Adaptive EIS with Business Rules Discovered by Formal Concept Analysis

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Abstract. Business rules component became essential part of the software such companies as ORACLE, SAP, IBM and Microsoft and this fact signifies new stage in the Enterprise Information System (EIS) development and applications. The efficiency of application such new tools depends from business rules development technology. The new generation of EIS software requires not only deployment strategy, but also tools for extracting business rules from description of existing practice. Along with manual business rules extraction from mountains of documents, there exists the possibility to apply data mining technology based on formal concept analysis. In this paper we are presenting, how suppliers and customers data, being accumulated in data base, may be used in Customer Relationship Management (CRM) system for fitting services and relations to customers and suppliers profiles.

l. Introduction

The modern enterprises' business processes are very complex, especially for medium and large business. They contain many conditions, restrictions and rules that are implicit and hidden in numerous documents, job manuals, applications codes and experience of employees. Such sparse rules dissemination creates difficulties for a company to rebuild the business in time, because of time spent on documents finding, the conditions and rules reveal, rewriting instructions and regulations, and to make changes to the IT components and applications. Great number of business rules and its variability urges the companies to allocate business rules as independent part of the business description [1-2]. The collecting of business rules together as a separate IT components managed by Business Rules Management System increases the response speed to the changing of competitive environment and speed of decision making.

The companies, such as Oracle, SAP, IBM and Microsoft, which are producing software for enterprise information systems during last two years the main effort have been focused at the problems of integrating broad spectrum of the different their software products, such as Web-applications, SOA, Collaboration suite, Data Warehousing, Application Server and so on. In the same time such business intelligence tools as Data Mining, Knowledge Discovery, and Business rules were regarded for a long time how not essential part or as special software and even were not included into structure of EIS software.

As a consequence, there arose a situation, when very complex and expensive software was targeted mainly at the secondary tasks in the business management, such as routine tasks of data processing, not towards the strategic planning tasks of top managers. As a result, in many cases, the efficiency of enterprise information systems, relative to the expenses for the implementation of these systems, was low and insufficient for the business users.

Meanwhile the concepts of EDM - Enterprise Decision Management [3] and ADS –Automated Decision Support [4] were proposed as an approach for possible automated decision making. Having in mind implementation business rules approach at the some enterprise, we will concentrate our efforts on the problem of including business rule capability in CRM business processes. Only in recent years the companies, mentioned above, have included a component of business rules in their software. It is important to note that rules-component has been integrated into business processes component and Data miming tools are applying for rule discovery. Let's consider some essential features of BRMS components EIS software of these vendors.

2. BRMS Component of the Leading EIS Software Companies

2.1 Oracle Business Rules

Oracle Business Rules [5] is a new product that provides all features needed to realize the "agility" and cost reduction benefits of Business Rules. Oracle Data Mining can analyze historical transaction data and suggest business rules. Oracle integrate Business Rules integrates with SOA/BPM facilities.

The Rule Author is a Graphical User Interface tool for creating and updating Rules. The programmers use the Rules Author to create a business rules, extracting it from documents and practice and converting these business terms to Java or XML expressions. Rule Author provides a web-based graphical environment that enables the easy creation of business rules via a web browser.

The Rules engine is implemented as a Java Class, and is deployed as a Java callable library. Java programs directly call the Rules engine. The Rules engine implements the industry standard Rete algorithm making it optimized for

efficiently processing large numbers of Rules. There are many types of services including "decision support" services.

2.2. SAP NetWeaver Business Rules Management

The SAP NetWeaver Business Rules Management [6] component complements and accelerates SAP NetWeaver Business Process Management. Together they have become important components of Enterprise SOA.

The Rules Composer is the rule modeling and implementation environment of SAP NetWeaver BRM. Because it is integrated within SAP NetWeaver Developer Studio, the Rules Composer is the most efficient way for developers to build rules-based applications targeted at the SAP NetWeaver platform.

