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MATERIÁLOVOTECHNOLOGICKEJ FAKULTY
SLOVENSKEJ TECHNICKEJ UNIVERZITY
V BRATISLAVE SO SÍDLOM V TRNAVE

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FACTUAL APPROACH IN DECISION MAKING – THE PREREQUISITE OF SUCCESS IN QUALITY MANAGEMENT

Marta KUČEROVÁ, Katarína LESTYÁNSZKA ŠKŮRKOVÁ

Abstract

In quality management system as well as in other managerial systems, effective decisions must be always based on the data and information analysis, i.e. based on facts, in accordance with the factual approach principle in quality management. It is therefore necessary to measure and collect the data and information about processes. The article presents the results of a conducted survey, which was focused on application of factual approach in decision making. It also offers suggestions for improvements of application of the principle in business practice.

This article was prepared using the research results of VEGA project No. 1/0229/08 "Perspectives of the quality management development in relation to the requirements of market in the Slovak Republic".

Key words

factual approach in decision making, quality management, data analysis, measurement and monitoring

INTRODUCTION

Quality Management System (QMS) includes all basic activities such as: quality planning, contracts revision, purchase and verification of purchased products, identification of product and product traceability, inspection and testing process, management of control and testing devices, management of non-conforming products, corrective actions and also verification of their effectiveness, etc. The result of all these activities is the data which have to be professionally processed and analysed using various tools and methods. Application of the factual approach principle in decision making in business practice leads to the implementation of the measurements and collection of the data and information needed to achieve that objective. It ensures that the data and information are sufficiently accurate, reliable and accessible; it leads to the data and information analysis, to the application of decisions and taking actions as a result of logical analysis based on experience and intuition.

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THE NATURE AND SIGNIFICANCE OF FACTUAL APPROACH IN DECISION MAKING

In accordance with the principle of factual approach in decision making, the organisation has to define, plan and implement the measuring and monitoring activities that are necessary to ensure conformity and improvements. This includes the identification of needs and use of appropriate methods including statistical techniques. An organisation has to perform these activities to make sure that the monitoring and measuring activities necessary to ensure compliance and improvements are defined, planned and applied. The current requirements on QMS also insist on the application of new measurement processes which are rather of systemic than technical character; that means they indicate the state of QMS. The measurement process is extended by the activities of measuring and monitoring which are related to the efficiency of the QMS, performance processes, customer satisfaction, employee and other stakeholder satisfaction, the costs in quality management, etc. These measurements should provide the basis for further analysis and continuous quality improvement. (Linczényi, 2004)

The principle of factual approach in decision making implies that effective decisions are based on the analysis of data and information. To meet this principle successfully, it is necessary to perform the following tasks in organisation:

- collecting accurate and reliable data from various processes in organisation,
- using appropriate statistical methods for data collection and analysis,
- training people to use statistical methods in data collection and analysis,
- encouraging managers to use the analysed data in decision making,
- ensuring accessibility of the data analysis results for the company employees, as much as possible.

APPLYING THE PRINCIPLE IN BUSINESS PRACTICE IN SLOVAKIA

In the process of transformation of our economy to a market economy, the industrial enterprises in Slovakia found themselves in a qualitatively new business environment, characterised by intense and rapid changes. Companies are forced to continually improve not only their products, but also their internal processes and systems, in order to increase their competitiveness (Bestvinová, 2006).

In this context, we solved a research task aimed at the perspectives of the quality management development in response to market requirements. Within the VEGA project, we conducted a research aimed at the review of the current state of application of the basic principles of quality management in 124 selected industrial corporations in Slovakia.

The survey data collection was carried out using the questionnaire and we addressed the respondents in the following representation: 35 % of automotive industry, 35 % of machinery industry, 30 % of other industrial sectors. Out of the whole group of respondents, 85 % (105) have already had QMS established, whereas the remaining 15 % of the respondents (17) have not had this system established yet.

The questionnaire was structured into eight sections according to different principles of quality management. Below is the list of those with a specific focus on the factual approach in decision making and its application in industrial practice in Slovakia:

1. Do you ensure systematic data collection in your organisation?
2. Does the management examine the objectivity and reliability of data from particular processes?

3. Are there appropriate statistical tools designed and established to analyse and evaluate data in your organisation?
4. Is data from the data collection and analysis available to all who need them to manage and control processes in your organisation?
5. How are the results of the data analysis used in your organisation?
6. What do you think are the benefits of factual approach in decision making?

The data obtained from the first question revealed that there are significant differences in ensuring the collection of data between the companies with QMS and companies without QMS. The results are expressed graphically in Figure 1.

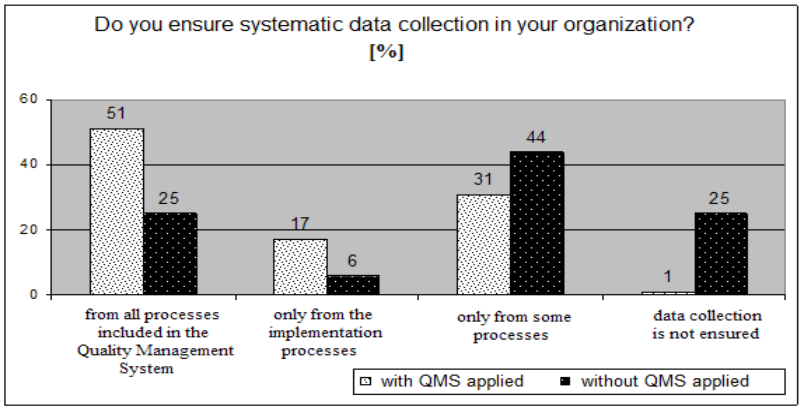

Fig. 1 *Graphical representation of responses to the first question*

Similar results were also obtained from the second question, in which we examined whether the management strives for objectivity and reliability of data from various processes. In this area, significant differences appeared between the companies with QMS and the companies without quality system, as we can see from the graphical representation in Figure 2.

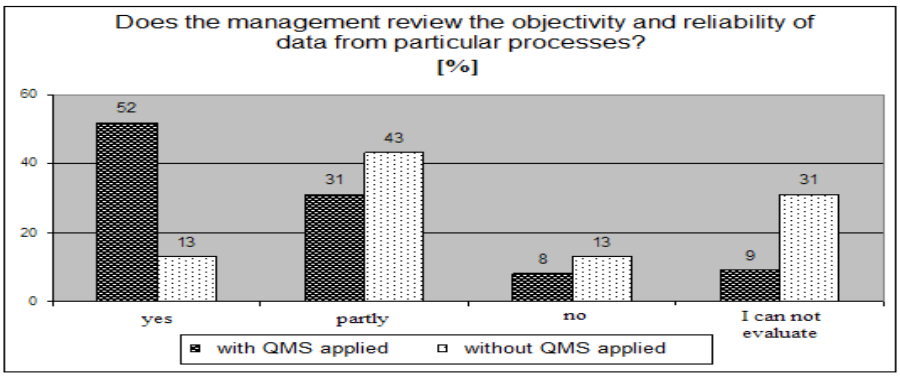

Fig. 2 *Graphical representation of responses to the second question*

The third question was aimed at determining, whether the organisations use appropriate tools and statistical methods in the data collection, analysis and evaluation. Based on the survey, we can conclude that this area is not handled at the required level in the corporate practice at the moment. One of the reasons of the unfavourable state is the insufficient knowledge of statistical methods amongst the involved employees and their inability to use

those methods. Within the survey, we ascertained this fact while analysing the principles of continual improvement and their application in business practice.

In most businesses nowadays, software applications are used for data collection regardless of the quality system. More than a half of the total studied organisations use software applications for data collecting. Figure 3 shows a significant difference between the organisations with implemented QMS (software applications use 59%) and those without QMS (software applications use only 44%).

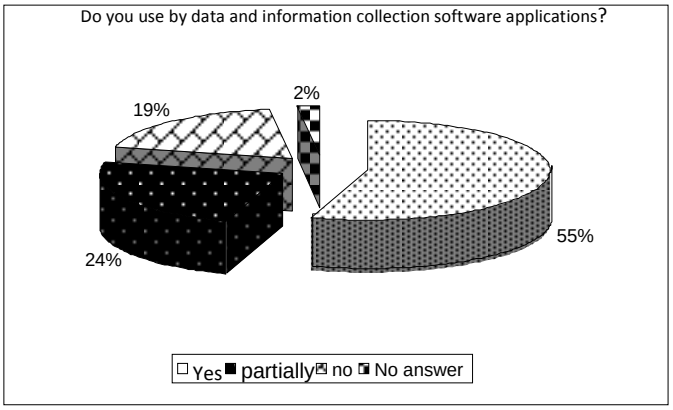

Fig. 3 *Graphical representation of responses to the fourth question*

Effective decisions must always be based on the data and information analysis; in other words, based on facts. To be able to follow this principle in practice, it is necessary to make all the recorded data related to quality management and other management systems available for all employees who might need them. In organisations with established quality systems, the necessary data is available to the owners of the processes in 63% of cases. In organisations without a quality system, it is only in 31%, and therefore we can say that the major differences in this area are between the studied organisations.

When we asked what the organisation uses the results obtained in the processes analysis for, the order of answers was as follows:

1. for processes improvement,
2. for setting the quality targets and standards,
3. as a basis for management review,
4. for planning funds within the QMS.

The survey revealed that factual approach in decision making mainly affects the field of measuring, monitoring and improvement. All these activities are very closely related to the analysis of data and the competent, and a proper decision cannot be made without them. Each organisation which deals with QMS has a responsibility to implement continuous quality improvement through the improvement of all processes and activities; and thus it contributes to improving the efficiency and effectiveness of QMS and the organisation overall.

These facts are clear also from assessing the following question which was focused on the benefits of factual approach in decision making. In this case, respondents were asked to choose three most important areas, so the results are expressed in absolute numbers (frequency). As we can see from Figure 4, the largest group of respondents chose the improvement of effectiveness and efficiency in the organisation as a benefit that decision making based on facts brings.

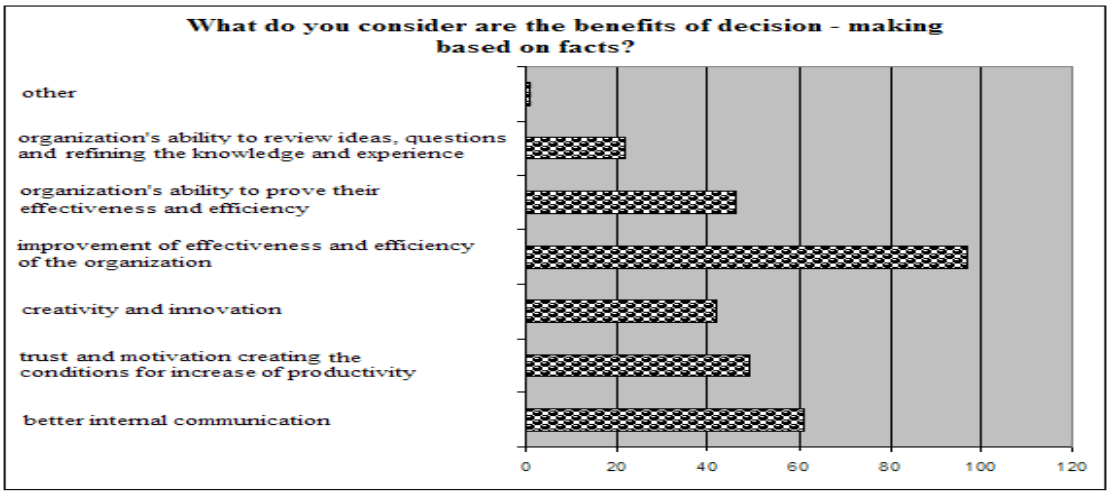

Fig. 4 *Graphical representation of responses to the sixth question*

Executives must be able to provide and also use objective information in QMS in the decision-making processes. They have to be aware of the trends in development of efficiency indicators of these systems and estimate the areas of further development objectively. These facts indicate greater demands on the level of knowledge about methodology and procedures of various measurements, both technical and systemic (Paulová, 2010).

