems. Very often used within the architecture of distributed systems is a three-layer architecture (Figure 4.2), which consists of the following layers:

- data layer,
- business logic layer,
- presentation layer.

The layer of data information is stored and retrieved from databases or files. Data are transmitted to the business logic layer and then to the user via the presentation layer. Business logic layer processes user requests and make

calculations. Is the intermediate layer between the data layer and presentation layer. The presentation layer is nothing but the user interface. Use it to the user sends requests and receives responses from the system.

Three-layer architecture [10] is the appropriate technology architecture for the client - server. Using the technology of client-server computer system is divided into two parts: client and server. Distribution layers can be made arbitrarily, leaving on one side of one layer and the other two. When the client-side presentation tier is a server-side business logic layer and data layer then the individual parties are called to as "thin" client and "fat" server.

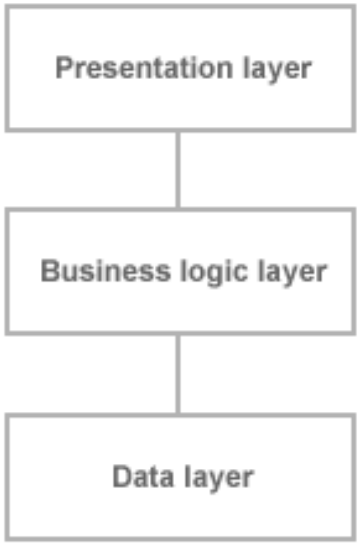

Figure 4.2 Three-layer architecture

By contrast, when the dividing line will be routed to the presentation layer and business logic layer is a client-side layer and server-side data then it is "fat" client and "thin" server. Application of "thin" client allows the use of heterogeneous environments and easy adaptation to a distributed environment. On the client side only if there is a graphical interface adapted to the selected operating system or independent of them. An example of "thin" client and "fat" server can be a website where users via a web browser (presentation layer) makes interaction with the server, which processes information (business logic layer) retrieved from the database (data layer). This solution requires a robust server that can handle the demands of many users at the same time. The role of the confines itself to the client to issue commands and display the results received from the server.

In the event of "fat" PC client user is responsible for processing and presentation of results leading to significant use of computing machines. Server functions boil down to execute a query to the database. This division has its drawbacks since every change in the software module supports the processing of force updates on the user. In addition, implementation of this option is difficult to achieve in heterogeneous environments.

Referring to the architecture of an expert system, you may notice a strong resemblance in comparison with three-layer architecture for client-server technology. Layer user interface expert system corresponds to the presentation layer,

a layer of knowledge processing - the business logic layer, the layer of the knowledge base - a layer of data. This simple analogy is not quite true. At the beginning of the chapter has been mentioned that the principle of an expert system consists of acquiring and processing knowledge. Therefore, you can even say that the business logic layer consists of the knowledge base on which the whole logic is hidden. Operation of the system boils down to requesting that the extraction logic.

Separation mechanism of the applicant from the knowledge base has its advantages [7], ie:

- ease of access to knowledge areas,
- the possibility of a simple update of the knowledge base without interfering with the interference system,
- ability to create universal expert systems is complemented by its own members know areas.

Separated of these mechanisms does not mean to put them on separate nodes. If you use client-server technology with the "fat" client that contains the user interface and processing engine, the entire knowledge base would be sent from the server to the user.

While the second option - "thin" client and "fat" server is no longer an appropriate solution, because all the processing engine including a knowledge base would reside on a single machine. Client would be equipped with only the layer of user interface based on web browser or other software.

The use of expert systems in various companies allows gathering areas expert knowledge, and thus a partial decoupling from them which affects the frequent rotation of highly skilled workers. In the case of distributed expert systems have additional benefit of access to specialists without knowledge of their presence. Experts can often be present at the time far distant from each other departments of the enterprise.

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