The Rules Engine is the run-time engine of SAP NetWeaver BRM, available as a predeployed stateless session bean in the SAP NetWeaver Application Server (SAP NetWeaver AS) Java of SAP NetWeaver CE. This tool gives IT developers the ability to generate reusable rules services out of the box, which is particularly helpful for integrating rules into composite applications.

The Rules Analyzer, a targeted environment for business analysts, will allow them to model, test, simulate, and analyze business rules without assistance from developers

2.3. MS BizTalk Server

BizTalk Server includes the Business Rules Framework [7] as a stand-alone .NET-compliant class library that includes a number of modules, support components, and tools. The primary modules include the Business Rule Composer for constructing policies, the Rule Engine Deployment Wizard for deploying policies created in the Business Rule Composer, and the Run-Time Business Rule Engine that executes policies on behalf of a host application.

The Business Rule Composer enables you to create rules by adding predicates and facts and defining actions. You can add facts and actions by dragging them to the Business Rule Composer design surface. The actions update the nodes in the specified document. You can also add AND, OR, and NOT operators to conditions to create complex comparisons.

The Business Rule Composer helps you create, test, publish, and deploy multiple versions of business rule policies and vocabularies to make the management of these artifacts easier.

2.4. IBM WebSphere ILOG Business Rule Management System

The IBM WebSphere ILOG Business Rule Management System [8] offerings include the next main components: Rule Studio, Rule Team Server,

ILOG Decision Validation Services, Rule Solutions for Office, Rule Repository, Rule Execution Server.

From within Rule Studio, a developer can:

• Create a logical business object model (BOM) for the application, and map it to a customized, domain-specific rule vocabulary.

• Create business rules in a natural language syntax, which can be expressed in one or a more localized versions (for example, English or Spanish).

• Create rules in the form of decision tables and decision trees

• Create technical rules in a platform-specific syntax.

• Separate rules in a rule set into tasks, and specify a rule flow to orchestrate the execution of these tasks.

The rule authoring and management environment for business analysts and policy managers is called IBM WebSphere ILOG Rule Team Server (RTS), a thin-client Web-based environment with a scalable, high-performance enterprise rule repository. The repository provides the BRMS with a central "source of truth", addressing the specific needs of rule-based business policy management.

The WebSphere ILOG BRMS offerings include Rule Execution Server (RES), a managed, monitorable execution environment for rules that can be incorporated into an application by being deployed to a J2EE or .NET application server, or embedded directly in an application.

3. Business Rules Applications for CRM

The most promising domain for application of business rules software at the current time is Customer Relationship Management (CRM). CRM is a business strategy, directed at the sustainable business building, the kernel of which is "client-oriented" approach. CRM also includes technology of customer retention and client-enterprise interaction history database maintenance. This strategy based on collecting information about clients at all stages of service life cycle, extracting knowledge from it and using this knowledge for business amelioration.

In this paper we will consider how business rule management conception can be applied to one of the Russian enterprise – Podolsk (town) Electromechanical Plant - PEMP (http://www.i-mash.ru/predpr/1250), which is producing hydraulic equipments. This enterprise is specialized in supplying of hydraulic and pneumatic equipment for energy companies and for construction, transportation and industrial complexes. The firm is producing various hydraulic equipment (pumps, motors, etc.), designed for application in marine hydraulics, transportation systems, facilities for the repair of wells, as well as railway equipment (locomotives). All the necessary spare parts and rubber products for this equipment are also manufactured.

The problem, nowadays facing this company, consists from reducing the amount of orders for products and from another side - customers churn. In

modern conditions the market is saturated with offerings, and the struggle for the client retention becomes one of the major problems of each company.

Analysis of customers data and as a result, selecting different customer categories and corresponding business rules, then providing to customers services, relevant to the customer's consumption profile. Flexible system of discounts and offers for client will allow the company to increase sales, identify and select the most valuable and reliable customers and, accordingly to their score, focus on them, and as final result, to improve efficiency of the business in general.