SUMMARY AND RECOMMENDATIONS FOR PRACTICE

Current QMS is based on process approach, and its importance keeps growing. The process-oriented QMS model highlights the importance of understanding and meeting customer requirements, which is necessary for monitoring processes from the perspective of creating values; obtaining results on processes performance and efficiency; and continual improvement of processes based on objective measurements results. It is therefore necessary to ensure the permanent monitoring, measuring and analysing not only of the processes, but also of QMS performance. Observed organisations perform this as an internal audit and do not perform other forms of monitoring and measuring, for example management review, self-assessment, etc.

For effective management of processes, it is necessary not only to systematically collect data about processes, but it is also important to test the collected data from the perspective of objectiveness and reliability. The survey results show, that only a half of the addressed organisations with applied QMS obtains data from every process. This is a significant deficiency, because, from the perspective of a satisfied customer, it is crucial that every process in organisation is clear, well managed and properly ensured. This status can be achieved only in the case, if the data from process will be objective and reliable.

Statistics is a necessity for an effective and meaningful quality management, and therefore it must be in the centre of attention on every level of company management and the study of statistical tools along with other quality management methods should be the basic approach in implementation of QMS or TQM (total quality management). The obligation of using the statistical methods should not be perceived and understood as a formal order or rule. It must be understood only as a recommendation of tools, which will enable to improve the company´s economical situation in the cheapest way while finding weak points in all stages. It will also provide sustainable quality improvement and stable statistical process – in this manner we prevent the occurrence of nonconforming products, we contribute to higher

quality for lower costs and thus meet customer satisfaction and requirements. It is therefore important to make the involved employees aware of suitable statistical methods and their utilisation and application in practice.

Many measuring and monitoring activities performed in industrial practice are only formal and the obtained data is not used effectively in quality management, so the information is not fully and sufficiently used on every level of organisation. In industrial practice, the considerable problem is that the data obtained in a difficult way, is not used effectively. There is a lot of data in every organisation, which is not systematically processed. This fact is reflected in QMS. A performed measurement in organisation does not make sense unless managers systematically deal with the obtained results within their strategic and operative decisions.

Only 50% of the addressed organisations with established QMS use the results of data analyses from measurements as the documentation for management review. Data analysis is however necessary for assuring that the QMS is effective and there are places and points identified in the process, where we need to collect and analyse data for the purpose of quality management.

In the context of factual approach in decision making, every organisation must define, plan and apply the measuring and monitoring activities which are necessary to achieve the conformity and improvement. It includes determining the needs and using the suitable methodologies, including statistical tools. The organisations must perform these activities to make sure that the monitoring and measuring activities necessary to ensure the compliance and achieve improvement are properly defined, planed and applied.

Managers must be able to provide and subsequently use in the decision-making processes the objective information about QMS, recognise and understand the trends in development of performance indicators of these systems, and thereby objectively forecast and determine the areas of further improvement. These facts result in higher demands for the employees' knowledge about the methodology and procedures of measurement; both, technical and systematic.

CONCLUSION

Factual approach in decision making is one of eight quality management principles. During the research, we studied the application of the principle in business practice and we compared the differences in its application in various industries in Slovakia. We determined important aspects, which have become a subject for further study in our research project. Data analysis is needed in order to make sure that the QMS is effective, and that the places or points to collect and analyse data for quality, detect potential problems and identify opportunities for improvement were identified in the process.

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INNOVATIVE APPROACHES TO TEACHING PACKAGING DESIGN USING THE EXAMPLE OF MINERAL WATER SUPPLY CHAINS

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Abstract

Designing the packaging of a product has many critical factors. In our paper, we present some of them on the example of a simple product: mineral water. In spite of the fact that today not only products, but also supply chains are competing with each other, designers sometimes pay little attention to considering the packaging system not only from the customer and the producer side, but for warehousing and transportation as well. We cover a lot of "what can go wrong" scenarios on the example of mineral water packaging for the purpose of defining the critical points in the supply chain.

Key words

packaging, supply chain, "what can go wrong" scenarios, practical skills

INTRODUCTION

Packaging is the process of enclosing or filling the product in bottles, plastic bags, paper or wood boxes, metal containers, etc. Packaging reduces the risk of wastage, spoilage, leakage, melting and evaporation in the process of transportation and storage. Equivalent to the development cycle of products, the packaging development cycle also effectuates the integration of downstream processes like process planning, production planning and maintenance (1).

Universities' role in today's world is to educate experts in all aspects. We strongly believe that faculties of technology which educate future engineers could benefit from the inclusion of practical classes in their curricula. In the frame of a conventional classroom lesson, it is often impossible to give 'practical' examples of sophisticated packaging tests (climate chamber or shocking test equipment), but it is possible to bring a simple bottle of mineral water to the classroom (4).

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PACKAGING – WHY IS IT IMPORTANT?

Packaging is becoming more and more important. Not long ago, people were buying goods in the store in simple packaging, e.g. milk in a plastic bag. Now, we buy goods in sophisticated packaging which includes much information. That's why we say that nowadays, packaging has a lot of different functions, such as protection (from mechanical and climate effects, insects, etc.), function of easier identification, convenience, promotion and innovative ideas (5).

In addition, product branding can be done using recognisable packaging. Also, empty packages have their resale value for customers. Packaging builds the image of the product and its producers. Effective packaging is the source of prestige to its producers. Packaging continues to be more important in the modern shopping environment of growing competition, open display of the product and self-service of the customers (3).

CHALLENGES IN DESIGNING THE PACKAGING FOR A CUSTOMER

When designers in a company prepare a strategy for a certain product, they consider quality, price, environmental effect, transportation, warehousing, waste management etc. Before the product is made, thorough research is needed into the market conditions, customer preferences, possible name of the product and an effective packaging for it. When designing packaging, the first item is the buyer's attitude (buying psychology). Afterwards, physics come into consideration (2).

While doing our research, we focused on the assortment of mineral water readily available in local markets. We found a wide array of different shapes of bottles available with different variations of packaging (in foil). We also inspected the quality of the bottle. Some of the bottles were made of weak plastics and were easy to damage during transport and also during shelf time. Others were of tougher plastics (2).

CHALLENGES IN DESIGNING THE PACKAGING FOR A COMPANY (PRODUCTION AND COMMERCE)

When product research is finished, it is very important to think about the quality of the packaging and its cost. For example (if we take a look at the bottles of mineral water), the bottles can be made of light plastics that is still hard enough to meet all the requirements for the warehouse and transport processes, but on the other hand, if we use harder (tougher) plastics, this can result in higher production costs and more impact on environment (5).

Here, also the packaging of the bottle comes into consideration. For example, if transporting the bottles shaped like a prism, there is not so much air between the bottles like in the case of transporting cylindrical bottles. We used two different water bottle shapes - Zala water brand, which is in a prismatic packaging, and Aqua Natur water brand which has a cylindrical packaging. A package of Zala water contains 20 pieces in a foil (half a litre bottles) and a package of Aqua Natur contains 12 pieces in a foil (5).

A pallet of Zala water contains 60 packages, which equals to 1.200 bottles on a EUR pallet. A pallet of Aqua Natur water contains 95 packages, which equals to 1.140 bottles on a EURO pallet. From this, we can conclude that prismatic bottles are more efficient in regard of spatial consumption than cylindrical ones. Speaking in larger scales, this means that a truck

with 2.42 meters x 16.50 meters, which can transport 39 pallets in one drive can transport 46.800 bottles of Zala and 44.460 bottles of Aqua Natur in one load, indicating a difference of more than 2.000 bottles.

The difference between cylindrical and prismatic bottles packed in foil packaging can be explained with a "Touching points" test. In this test, we take a coloured marker, match one bottle with it and then press the bottle together with the other one. We used two cylindrical and two prismatic bottles. When touching each other inside the foils packages, there is friction between the bottles. The friction occurs in every movement of the packaging. If the packaging is not good enough, it can be easily damaged during transportation (for example in case of road bumps and so on). Results were as shown in Figures 1 and 2.

Based on this test, we can see that prismatic bottles have more touching points. In theory, that means that the friction points are more distributed all over the surface, so the friction is lower than in the case of cylindrical bottles. If taking transport into consideration, we can say that with prismatic bottles, there is less unused space in the packaging itself than with cylindrical bottles. With prismatic bottles, space on pallets is more likely to be better used than with cylindrical ones.

Fig. 1 *Impact on a prismatic bottle (Zala water) (own source)*

Fig. 2 *Impact on a cylindrical bottle (Natur Aqua water) (own source)*

We can state that prismatic bottles are more stable and more resistant to horizontal forces than cylindrical ones; but the material quality also comes into consideration here.

CHALLENGES IN DISTRIBUTION

Distribution has a specific role in logistics. If the product is not available when a customer wants to make a purchase, this can be reflected as both, loss of reputation of the store as well as the loss of profit for both producer and seller (5).

Another performed test in our research was the "Foil finger" test. The quality of the foil used for strapping together a certain number of the same product must be appropriate. This means it has to withstand all the handling operations throughout the supply chain. During our research, we found that a single package of mineral water is moved or touched eight times during its journey from the production plant to the end customer. This means that the foil must be strong enough not to brake during handling. The handling is mostly done by lifting the single packages by hand. In the testing itself, the foil tore on average during the 3rd or 4th lift.

The test was done by lifting the package with different combinations and number of fingers on the same packages of mineral water as in the previous test - Zala package of 20 bottles and Aqua Natur package of 12 bottles. We started the procedure with one finger. Here, the pressure was the highest and the foil tore after the 1st or 2nd lift. The second foil test was with 2 fingers. We found it to be the best way to pick up the pack, because it is easier, more comfortable and does not damage the foil. After the 3rd lift, the foil tore. The third test was with four fingers. It is good for the foil, but it is not comfortable for the person performing the handling. In this case, the package withstood the handling.