Business rules manually could be derived from several sources, and three main sources may be described as follow: policy statements and objectives of organization, business processes, external factors (e.g. laws and regulations). The tracing the sources of business rules can help to the personnel to discover the need of changing BR. If the content of the source is changing, the rules, relating to this source, has to be modified or removed.

Business rules can be described in a simple natural language or by mean decision tables or in form of decision trees. If simple natural language would be chosen, the rules can be easily readable and accessible to all interested parties: business owner, business analyst, technical architect, and so on.

According to business rules for each category of customers the company is offering different set of products and services according to different customer's profile.

Table 1. PEMP customer relationship business rules

Business Rules	Formalized Rules	Source Type
If the volume of sales order from 80,000 to 120,000 rubles and the status of the client "risk", then give a discount of 5%	IF 80 000<order_value< 120 000 and status = "bad" THEN set discount 5%	Corporate policies, dynamic
If the volume of customer order less than 80 000 rubles, then do not give a discount	IF order_value<80 000 THEN set discount 0%	Corporate policies, dynamic
If the industry of the client equipment, then to appoint a corporate rating of 2	IF otrasl = "1" THEN score:=score+2	Corporate policy, static
If the industry of the client shipbuilding, then assign a corporate rating of 8	IF otrasl = "3" THEN score:=score+8	Corporate policy, static
If the term of the client in this sector from 11 to 20 years, to appoint a corporate score equal to 14	IF 11<srok<20 THEN score:=score+14	Corporate policy, static
If a corporate customer rating greater than 25, then a status of reliable customer	IF score>25 THEN status:="good"	Corporate policy, static

We have been elaborating the business rules of this enterprise in the next stages:

➢ Defining the main sources of business rule,
➢ Business rules formalizing and catalog creating,
➢ BRMS market analyses and choosing appropriate system,
➢ Creating a model in the BRMS environment,
➢ Data base development and loading data about products and customers,
➢ Testing the model,
➢ Integration with EIS.

As a result of this work hundreds of business rules were selected, several examples of which are presented in the Table 1.

We suppose that the business model, based on business rules, makes possible for the plant quickly adjust production and services to changing conditions of market environment by applying a procedure of clients clustering according to their significance. The results of such clustering are used for risk rating evaluation and for using flexible discount system, that makes possible to retain profitable clients churn to another companies.

In our work for experimental part of research BRMS Visual Rules Modeler was selected and installed. As announced Bosch Software Innovations GmbH, Visual Rules Modeler now became the part of Visual Rules Suite Version 11.2 and is available now for download [9-10] . The next structure of the database, containing products and customer data, was developed (figure 1).
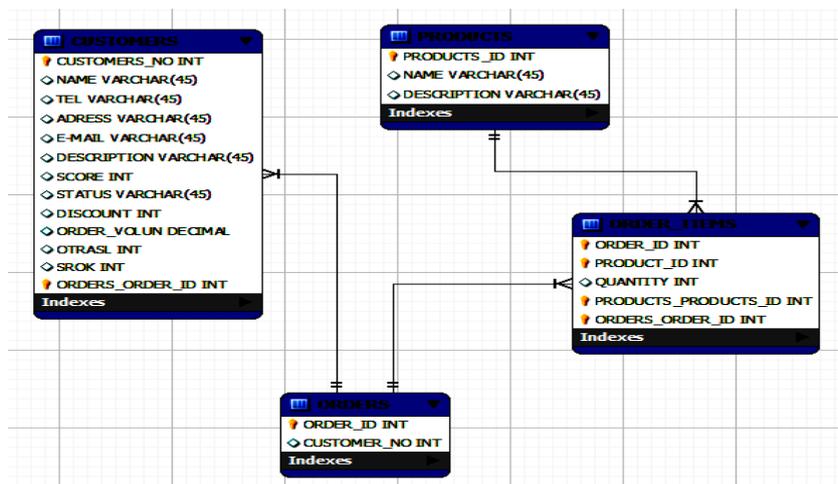
Figure 1. Database structure