Fig. 3 *Foil test using 2+2 fingers (own source)*

Fig. 4 *Foil test using only one hand (own source)*

Transportation

Transportation in this era is definitely a necessity, but it is also very expensive. Another test we performed is the "Temperature" test. We took samples of both types ofmineral water tested, Zala and Natur Aqua. We assume that during winter, the pallets with the products are exposed to open climate conditions for at least a part of their journey (depends on the length of the transportation) and this can have an impact on the product. We tested the effect of winter conditions on the water by keeping it at the temperature of 5° Celsius. We made three different tests – exposure to low temperatures for an hour, for 2 hours and for 3 hours. We then checked the effects of the "winter" climate on the bottle content. The results were as follows [2]:

RESULTS FROM FREEZING TEST (own source) Table 1

TIME	ZALA WATER	NATUR AQUA WATER
1 HOUR	nothing happened	nothing happened
2 HOURS	about 5% frozen	about 10% frozen
3 HOURS	about 70% frozen	about 95% frozen

Warehousing

Warehousing and stocks present an expense to any company. The more stocks a company has, the bigger the warehouses are needed to store goods. Even though "just-in-time" production is excellent on paper, it is really hard to achieve in everyday life. Sometimes, the warehouses built and sheltered are not enough to store all the products, so some of the goods have to be stored outside, for example under a tent or in the open air. We also have to consider the demand on the market. Mineral water is one of the products the demand for

which seasonally changes: people drink more water during summer time and less in the winter time.

During the winter and summer time, there can be a lot of sudden climate changes influencing the products during transport. For example, if the temperature in a warehouse is 25° and there are 50° or 60° Celsius in the truck, that can result in a shock. The same applies to winter time - if the temperature inside the warehouse is 25° Celsius and -10° Celsius outside, it is also a shock.

Another test performed was the "Drop" test. Here, we threw two different bottles, the prismatic and the cylindrical ones, from different heights and monitored the damage. The drops were made from 1 meter, from 2 meters and from the 6th floor, approximately from the height of 12 metres. From the height of 1 meter, there were no physical changes on any of the bottles. The height of 2 meters led to some physical changes on the bottles, the plastics was damaged, but there was no evidence of leaking from the bottle. When dropped from the highest point, the prismatic bottle got damaged in the first trial, and the cylindrical bottle showed no changes in the first trial. In the second trial, the cylindrical bottle was damaged.

Fig. 5 *Damage on the rectangular shaped bottle (own source)*

Fig. 6 *Damage on the cylindrical shaped bottle (own source)*

Waste management

Waste management is one of the issues in logistics, which are very important from multiple points of view. First, the environmental aspect has to be considered for preserving the natural environment as well as in regard to recycling capabilities. If we choose the right way to handle our waste, we can help the environment and the planet.

However, what is the best way to handle our waste? In logistics terminology, it is called waste management. Some of the waste is used in power plants, some of it is used for recycling and some is biologically degraded. These are all ecological ways to manage the waste. The final test in our research was the "Compression" test with a machine squeezing the bottles together. The test was made with three bottles of each shape to get an average result. The result was that the cylindrical bottle is much more squeezable than the prismatic bottle.

CONCLUSION

In this paper, we described a lot of factors connected with packaging and the supply chain. The task was how to demonstrate to university students the importance of different packaging aspects in handling processes. The tests that are presented in the paper can be easily accomplished in any classroom and can attract the attention of students. What is more, it is possible to extend this application to the field of e-learning studies.

The learning-by-doing method based on personal experience (dialectic approach) is able to help in education and training of students to get the required specific viewpoints and develop their innovative and cooperative skills and competencies.

The main outcome of the presented research is that, during the classroom lessons, it is clearly seen that in spite of the increasing supply chain competitiveness, designers sometimes pay only little attention to the packaging system, not only from the customer and the producer's point of view, but the warehousing and transportation aspects as well. There are many logistics cost saving possibilities, like adjusting the size of packages to the dimensions of EUR pallets, and designing the packaging system according to the real physical prerequisites and climate effects alongside the supply chain.

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BEGA – ANDROID-BASED BEERGAME SIMULATION SOFTWARE FOR INTERACTIVE TRAINING AND INNOVATION

Katarína LESTYÁNSZKA ŠKŮRKOVÁ, Norina SZANDER

Abstract

The supply chain management challenges and inventory holding problems can easily be demonstrated by the widely known BeerGame simulation. In the Szabó-Szoba R&D Laboratory, we developed an android-based software application for tablets and smart phones for the purpose of having an adaptable, entertaining and effective program which can provide a real life experience to the participants about the nature of the bullwhip effect. Having an appropriate and comprehensive performance measurement system with the critical parameters and KPIs is inevitable for finding the right solutions - We used four perspectives of the Balanced Scorecard method. The innovative force of our research is based on the trainings: the discussion on outcomes and the team learning. The purpose of the current development is to build a new feature in the software: an artificial client can substitute one or more players in the supply chain, which makes decisions by using genetic algorithms.

Key words

BeerGame, Balanced Scorecard, Bullwhip effect, Genetic Algorithm

INTRODUCTION

The BeerGame logistics management game is widely used to demonstrate the inventory imbalance problems in supply chains. In the frame of the game, participants impersonate a four stage supply chain, and make their own decision about actual orders in every round according to the previous demands and expectations. The factory is responsible for production, and the other three collaborators for distribution towards the customer. The aim of the players is rather simple: each of the four traders has to fulfil incoming orders by forwarding the required units of beers to the partners in the chain with minimal total cost (the charge of inventory holding is 1, in the case of backlog the related cost is 2). Communication and collaboration are not allowed between the supply chain stages. This game can be used in

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the formal education and in trainings, as well to model real life situations and to highlight the difference between the practice and theory by the learning-by-doing method.

THE BULLWHIP EFFECT

The competing supply chains are characterized by the ever growing extension. The need of mass-production keeps increasing in the industry while, on the costumers' side, the demand of unique goods is extending. These cross-purposes cause the elongation of supply chains and turn them into the supply networks with more and more processing, forming, storage stations, all in all resulting in huge transportation and forwarding needs. This system structure has a serious and inseparable drawback, the presence of the bullwhip-effect (1).

Because of the growing globalization of supply chains/networks, we can observe an increasing number of the bullwhip-effect which is a really expensive phenomenon: at different stages of the distribution channels, high inventory levels arise, although, at the same time, other stages suffer from serious shortages. Therefore, the end users in many cases cannot get the desired product. On the other hand, insufficient or excessive production and warehouse capacity establishment and its inappropriate coordination cause the inaccurate production, delivery and distribution plans. The consequences are the growing total cost of supply chains, lower profit rate, and loss of competitiveness. The inappropriate usage of resources implies the increasing logistics costs and declining customer service and its adverse effects, which worsen the performance of companies and supply chains (1).

The inventory levels at different points of supply chains vary separately from the real costumer demand because of the bullwhip-effect. The usage of resources as production-, distribution-, and warehousing capacities is apparently not effective. The emerging shortage and unnecessary accumulation of inventories at different stages with the passage of time and the fulfilment of the backlogs of orders run through the whole supply chains. Therefore the systems/networks loose their balances and these swings maintain the presence of the bullwhip-effect for an indefinite time. Despite the fact that this phenomenon has been known for long time, its examination, accurate detection and modelling, is still a subject of intense scientific interest (1).

Based on many scientific researches, the trigger of the bullwhip effect can be traced by the lead time of information and material. A supply chain's reaction on a change in the end customer demand is delayed firstly because it takes time to pass on information about the change to suppliers, and, secondly, because these suppliers need time to adjust their capacities and deliveries. The longer a supply chain is unable to react to a changed demand, the heavier it needs to react as soon as this is possible. The bullwhip effect increases with longer lead times. In addition to the lead time of information and material, the bullwhip effect is caused by other factors:

- Demand forecast based on orders of the succeeding tier
- Historically oriented-techniques for demand forecast
- Batch ordering
- Price fluctuation
- Exaggerated order quantity in case of delivery bottlenecks

Commonly, demand amplification is mostly caused by some internal mechanism or event; it is not due to something external to the system. Although the customer demand may be extremely volatile, it is self-induced worsening of any situation. As bullwhip is a time-

varying phenomenon, graphical representation of system behaviour is extremely helpful. The next Figure shows specific demand amplification in a six month period.

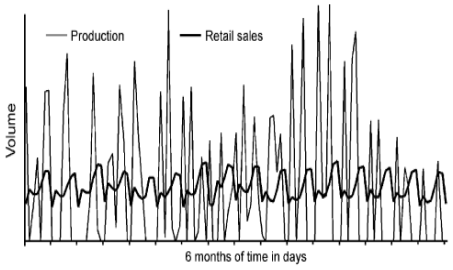

Fig. 1 *Demand amplification typical of time series to be viewed through the "variance" lens (Porter, 2005) [2]*

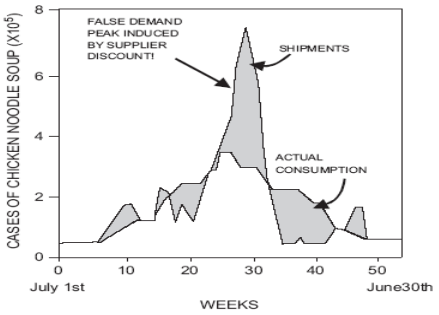

Fig. 2 *Demand amplification of time series to be viewed through the "shock" lens – Fisher 1997 [2]*

The previous Figure is a typical example which illustrates how a major manufacturer ''gambling'' by offering a temporary discount severely disrupts the system both upstream and downstream. This causes a ''shock'' to the system forcing retailers to stock up rapidly, then run stocks down as they realise customer sales are relatively smooth. In this case we can easily catch the bullwhip-effect (2).

BEERGAME

The beer distribution game (also known as BeerGame) is a simulation game developed by a team of professors of MIT Sloan School of Management in early 1960's to demonstrate a number of key principles of supply chain management. The Game is played by teams of at least four players, often in heated competition, and takes from one to one and a half hours to complete. A debriefing session of roughly equivalent length typically follows to review the results of each team and discuss the lessons involved.

History

The BeerGame (or beer distribution game) was invented in the 1960s by Jay Forrester at MIT as a result of his work on system dynamics. The BeerGame has proven to be a very simple, yet effective experiential exercise for teaching the dynamics of marketing and logistics channels specifically and systems in general. Since then, the BeerGame had been played all over the world by people at all levels, from students to presidents of big multinational groups. The purpose of the game was to show how the patterns we create in our relations with the world around us sometimes give unexpected and undesired results. This is an expression for what is called system dynamics. Jay W. Forrester in the USA first developed the ideas and theories behind this branch of science. The game can represent how we (re)act in such trading situations, and how these situations lead us into standard ways of "thinking" that we accept without question, don't we? (3)

BeerGame, on the tablets

After we held some BeerGame training with the traditional forms of the concept, it became clear that we need a better solution for further experiments and analysis of the results.

For this, we started to develop the BeerGame software for android devices in the Szabó-Szoba Laboratory. The purpose of this project is to join together the advantages of previous implementations. In the actual state of the software, the processes at the different positions are totally synchronised; the documentation is automated but easy to follow. With this, we successfully excluded the drawbacks of the original, paper based form of the game. That version was hard to follow - even more if somebody plays for the first time - because of the complexity of the rules. In fact, it slows down the gameplay and gives place to the mistakes. Unfortunately, it is really hard to puzzle out the errors and to correct them, what takes away the fun. The BeerGame application also prevents the opportunity of cheating or making accidental mistakes. The results are immediately apparent, help the discussion of experiences and better understanding the background of the bullwhip effect. At this point, it is really important, that the participants can share their experiences, observations and knowledge The tablets are very practical and manageable and provide an excellent graphical appearance. The only drawback we found until now is that it is not really expressive in material handling. A solution to this can be the involving of other devices or better graphical visualization.

Training environment

The game in our trainings lasts for 24 round. This is long enough to see the trends and the challenges, also short enough not to get bored. By this time, every participant gets some experience about managing a supply-chain, can observe the difficulties, possibilities, typical tricks and some coincidences. That is the time when they can share the feelings, experiences and some information with each other by the lead of the trainer. This discussion is very important in the aspects of recognition and learning. Typical observations:

- the evolved shortage spreads along the chain,
- usually the factory has the biggest shortage and the retailer has the least,
- at the half of the gameplay (10-12th round), each of the participants gets frustrated by the appearing backlogs and makes the decisions in panic – worsening the situation,
- the period with the shortages is followed by a period with high inventory level,
- the bullwhip effect emerges without exception.

The time frame usually lets another round. In such case, the participants are more experienced, they can focus on the discussed and relevant details, they configure some kind of tactics regarding to the consequences. In the second game, they usually feel themselves confident and assume that the bullwhip effect at this time will not upset the balance. But is does - in all cases.

The game, as we can see, is quite simple, easy to understand the tasks and the functions. A great advantage is that from the server, we can get instantly the results, so that the experiences can be discussed immediately after the game.

THE BALANCED SCORE CARD SYSTEM AS PERFORMANCE MEASUREMENT APPROACH

We had to realize that the traditional efficiency measures by themselves – because they are considering mostly the financial parameters of production processes – are inadequate in providing a complete and useful overview of organizational performance (in our case it means the performance of the whole distribution channel as a system). For better understanding of

the relations not only on the operational but also on tactical and strategic levels, the use of Balanced Score Card measurement system is widely accepted: it is operating on the financial, marketing (customer-related), operational (internal-business processes) and strategic dimensions (learning and growth) (5).

In other words, the typical BSC consists of four perspectives - financial and non-financial measures to guide implementation and evaluation: financial, customer, internal/process, and learning/innovation, in addition focuses both on the short- and long-term objectives of the organization (5).

With the BeerGame software, we can create graphs to demonstrate the bullwhip-effect and its consequences regarding to the four perspectives. The typical results are shown below:

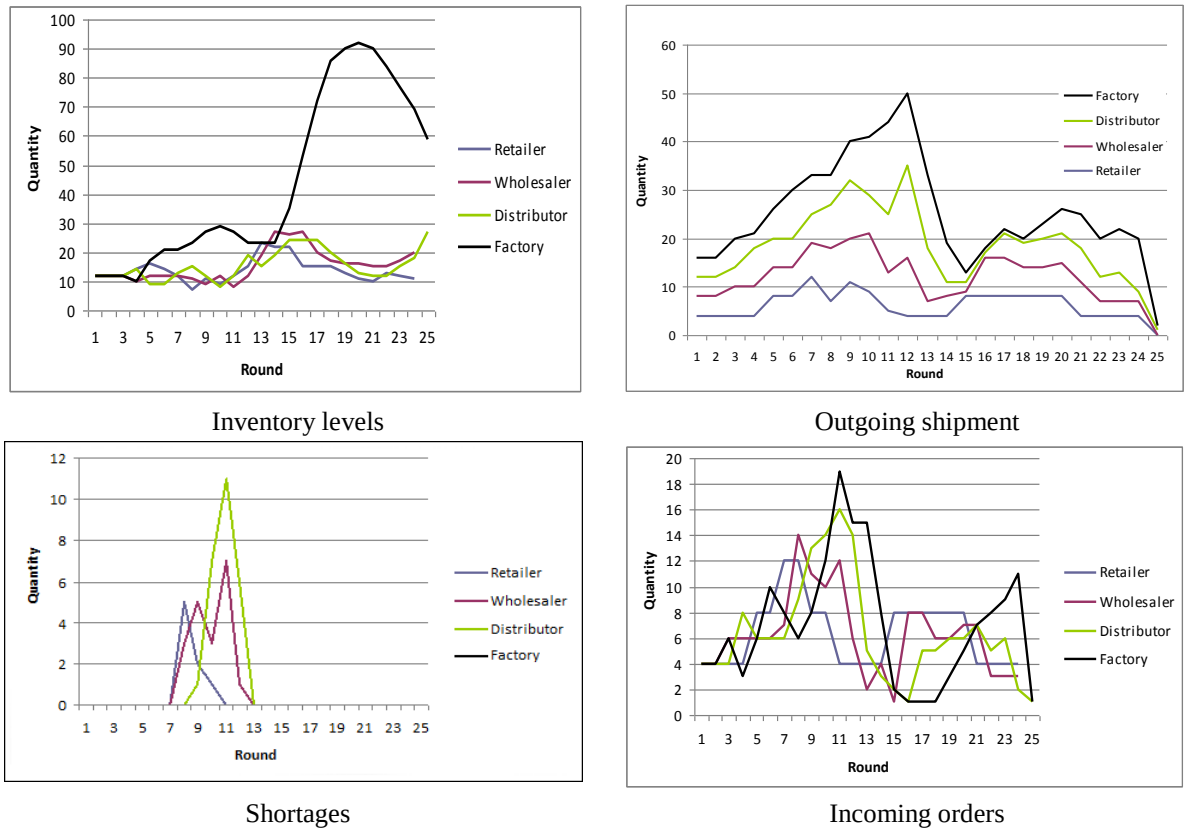

Fig. 3 *Illustration of the bullwhip phenomenon (own source)*

GENETIC ALGORITHMS

One direction of the actual research is the application of genetic algorithms. It is possible to substitute one or more players with an artificial client, who makes its decisions as close to the optimum as possible. This BeGa development might support the examination and optimization processes of different supply chains.

The Genetic Algorithms can be used in general to search in a search space. The basic idea of them is to handle the possible solutions as natural individuals and use the evolution to find the best ones. More precisely, they do this search by changing the genotype of these individuals, and giving some kind of priorities for the best ones (6).

Although, there is no definition of genetic algorithm accepted by all in the evolutionary−computation community that differentiates GAs from other evolutionary computation methods, but it can be said that most methods called GAs have at least the following elements in common: populations of chromosomes, selection according to fitness, crossover to produce new offspring, and random mutation of new offspring. The individuals are often represented by bit strings and the evolutionary modifications are made on the zeros and ones. To compare the differences between the specific individuals, all the GAs need to have a good fitness function determining how good a specific individual is. The genetic algorithms use three basic operators to find better and better solutions to the problem. The Selection operator selects chromosomes in the population for reproduction. The fitter the chromosome, the more times it is likely to be selected to reproduce. The Crossover operator randomly chooses a locus and exchanges the subsequence before and after that locus between two chromosomes to create two offspring. Finally, the Mutation operator randomly changes some of the genes in a chromosome (6).

Finding a proper fitness function is one of the most crucial points of creating optimization algorithms. In case of supply chains, it is quite difficult to find this function because there are several viewpoints from which the system should be optimal. For example we should resolve the inconsistency of every participant has a supplier and customer role at the same time and find an optimal solution. It is worsening the situation that we also have to take into consideration the performance of the whole chain. Therefore, we have to use a function which is flexible enough to be able to create a global optimum. To solve this problem, we use the four perspectives of BSC, and the fitness function is the weighted average of the values of these indicators. So the main objects of the parties can be determined by defining the correct weights of the indicators.

CONCLUSION

Avoiding the bullwhip effect is a challenge the modern economy is facing. It is crucial to recognize the wave propagation in the chain in time, and find the solution to the inventory management problems. In the frame of the BeerGame trainings, participants can get real-life experiences in this field, and they can invent the appropriate logistics performance measurement system at the same time. On the way of the BeGA development, it will be possible to substitute one or more players in the simulation environment with an artificial client, who makes its decisions as close to the optimum as possible by using genetic algorithms. The fitness function can be derived by Balanced Scorecard performance measurement indicators. In the trainings with many company experts, we intend to create typical patterns of customer demands to highlight the need of the local, company-specific bullwhip-recognition tools and appropriate replenishment rules.

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REVIEW OF SPECIAL STANDARDS IN QUALITY MANAGEMENT SYSTEMS AUDITS IN AUTOMOTIVE PRODUCTION

Yulia ŠURINOVÁ

Abstract

Quality management systems (QMS) in automotive industry generally have several differences in comparison with other industrial branches. Different customers have their own specific requirements, including requirements for quality audits. Audits are one of the core-tools of quality management to make the PDCA (Plan – Do – Check – Act) cycle work. As a matter of fact, compliance with ISO/TS 16949:2009 requirements is a condition for supplying the automotive industry. However, there are some standards which co-exist together with the ISO 9001 based management systems and technical specification for QMS in automotive ISO/TS16949. Which are those specific standards in automotive industry and what standard to use and why – those are the questions to be answered in this paper. The aim of the paper is to review what standards are used for audits implementation in automotive industry in the Slovak Republic, and why the organizations keep following those "extra" standards even if certification for ISO/TS 16949 is required by all the car makers. The paper is structured as follows: after short introduction to the topic and related terms, presented is our methodology. . In the third section, the achieved results are discussed. And finally, the principal findings of the paper, limitations and conclusions are presented.

Key words

quality management system, automotive production, customer specific requirements, audit

INTRODUCTION

Automotive companies are finding that globalization offers many challenges and opportunities. By establishing an integrated management system, companies can manage the complexity of a global operation so that they can leverage these opportunities where it makes sense for their business. Within times of economic crises, each organization makes its best to effectively manage their internal and external processes. It finally leads to the establishment of their specific requirements for suppliers. It has become not enough to build the quality management system according to ISO 9001:2008, not even enough to meet the requirements of ISO TS 16 949:2009 which was developed especially for the automotive production. It is

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important nowadays to meet the specific requirements of each customer (Šurinová, 2011). Modern companies have to adapt their products precisely to customer needs, and therefore parameters of manufactured products are adjusted to the individual requirements of customers. Different customers determine their specific requirements based on their special market strategy in order to satisfy customers' needs (Saniuk, 2013). Customers´ special requirements are often based on the manuals of the American quality management standards QS 9000 or the European standards for quality management VDA. Globalization brings best improvement tools and methods to the world business, which have been developed in different countries and companies in the world. Organizations help each other to improve their internal and external processes. Using the same tools for the same processes in different organizations in the world will help their suppliers who can use familiar techniques to communicate with different customers and satisfy different customers' needs (Šurinová, 2011).

Organizations exist for a purpose, sometimes set out in a Mission or Objectives; then they plan and act in ways intended to achieve these objectives (Woodhouse 2003). An organization is exhibiting quality if it does what is necessary to achieve its goals, and a quality audit checks an organization's effectiveness in achieving its goals. A number of structured approaches to quality have been proposed, and a long-standing one is the ADRI sequence (approach, deployment, results and improvement). The first three steps correspond to the three stages of a quality audit, and the explicit inclusion of the last steps shows how quality audit can lead to quality improvement (Woodhouse 2003).