In this data base table «CUSTOMERS» contains the clients legal entities data such as title, description, legal address, phone number, email address, branch of the industry, the term of operation of the client on the market, besides the table contains several computed field to store such data as score, the volume of orders and size of the discounts, computed as a result of the business rules application. Data about customer's orders are saved in tables «ORDER» and «ORDER_ITEMS». Table «PRODUCTS» contains the hydraulic products items catalog of company.
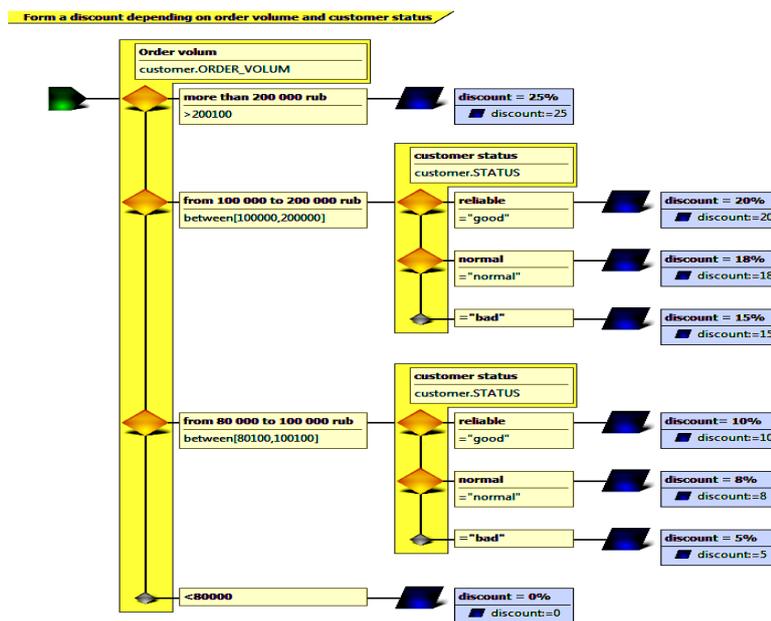
Figure 2. Business Rules, that assign the discounts to the clients

With application Visual Rules Modeler was created business rules stream "Discount Assign", depending from order volume and client status. Stream rules "Discount Assign" illustrates the rule set, which assigns discounts to customers. Business Rules allow management to create a flexible system of discounts, which values can be easily modified (figure 2).

As can be seen from database and database views, into database fields, such as score, status, and the order volume discounts, corresponding values have been inserted. These values were computed in accordance with developed business rules model for certain customer and logic of the discounts assignment decision to the different users. So through the developed business rules model, companies can quickly adapt to changing environmental conditions and dynamic competitive environment.

At the testing stage the data, prepared for the model testing, were loaded to the data base and then the values of discount percentage were computed according business rules to different customers are presented at figure 3.

Figure 3. Clients discount percentage data, computed according Business Rules

Rules stream at figure 4 shows that business rules stream is actually displayed as graphic interface for development the program, which may contain as business rules for conditions checking, as SQL data base commands "SELECT" or "INSERT", performing in the definite order, according to business process model.
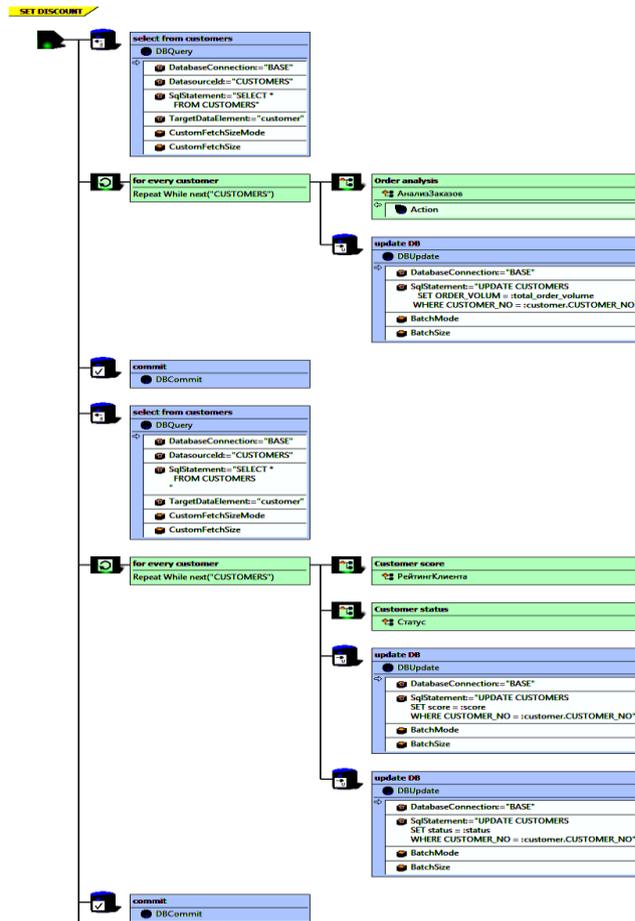
Figure 4. Rule stream as a program, containing business rules and
SQL operators

4. Rules Discovery by FCA Method

One of the problems which confronts business analytics is problem of
business rules discovery. This problem is very hard and has very high
dimension. The data mining method that may be used for extracting rules from
client and services data (figure 5).
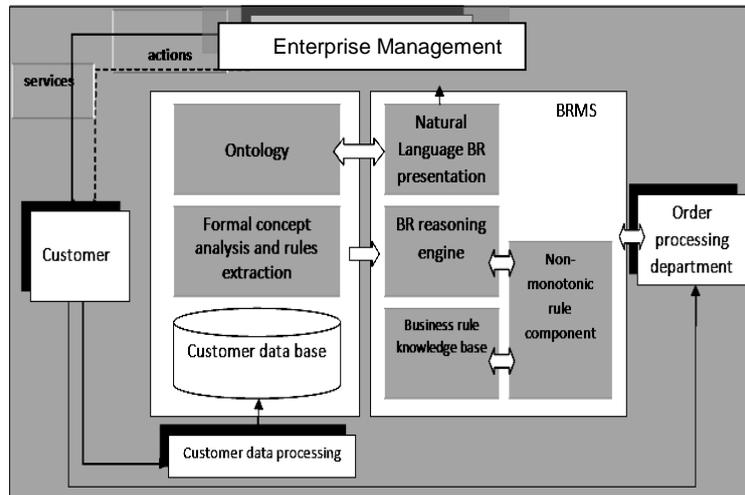
Figure 5. Adaptive EIS, self-adjusting to the customers' consumption profile and motivation customers to increase volume of consumption

At the figure 5 is presented adaptive EIS, where feedback loop used for adjusting EIS services on the base of analyzing customers' data and applying the results for correcting services and products to customer consumption profile.

The possibility of applying different data mining methods as a mean for implementation such feedback was widely discussed in the scientific literature [11-12]. The formal concept analysis is one of such method. Formal concept analysis was primary proposed by R. Wille in 1982 year [13] and it finds its application at the different domains for discovering data structure.

Aside from selection clients group and its visualizing this method provide possibility for searching attributes dependencies in form of implications. The clients may be regarded as objects and their personal data, kinds of services, intensity services consumption and performed with them marketing actions as a attributes, which customers have. Upon this data, the set of objects with common attributes values may be discovered.

The data are presented as formal context that is as a table, the rows of which correspond to object and the columns – to attributes. If some object has definite attribute value then at the intersection is placed one (or cross). The essence of the method consists in the next [14].