DESCRIPTION OF THE APPROACH, WORK METHODOLOGY, MATERIALS DESCRIPTIONS, EXPERIMENTS

The ISO/TS 16949:2009 is an automotive industry-specific customer mandatory requirement. Undoubtedly, there are plenty of customer specific requirements for quality auditing in automotive production. Even in the field of quality audits, some customers do not seem to know what they want. In automotive production, ISO/TS 16949 certification is required; on the other hand there are VDA standards which are required by the German companies. The ISO/TS 16949:2009 is based on ISO 9001:2008 and the process approach is followed there. However, careful studies show, that the "process approach" is not emphasized in VDA6 series. We can state now, that VDA6 series should be treated as another customer specific requirement and the organization using those standards must be extremely careful with the VDA6 requirements implementation. In other words, sometimes we need to design, develop, and manage a process beyond the VDA standards (just like some supporting process), so it may be difficult for organizations to find an answer how to deal with it.

To fill this gap, building on the available literature, we attempted to verify the ***study´s hypothesis:*** VDA6 series should be treated as a customer specific requirement which can improve the auditing system in an organization.

To test the hypothesis, a *literature search* was carried out. The core job was performed reviewing the VDA6 series standards requirements and comparing the fresh revision of the VDA 6.3 2010 with the previous standard revision. Besides, the ISO/TS16949:2009 special requirements were reviewed. To verify the review results, the information available in the article was validated in various Slovak automotive supplying organizations. To make conclusions, the *synthesis* method was used to prepare the table comparing the VDA6 series standards with ISO/TS 16949. The concept of narrative is underlined as a key to discovering the relationships between the standards.

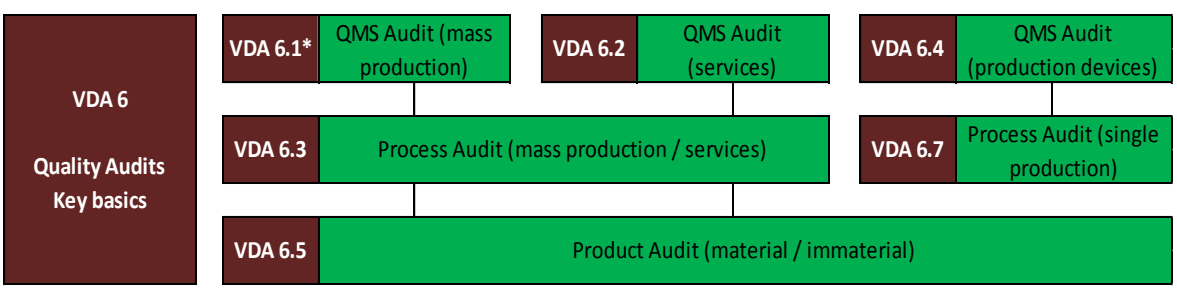


Fig. 1 *VDA 6 series structure (VDA 6, 2006)*

This paper is based primarily on an extensive literature review of the related standards, including the analysis and synthesis of domestic and foreign professional literary sources, mainly studies, documents, journals related to this topic, as well as textbooks, websites etc. It is a descriptive investigation. Spread sheets and word expression interpretation were used as complementary methods.

VDA6 series review

Increasing requirements in automotive production make organizations change and continuously improve quality management system. The German automotive industry is recognized on all sides as having successfully followed a premium strategy – developing brands which stand for high performance and high quality and production values. The aim of VDA standards development is reaching Automotive Excellence (VDA 6, 2006). Quality strategy by VDA is a complex quality management throughout the product´s lifecycle. Organization´s processes have to be monitored, so that processes´ reliability can be ensured and defects occurrence prevented. Processes and system audits are the core-tool for continuous improvement. VDA6 (2006) series consists of totally seven standards (Figure 1).

Having compared VDA 6 series and ISO 19011:2011 it can be concluded, that VDA 6.x standards are more specific with their requirements. The VDA 6 standards give us specific formulas of how to determine the audit range, how to quantify the analysed system/process effectiveness and establish requirements for auditors.

It is true that some of the VDA6 series standard indicate the evaluation system which sets the rules to quantify how the analysed process or system meets the requirements. For example, according to the VDA 6.3, each analysed process is evaluated according to the scale:

0 (requirements not met),

4 (requirements not enough met or there are significant deviations),

6 (requirements partially met or there are bigger deviations),

8 (requirements mainly met or there are small deviations),

10 (requirements met).

Having analysed the VDA6 series standards, we can state that different standards from the VDA6 series have their own evaluation criteria. Questionnaires (for VDA 6.1 and VDA 6.3) or process signs (for VDA 6.7) may serve as an example of audit criteria. Each of these standards has also its own evaluation formulas which help to quantify the degree of meeting the requirements on a process/system. VDA 6.2 which was developed for auditing services in automotive industry cites ISO 9001 and sets special requirements for services, considering

ISO/TS special requirements. Further on, only the most widely used VDA 6 series standards will be described.

VDA 6.1 Quality management system audit

VDA 6.1 is a special standard which added some special field-specific requirements for quality management systems audit and had some special features related to ISO 9001(Štetinová, 2005). In its content, it substantially covers all elements of ISO 9001 and partly goes beyond. VDA6.1 provides a questionnaire for assessing a company's quality system (Klaus J. Zink, 1998). Comparing ISO 9001 and VDA 6.1, there are some specific areas in VDA6.1 which are not covered in ISO 9001. Those are (VDA 6.1, 2010):

- Financial accounting in QMS part 05 (methods of reports writing, internal quality costs, external quality cost);
- Organization strategy (business plan including cost, sales, quality, etc., performance indexes evaluation: the whole factory indexes, benchmarked indexes);
- Contracts review/marketing quality;
- Design management (best practices of implementation);
- Handling, warehousing, packaging;
- Quality records management (customer information);
- Service (on time warning system).

VDA 6.1 is divided into two main parts: Management and Products, and Processes. VDA 6.1 has special formulas to evaluate the quality management systems efficiency. According to the special questions and the formulas, organizations have to be at least 90% efficient to be VDA 6.1 certified (Štetinová, 2005).

VDA 6.1 has been valid since 1998. Since April 1, 1999 this standard has been obligatory for all the German automobile producers. The aim of the standard was to make the automobile producers continuously improve their processes, prevent problems occurrence, eliminate critical factors in production systems and others. The standard was based on ISO 9001:1994 and was lately revised in 2003 (Štetinová, 2005). The standard has not been revised according to the ISO 9001:2008 due to the fact, that registration to ISO/TS 16949 is now accepted instead of VDA 6.1.

To conclude the above mentioned, it is evident, that VDA6.1 audits standard used to be widely implemented in automotive production, but in the light of the current research, we can conclude, that it is being replaced by ISO/TS 16949 general specifications for quality management in automotive industry.

VDA 6.3 Process audit for mass production

VDA 6.3 is one of the most widely used standards for the German vehicle makers supplying factories. It is an excellent tool for process audits within the automotive industry acting as a guideline for performing audits. According to Cameron (2001), it provides information on the significance and application scope of a process audit over the entire product life cycle. It defines the audit process, the criteria for evaluation of the process, audit results and the requirements of the processes. At the heart of the standard, each step in the

process is modelled with six links and is governed by the Deming Loop – Plan Do Check Act. There are three grades that an organization can reach under VDA 6.3 – A, B & C. This means that an organization can pass the audit, but still have a scope for further improvement (Cameron, 2011).

There is no doubt, that VDA 6.3 defines a process based audit standard for evaluating and improving controls in a manufacturing organization's processes. In order to continuously monitor and improve processes in organizations and to provide processes´ reliability, the VDA 6.3 was designed. Together with VDA 6.1 and other VDA6 series standards, it may be treated as customer specific requirement of the European (German) automobile producers. The VDA 6.3 standard was designed in 1998 and revised in 2010 in order to follow the changing environment in automotive production. Processes risks and weaknesses as well as the interactions between processes have to be followed. In other words, revised in 2010, the standard was comprehensively restructured to reflect the changes in ISO 9001:2008 and customer specific requirements in the automotive industry.

Having compared the latest 2010 revision with the previous VDA 6.3 standard version, the following new aspects in 2010 revision were modified:

- Requirements on risks analysis and project management were added;
- Feedback system importance was emphasized;
- Suppliers evaluation system was amplified and the evaluation scale was changed;
- The questionnaires have to be supplemented by "knowledge database" in order to emphasize special requirements of different processes.

The revised VDA 6.3 supports process approach and thus is still widely used to perform audits of suppliers. The standard includes the questionnaire for each audit phase. It also contains the evaluation system which provides the formula of how to evaluate standard requirements fulfilment. Besides, there is the supplier categorization matrix included in the VDA 6.3.

In particular, the standard can be used by any organization, either for internal process audits, or for evaluating potential or existing suppliers. Compliance with VDA 6.3 is mandated by some vehicle makers and encouraged by others. VDA 6.3 provides an opportunity to master some of the tools and approaches that have helped make this success possible. VDA 6.3 is particularly useful in any sector that wants to follow a premium strategy and ensure that the supply chain is capable of supporting the approach to global competitiveness (Cameron, 2011).

ISO/TS 16949:2009

It is true, that most production enterprises in Slovakia have an implemented management system; however, it is implemented with different levels of application of fundamental principles derived from relevant documents. Based on the VEGA research project "Prospects for the development of quality management in relation to market requirements in SR", which was implemented in the previous period in the STU, it was found that a good level of the principles of quality management application is in the automotive industry which is related to the requirements of ISO TS 16 949 (Paulová, 2010).

The ISO/TS 16949:2009 is an automotive industry-specific version of ISO 9001:2008. It adds a supplemental requirement unique to the automotive industry. ISO/TS 16949 intends to

provide not only a standard for auditing, but a systematic method to improve quality. The most important of these relate to what is referred to as the automotive core tools, which include:

- Advanced product quality planning (APQP) or VDA2´s PPF (Production Process and Product Approval). The fifth edition of the VDA volume 2 was fundamentally revised in 2011 and adapted to the current automotive demands. Correlations to existing VDA volumes (e. g. maturity level assurance, VDA 6.3) are highlighted and integrated. The APQP as well as PPF provide common guidelines for a structured approach for defining and establishing the steps needed to ensure a quality product and robust production processes.
- Production Part Approval Process (PPAP) or VDA2´s EMPB (Erstmusterprüfbericht). These methodologies the designed to provide evidence that all customer´s Engineering design records and specification requirements are properly understood and fulfilled by the manufacturing organization. According to Shrotri (2012), the tools were designed to demonstrate that the new established manufacturing process has the potential to produce a product that consistently meets all requirements, and actual production runs at the quoted production rate.
- Failure modes and effects analysis (FMEA). It is a systematic, proactive method for evaluating a process to identify where and how it might fail and to assess the relative impact of various failures, in order to identify the parts of the process that are most in need of change.
- Measurement systems analysis (MSA). This methodology provides an introduction to the measurement system analysis, along with the guidance on how to conduct measurement system studies to ensure the quality of data used for the product and process evaluation.
- Statistical process control (SPC).This methodology provides an introduction to the statistical process control and presents general guidelines for selection and application of statistical techniques to monitor, analyse and improve production and supporting processes.

In order to perform an audit of core-tools of the automotive production, the auditor has to be specially trained on related core-tools (Kausek, 2006). Some companies (Ford and General Motors) have special requirements for auditors' trainings. Application training, however, does not always provide an insight into how to audit these tools. By combining knowledge of the methodology with the audit techniques of knowledge, the quality system auditor can be expected to find the systematic weaknesses present in the quality planning process.

According to Kausek (2006), auditing ISO/TS 16949 requirements on Quality management system requires the auditor to understand the requirements of these and other additional automotive-specific requirements, and how they fit within the overall structure of the quality management system.

Except for the special core-tools of auditing, the audit according to ISO/TS 16949 should evaluate all the processes built in the audited organization. In case of ISO 9001 certified organization, usually ISO 9001 requirements have to be checked. In case of ISO/TS certification, the auditors have to work with the ISO/TS requirements and plenty of others customer specific requirements.

Every year, the International Organization for Standardization (ISO) performs a survey of certifications to management system standards. The survey 2011 shows, that the number of

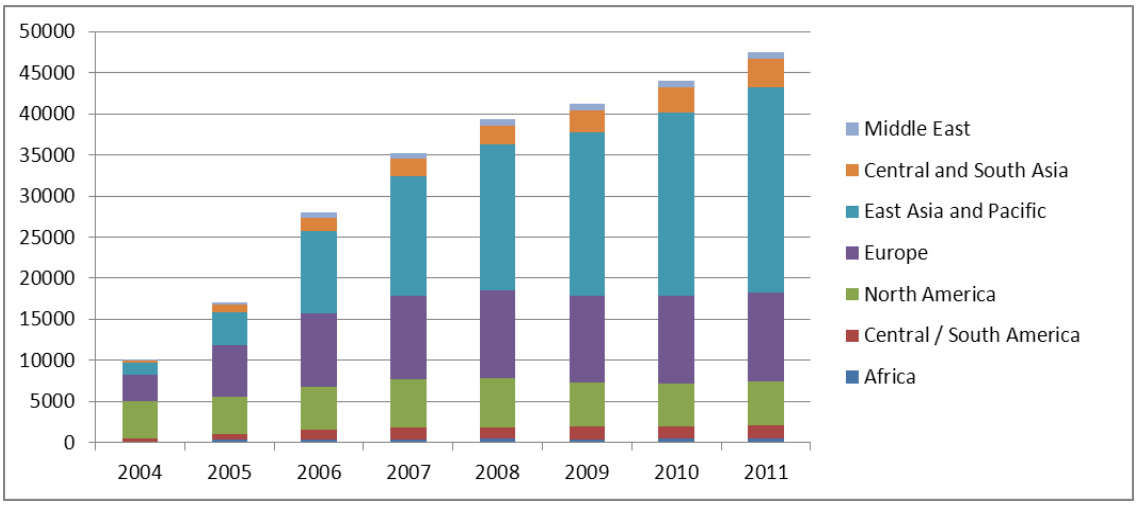
certificates of ISO/TS 16949 continuously grows from the year 2004 in each region all over the world (Graph 1)

Undoubtedly, this is due to the expansion of the automotive industry, but this fact also suggests that the standard is highly efficient; otherwise, it would not be so widely used.

DESCRIPTION OF ACHIEVED RESULTS

Since the early 1980s when quality emerged as an important facet of competition, researchers and practitioners have been trying to empirically test the relationship between quality management and performance. Early publications reported anecdotal evidence of the benefits of quality management. These were followed quickly by surveys on the benefits of quality practices conducted by consulting firms and business organizations (Hiam, 1993).

Several empirical studies have explored the relationship between quality management practices and quality conformance. For instance, (Flynn, 1995) explored the quality management practices of high-, medium-, or low-performing plants based on self-reported yield rates. The results showed that process control was used more often by high than low performers. However, the other statistically significant quality management practices (employee involvement, new product quality, concurrent engineering, feedback, and maintenance) showed that the high and low performers had high usage levels, while the medium performers had lower usage levels of these practices. The authors suggested that perhaps low performers, aware of their problems, were emulating the practices of high performers but had not yet attained the performance benefits (Seungwook, 2001).



Graph 1 *Number of ISO/TS 16949 certificates (ISO Survey 2001)*

We make it absolutely clear that VDA6s series have some benefits in comparison with ISO/TS 16949 (Figure 2), representing a specific tool to increase the efficiency of the QMS. In fact, VDA standards set some further requirements on automotive suppliers which can help organizations to improve the processes efficiency using the approved and validated standard. However, VDA6.x can be treated as a customer specific requirement and must be applied if it is a customer´s special requirement. However, the VDA standards may serve as a guideline for the internal process audits implementations or form the basis for the suppliers' evaluation system even for the organizations which customers require the VDAs usage.

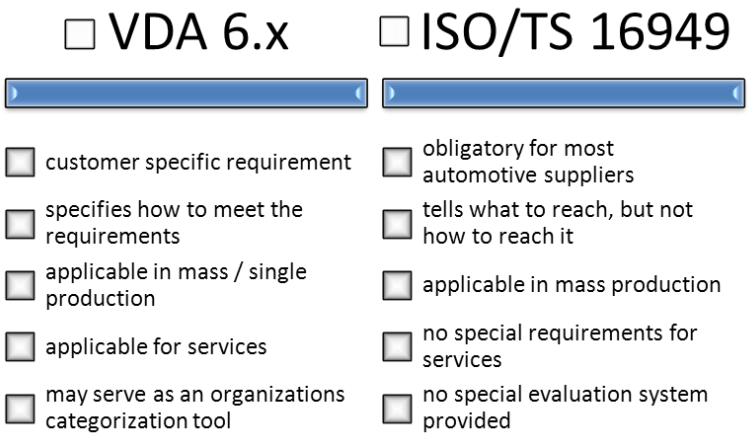


Fig. 2 *Comparing VDA6s and ISO/TS 16949*

Despite those reasons, the fact is that ISO/TS 16949:2009 is the only quality management standard for automotive industry which is recognized and accepted by each car maker all over the world. The VDA6.x standards are usually required by the German organizations and are co-integrated together with ISO/TS 16949 requirements.

CONCLUSION

Audit contributes to the achievement of business goals and it has more positive than negative effects on business performance. Therefore, the paper demonstrates how to use various audit standards not only to assure the conformity of the QMS with the standard's requirements, but also to assure business improvements using optional specifications. The results obtained confirmed the study's hypothesis. The ISO/TS 16949 standard is highly efficient for the quality management systems implementation and auditing, nevertheless, in practice, there are some commonly known and used standard which can help organizations perform the audits according to the verified and validated special formula (VDA6.x are the examples of such standards). This evidence is consistent with the answers of the individual organisations which we interviewed in order to verify the survey results.

Audits are the source of quality information and the audit outcomes and results should be used in terms of project management. This paper was supported by the VEGA project 1/1203/12 "Information quality management within the project management in industrial organizations in SR".

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2013 Number 33

EXTRACTING PROCESS AND MAPPING MANAGEMENT FOR HETEROGENNOUS SYSTEMS

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Abstract

A lot of papers describe three common methods of data selection from primary systems. This paper defines how to select the correct method or combinations of methods for minimizing the impact of production system and common operation. Before using any method, it is necessary to know the primary system and its databases structures for the optimal use of the actual data structure setup and the best design for ETL process. Databases structures are usually categorized into groups, which characterize their quality. The classification helps to find the ideal method for each group and thus design a solution of ETL process with the minimal impact on the data warehouse and production system.

Key words

data warehouse, ETL process, categorisation

INTRODUCTION

When the company has already decided about the integration of the data warehouse into their structures, there is a long period of hard work which does not stop even after the implementation of the data warehouse. Creating a data warehouse as a process of creating a logical and physical model is a separate chapter, which is documented in a number of different theories. In this article, we would rather deal with the way of how to establish a data warehouse to a company and integrate it into the existing systems. Actually, important and necessary are sensitivity and knowledge of the internal structure and even the status of different production systems as the source for a data warehouse.

INTEGRATION OF DATA WAREHOUSE INTO PRODUCTION SYSTEM

Terms ETL (Extract - transform - load), respectively ETT (extract-transform - transport) process are widely used for integrating the data warehouse into the production systems.

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Pump provides us with the correct and if possible quick loading of data into the warehouse. This process is much more extensive and complicated than it might appear at first sight, and ultimately causes most of the problems, especially during the design phase. Its role and benefits are undeniable.

Data Pump is designed to:

- Extract data
- Transform data
- Data Transport

MANAGEMENT OF THE DATA PUMP CREATION

Function of the data pump is clearly defined, but the goal of this article is to minimize influence to production systems.

For the complete implementation of all required functions and the loading of data into warehouse without affecting the operation in the company, we come out from the defined state. Therefore, in production, we have to identify the window in the main operation, either overnight or at early morning hours.

Also to be taken into account is, that time is provided not only for filling the data warehouse, but also for running the operation. From this requirement, it is quite clear that the complete recovery of data in a data warehouse is impossible due to the lack of time window for a single filling. Data warehouse has to provide actual data for a reasonable price during its operation, and, at this moment, we are unable to provide it.

On the other hand, the total recovery method could be appropriate, considering the fact, that the primary system requires no changes in the database structure and, in this direction, the data pump would work as a copier.

In addition, a very interesting solution is when we use everyday backups which are made in every company. They should work in parallel environment, and after completing the remaining resources, using the same parallelism, we would achieve all the required data in time. The given operation would be more expensive by buying the necessary licensing, hardware and governance of other systems and so on. We did not reject this opportunity because we know that the multinational corporations providing solutions in the area of data warehouse obstacles do not stop and use the possibilities of accurate copies of the production environment, because the total cost of establishing and operating a data warehouse is covered by the buyer. The Figure 1 describes a usual process of corporations using a standard model. This model is fast an easily applicable to every customer and system, but it is not efficient in comparison with performance versus price. In this process, there is a method which provides the easiest way of extracting data from each source. Usually, every next step after extracting is impacted by this technique of extraction and it can be mostly seen in load and transfer. Process is not optimized for ETL tool, but for source system, which increases the budget for maintenance and makes improvement more complicated.