Formal *context* $K:=(G,M,I)$ consists from sets G,M and a binary relation $I \subseteq G \times M$, where M –attribute set, G –objects sets, expression $(g,m) \in I$ - signifies that object g has attribute m. Formal context may be presented as binary matrix, rows of which correspond to object and column – to attributes values. Let us define the mappings for $A \subseteq G$, $B \subseteq M$:

$$\phi: 2^M \to 2^G \quad \text{and } \psi: 2^G \to 2^M \quad .$$

$\phi(A) = def \{m \in M \mid gIm \; \forall g \in A\}, \; \psi(B) = def\{g \in G \mid gIm \; \forall m \in B\}, A \subseteq G, B \subseteq M.$

If $A \subseteq G, B \subseteq M,$ then

pair(A,B)- is named as a formal concept of context K, if $\phi(A) = B$, $\psi(B) = A$ (or another notation: $A' = B$, and $B' = A$). The object set A is named as extent and attribute set B – intent of the concept. Therefore, the formal concept it is a set of objects and corresponding attributes, such that every object has all attributes from the attribute set. In case, when extent of concept C_2 is included into the extent of concept C_1, that is $Ext(C_2) \subseteq Ext(C_1)$, we say that C_1 is a superconcept and C_2 – is subconcept. The concepts hierarchy is defined by relation subconcept-superconcept:

$(A_1, B_1) \leq (A_2, B_2) \Leftrightarrow A_1 \subseteq A_2 \; (\Leftrightarrow B_1 \supseteq B_2).$

For formal context (G, M, I) and $X \subseteq G, S \subseteq M,$

1. $X_1 \subseteq X_2 \Rightarrow X_1' \supseteq X_2'$ для $X_1, X_2 \subseteq G,$
2. $S_1 \subseteq S_2 \Rightarrow S_1' \supseteq S_2'$ для $S_1, S_2 \subseteq M,$
3. $X \subseteq X''$ и $X' = X'''$ для $X \subseteq G,$
4. $S \subseteq S''$ и $S' = S'''$ для $S \subseteq M.$
5. $X \subseteq S' \Leftrightarrow S \subseteq X'.$

The ordered set of all formal concepts of (G,M,I) is denoted by $L(G,M,I)$ and is called the concept lattice of (G,M,I). Infimum and supremum of the $L(G,M,I)$ are given by:

$$\bigwedge_{j \in J} (X_j, S_j) = (\bigcap_{j \in J} X_j, (\bigcup_{j \in J} S_j)''),$$

$$\bigvee_{j \in J} (X_j, S_j) = ((\bigcup_{j \in J} X_j)'', \bigcap_{j \in J} S_j).$$

The most important problem is: how to build the concept lattice for the context (G, M, I). We obtain the most simple answer, creating (X'', X') for all $X \subseteq G$ or (S', S'') for all $S \subseteq M$.

In practice, in our work we use A. Yevtushenko's system of data analysis "Concept Explorer", (http://sourceforge.net/projects/conexp/), [15]. The context for our PEMP example is depicted at figure 6, where data about customers, their consumption profile, values of score for clients, the efficiency data of preferences and discounts are contained.

Figure 6. The context, describing customers of the PEMP.