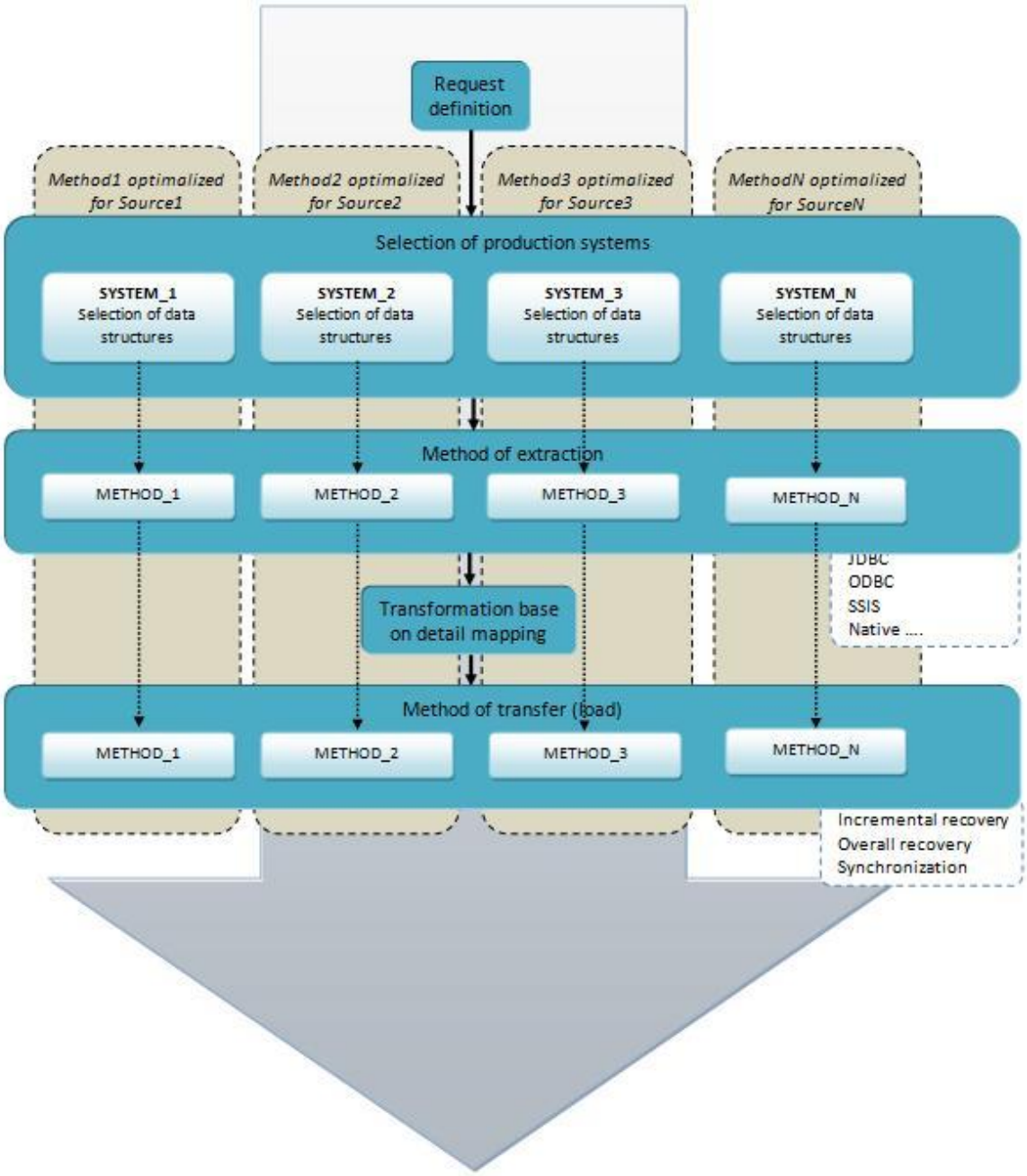

Fig. 1 *Selection process for method of extracting used by multinational corporations*

We ourselves selected a way how to effectively use the space at night, respectively in other empty hours and opportunities of data pump and its components. If we decide to intervene into the production systems, it could have considerable consequences such as the slowdown during normal operations, but also during night operations (5). In this regard, it is also necessary to have on mind a longer-term growth of data and also the length of the processing of runs. Having considered all the facts, the combination of both ways, i.e. the overall recovery and incremental recovery, seems to be the most reasonable way. Thanks to its variability, the data pump, will choose which part will be managed and in which way. To fully use the variability, it is necessary to define the process of data selection (4).

IDENTIFY PRIMARY SOURCES AND TABLES

The first step is to identify primary sources for data warehouse. List of the sources is based on customer requirements. Designer has to make a list of sources and reduce the effect of one perspective. By analysing the systems, the designer gets a high level analysis of architecture. This process helps better categorize the primary systems into the main systems, the systems with a support role or the systems with redundant data and the systems which are important for overall reconciliation. We also cannot forget the various other sources, except for conventional production systems, there are different external inputs mostly defined as manual inputs. Those might be different Excel spreadsheets or other databases, possibly code lists that were hard coded in the code due to the poor primary system architecture. Structure of these resources is usually the most difficult to collect and define. On the other hand, they can bring colossal value to the company. The manual inputs are then treated individually, while we are trying to unify them from regarding their structure. This can help us later when defining interfaces and the process of transformation. Consequently, it is necessary to determine how the data is transferred from the individual primary sources into the basic layer of data warehouse. In this case, it is easier to define a single path for all sources, what is then easier for management of data pump and mainly for maintenance. It is not necessary to look for a perfect way of selection of each source, because during the life of data warehouse the technology will evolve and come with a better solution for a source system. What is more, this method of finding the ideal solution of data transfer could increase the time for implementation and make the maintenance more complicated. It is more correct to choose one stable and verified solution and if possible, use it for all sources (2). Important in transferring data into the data warehouse is to set up independent process for obtaining data from the source system and independent import the data into a data warehouse. Their independence is important for two reasons. The first one is not to affect normal operation. The other reason is an independent import of data from the source systems into the data warehouse. This independence provides us with flexibility in processing the data warehouse, which does not affect the primary operations of the systems. With the correct time management, it does not affect the users of data warehouse either.

It is necessary to realise that the processing of the data warehouse is usually computationally more demanding as for the capacity, rather than the operation of primary systems, and independence is therefore desirable.

Next step is to identify the individual tables in the production databases necessary for data warehouse.

The production systems are often extremely overloaded with historical data, tables supporting the application run, various auxiliary calculation tables and other redundant data warehouse. It is necessary to exclude these tables from the data transfer pump, thus saving some time and also storage space. This removal of redundant information provides us with higher speed, when the record to data storage takes less time during the copying of data. After initial cleaning the data structure lists, selected tables are divided into several groups, namely those that have a low number of records, tables with higher number of not very frequently changing records, tables with a higher number of very often changing records and tables with high number of records.

AGGREGATION PROCESS AND MAPPING MANAGEMENT

The preceding paragraphs described the principles that allow us to correctly define resources and loading the data readings which are closely related. These are just parts of the ETL process. It continues with a detailed mapping of the entity (i.e., aggregating source systems into the data warehouse), so that data is ready for reporting. The described process is independent from the chosen method of building the data warehouse, using either a top-down method (Inmon method) or bottom-up method (Kimball method).

Entities are defined by reporting requirements of customer and represent the subjects of interested subjects from the customer's point of view. Each entity has its own attributes (values), which represent this entity. Every single attribute is mapped to the source systems while mapping all the values from the source system.

Mapping in this sense is defined as the implementation of transformation rule in metadata in an ETL tool programming language.

Mapping ends up with the process of setting up historization, in order to minimize the volume of data with actual value and therefore optimize the performance of data warehouses. Historical mapping takes place to clearly define the rules which are set up.

When describing the aggregate mapping, I purposely did not mentioned any schemes, facts, metrics or dimensions, because the same method will be used whether we decide to go through integration layer, or we do mappings directly into stars schemes; mapping can be also used between the integration layer and stars schemes. The difference between the above-mentioned layers is in the depth of aggregation of the given entities, and therefore also in the complex pre-calculations of data.

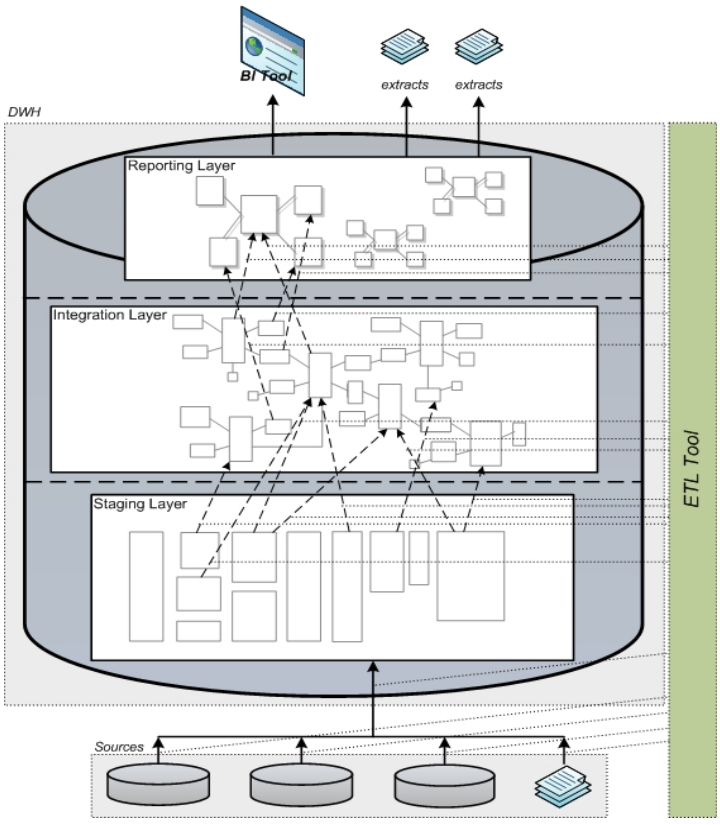

Fig. 4 *ETL process from extraction to higher layer mapping*

The mapping process depends on various circumstances, unlike the previous process, which should provide us with the data independent from the primary systems. A process map of loading and processing the individual entities allows a flexible reaction to data processing in case of data error or other unexpected situations.

The ETL process does not end when data is loaded into the data warehouse, but passes across the entire spectrum of the data warehouse and ends up with history mapping of the most aggregate entity. To facilitate the operation and readability of such an extensive process, various ETL tools are used.

CONCLUSION

All data structures of source system should be categorized into groups. After categorization, it is necessary to think about what various primary systems provide right now, and what the limits or benefits of the current solutions are. The process proposed in this paper provides a unified solution of how to be more efficient in categorization and extraction of data from sources. It helps remove a complicated design of data extraction, and thus focus on the specific features of the solution, such as mapping data in the data warehouse. Proposal of process provides a solution support independent from the system or database platform, data structure and data model of sources. What is more, this proposal supports uniformity and simplicity of solution and it can be used also for the maintenance and improvement of ETL process.

ETL process does not finish even after loading the data into the data warehouses, but it is necessary to focus on the correct management of the integration of data into entities. Here, it is important to know the rules of filling the attributes of the aggregated entities of the primary systems. The dependencies created by the integration of multiple systems ETL tools are used to manage and administer these rules.

Since we provide solution not for a few months, years or decades, it is necessary to carefully analyse the situation, especially in general areas such as export, loading data, handling ETL processes and dependencies. This does not lessen the importance of mapping the data into an aggregated entity, because we need to ensure the correct load of the data warehouse even in aggregated layers.

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APPLYING DATA MINING METHODS IN ANALYSIS OF STRUCTURAL RELATIONSHIPS IN THE SYSTEM OF RANDOM PROCESSES

Michaela HORALOVÁ KALINOVÁ, German MICHAĽČONOK

Abstract

The aim of this paper is to present the possibilities of applying data mining techniques to the problem of the structural relationships analysis in the system of stationary random processes. In this paper, we will define the basic problem areas of analysis of structural relationships and we will show how to solve these problems by the methods of data mining. Individual solutions to selected problem areas will be demonstrated on a model which was designed in MATLAB. In the experiment, we will identify the existence and the nature of the process relationships in the system of stationary random processes based on the results of analyses.