The concept lattice for our case is presented at figure 7. This lattice provides us an opportunity to explore and interpret the relationship between concepts.
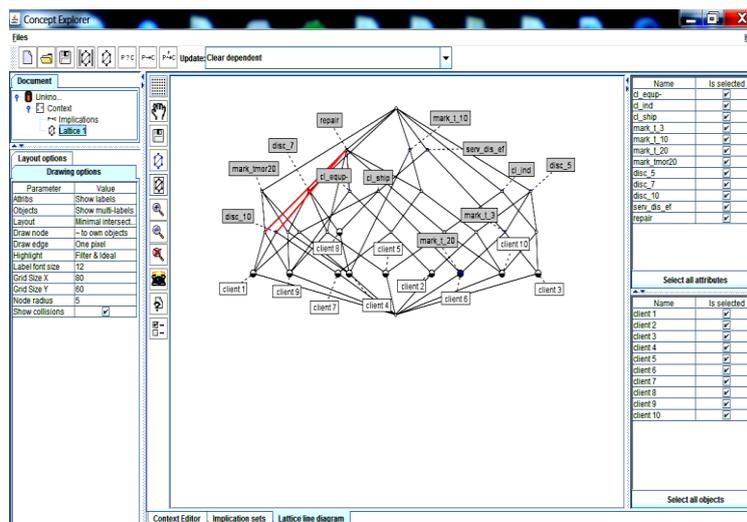
Figure 7. The concept lattice

The dependency notion between attributes is based on the next idea: if for all objects in the context, for which some property P is true, some another property C is also true, then implication $P \rightarrow C$ is valid. More precisely, the implication $P \rightarrow C$ is valid in a context $K = (G, M, I)$, where $P \subseteq M$ and $C \subseteq M$ iff $C \subseteq P''$.

5. Rules Quality Criteria

The implication means that all objects of context which contain attributes *P* also contain attribute *C*. That is in the situation *P* manager must make decision *C*. Let us define the next measures of rules quality:

- *Support: supp(P) = Card(ψ(P)/Card(G)* – the rate of objects, containing nonempty values of attributes P, comparing to all number of objects.
- *Confidence: conf(P$\Rightarrow$C)= supp(P$\cup$C)/supp(P),*
- *Lift: lift(P$\Rightarrow$C)=supp(P $\cup$C)/ supp(P)$\times$supp(C),*
- *Conviction : conv(P$\Rightarrow$C)=1-supp(C)/1- conf(P$\Rightarrow$C).*

The implication set, discovered by Concept explorer, are business rules, some example of which are presented below. Business rules with confidence 100%:

- **IF branch of the client = equipment THEN repair_discount_5%;**
- **IF time on a market > 10 THEN repair_discount_5%;**
- **IF time on a market > 20 THEN repair_discount_10% and service_discount and consulting_free;**
- **IF branch of client = shipment AND time on market> 20 THEN serv_discount AND sale_discount = 10% AND repair_discount.**

The rules with confidence less than 100%:

- **IF branch of client = shipment THEN serv_discount;** (confidence 80%)
- **IF branch of client = industry THEN consulting_free;** (confidence 60%)

We assume that data may be incomplete or contradictory and therefore implication derived by Concept Explorer should be considered within the frame of non-monotonic logic [16], and realized as defeasible theory rules [17]. Defeasible logic is practical non-monotonic logic, containing facts, strict rules, defeasible rules and supporting relations.

Non-monotonic reasoning is an approach that allows reasoning process with incomplete or changing information. More specifically, it provides mechanisms for taking back conclusions that, in the presence of new information, turn out to be wrong and for deriving new, alternative conclusions instead.

The non-monotonic subset of the rules is obtained by computing the lattice corresponding to the subcontext consisting of the original context without those attributes which do not apply to the set of all objects. FCA computes the minimal base of implications corresponding to the actual context and asks the user if each single implication is valid in the universe of objects or if a counterexample is known. The counterexamples are than added to the

context and the implications are newly computed until all implications are accepted.

6. Conclusion

In this paper we have considered the conception of adaptive EIS, which has possibility of tuning its business rules set by mean customer's data mining with applying Formal Concept Analysis method. This approach is especially important when number of business rules, which are changed with time, counts by thousands.

We have shown that on the way of including into the structure of modern EIS means for automated decision making, the essential role may play Formal Concept Analysis method, which can help to find out specific dependencies between observed customers' data and services provided by business.

The next step may be research the adaptive EIS with varying structure, including data base structure, procedures and semantic concepts of language, describing the domain of application.

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