Key words

random processes, analytical methods, data mining, complex systems

INTRODUCTION

Growing complexities of processes in the modern technical systems and their decentralized nature have lead to the necessity to apply the new identification technologies of real system structures. One of the important phases of the analysis of complex processes is to identify the structural relationships. The process of structural analysis can be based on a priori information, on physical laws, but also on the empirical experience concerning the identified processes. In a complex process which consists of a set of processes at the defined resolution level, it is often impossible to detect the structural relationships typical for high complexity based on a priori information, and therefore it is needed to apply the modern approaches, methods and instruments in the process of structural analysis (3).

The base of experimental data has the significant impact on the accuracy of the structural analysis. Since the various forms of decentralization and inconsistency of data are in the complex processes, method of data collecting and pre-processing is very important in the analysis process. We also have to suppose the great requirements for computing resources in

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the analysis phase. Moreover, many processes in complex systems are not explicitly deterministic, but have a random character. Structural analysis, which assumes collecting and processing the large volumes of data of various informational value, can have a specific character, particularly in the case of random processes (5). Data mining methods provide a possible solution in the tasks. One of the modern analytical methods is the process of data mining, which is one stage of a complex process of knowledge discovery in databases presented as KDD (1).

ANALYSIS OF STRUCTURAL RELATIONSHIPS IN THE SYSTEM OF RANDOM PROCESSES

Random process is a random function of time, which is represented by an infinite set of random variables. Sets of values of random variables represent the application of a random process. The values of the individual applications of random process can be experimentally measured and statistically evaluated. The main aim of process of structural analysis in processes of the system is the analysis of relationships. Relationship between processes can be understood as the process of transforming a set of input (independent) processes into the output (dependent) processes.

The main aim will be to show how to detect the existence of the transformation process in the system of random processes and to estimate their character within the analysis of structural relationships. We assume a set of stationary random processes in which we will distinguish a set of input (independent) processes and a set of output (dependent) processes which result from the transformation input processes.

In systems of processes, we can assume the transformations of various characters based on the nature of objects (elements of the system) which cause the transformation input process or a set of input processes to the output process. Based on the transient characteristics of objects, we can consider proportional, derivative and integrative character transformation relations.

From the range of the data mining methods, we used regression analysis methods and methods of neural networks, for solving the tasks. Especially the methods of neural networks represent a powerful tool in the primary analysis and extensive database (2, 4).

DESCRIPTION OF THE EXPERIMENTS

The aim of the experiment was to show, how to detect the existence of the transformation process of proportional and derivative nature. We observed statistical indicators in the active experiment and in the analysis of the values generated in different frequency bands.

A model of system processes was designed in MATLAB as shown in the following scheme:

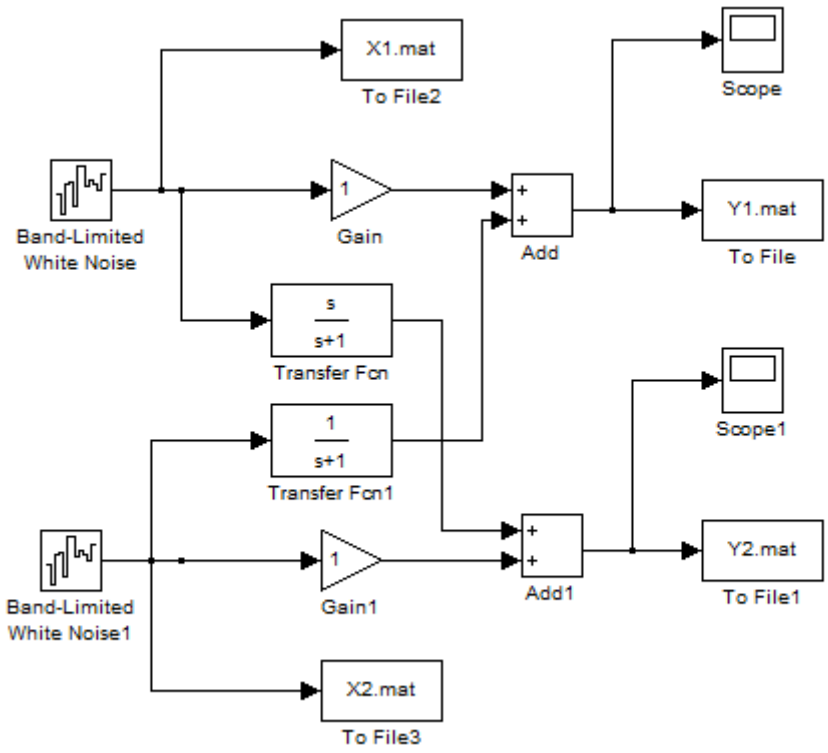

Fig. 1 *System model in Matlab*

In order to cover the highest possible frequency range, random signals were generated with normally distributed values and sampling period Ts = 0.1s, measurement time Tm = 100s and repeatedly with a sampling period Ts = 10s, and the measurement time Tm = 10000s on the inputs X1, X2. We obtained the values of realizations in two different frequency ranges, and these are the values in the range of 0.02 Hz - 5 Hz and 0.00002 Hz - 0.05 Hz by Shannon-Kotelnikov theorem. Then we analyzed the influence of realizations of input processes on the individual output processes in the frequency ranges through selected data mining techniques, i.e. using the basic linear model (LM), a linear regression model (LRM) and a linear predictive model of neural network (NS). We monitored selected statistical indicators in interpreting the results. In the linear regression model, it was primarily a significance level model (Sig.), the coefficient of determination (R Square) which indicates the proportion of explained variability by the model, the correlation coefficient (R) indicating the tightness of the linear dependence, as well as the values of the coefficients of the linear representation especially the value of the standardized Beta coefficient which expresses the percentage impact of the j-th independent variable on the dependent variable. In case of the linear model and the predictive neural network model, it was the value which determines the accuracy and corresponds to the percentages of the determination coefficient. The results of analyses for the individual frequency ranges are shown in the following tables:

THE INFLUENCE OF X1, X2 REALIZATIONS TO THE Y1 REALIZATION Table 1

	LM	**LRM**				**NS**
	Acc. [%]	Sig.	R	R Square	Coeff.	Acc. [%]
Y1 - X1, X2	95.7	0	0.979	0.959	X1, X2	95.7
	Coeff.	**B**	**Std. Err**	**Beta**	**Sig.**	
	X1	0.994	0.007	0.979	0	
	X2	0.098	0.007	0.096	0	

THE INFLUENCE OF X1, X2 REALIZATIONS TO THE Y1 REALIZATION Table 2

	LM	LRM				NS
	Acc. [%]	Sig.	R	R Square	Coeff.	Acc. [%]
Y1 - X1, X2	99.9	0	1.000	1.000	X1, X2	99.9
	Coeff.	**B**	**Std. Err**	**Beta**	**Sig.**	
	X1	1.000	0.000	0.728	0.000	
	X2	1.000	0.000	0.721	0.000	

THE INFLUENCE OF X1, X2 REALIZATIONS TO THE Y2 REALIZATION Table 3

	LM	LRM				NS
	Acc. [%]	Sig.	R	R Square	Coeff.	Acc. [%]
Y2 - X1, X2	97.4	0.000	0.987	0.975	X1, X2	97.4
	Coeff.	**B**	**Std. Err**	**Beta**	**Sig.**	
	X1	0.997	0.007	0.691	0.000	
	X2	1.011	0.007	0.708	0.000	

THE INFLUENCE OF X1, X2 REALIZATIONS TO THE Y2 REALIZATION Table 4

	LM	LRM				NS
	Acc. [%]	Sig.	R	R Square	Coeff.	Acc. [%]
Y2 - X1, X2	67.3	0.000	0.820	0.673	X1, X2	67.3
	Coeff.	**B**	**Std. Err**	**Beta**	**Sig.**	
	X1	0.970	0.32	0.556	0.000	
	X2	1.048	0.31	0.606	0.000	

EXPERIMENTAL RESULTS

Based on the values of statistical indicators, it was shown that the process X1 has a significant impact on the process Y1 and the X2 realization has only a minimal effect on the process Y1 in the experiment with the sampling period Ts = 0.1s (Table 1). The values of Beta coefficients showed that the impact of the realization X2 on the realization Y1 significantly increased by narrowing of the frequency range (Table 2). It is seen in the results of the analysis of realizations of processes X2 and Y1 that the characteristic of proportional element with the inertia, which caused filtering out the high frequency components, caused the effect. Since the value of non-standardized coefficient for the X1 realization remained identical in both experiments, it confirms the assumption that between the X1 and Y1 realizations, there exists purely a relationship of proportional transformation character due to the presence of the proportional element without inertia.

Analyzing the transformation relations of realization of an independent process on the dependent process Y2, we came to the following result. It was seen based on the values of statistical indicators in the experiment with the sampling period Ts = 0.1 that the X1, X2 realization have almost the same effect on the realization of Y2 which is statistically significant (Table 3). The value of determination coefficient decreased significantly by

narrowing the frequency range, and thereby the proportion of unexplained component increased (Table 4).

Since the primary property of the derivation element is its ability to transmit high frequency and to filter low frequency range, this result confirmed the presence of the transformational relation of derivation character. From the values of other statistical indicators, we were unable to clearly identify which relation it was. If we wanted to define the nature of relations more precisely, we would have to identify each relation separately. We could reach it by gradually disconnecting resources of realizations of random processes and then repeating the experiment.

CONCLUSION

The results of the experiment show that using the chosen methods of data mining we can obtain the information about the mutual interactions between the input (independent) and output (dependent) processes in the stationary stochastic processes. By monitoring the changes of the statistical indicators in each frequency range, we can reveal the existence of the derivative and integrative character of transformation relations.

The experiments showed that the problems of structural relationships in the systems of random processes can be solved using the data mining methods, thus providing a powerful mechanism for solving a wide range of tasks of the structural analysis.

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BUSINESS INTELLIGENCE IN PROCESS CONTROL

Alena KOPČEKOVÁ, Michal KOPČEK, Pavol TANUŠKA

Abstract

The Business Intelligence technology, which represents a strong tool not only for decision making support, but also has a big potential in other fields of application, is discussed in this paper. Necessary fundamental definitions are offered and explained to better understand the basic principles and the role of this technology for company management. Article is logically divided into five main parts. In the first part, there is the definition of the technology and the list of main advantages. In the second part, an overview of the system architecture with the brief description of separate building blocks is presented. Also, the hierarchical nature of the system architecture is shown. The technology life cycle consisting of four steps, which are mutually interconnected into a ring, is described in the third part. In the fourth part, analytical methods incorporated in the online analytical processing and data mining used within the business intelligence as well as the related data mining methodologies are summarised. Also, some typical applications of the above-mentioned particular methods are introduced. In the final part, a proposal of the knowledge discovery system for hierarchical process control is outlined. The focus of this paper is to provide a comprehensive view and to familiarize the reader with the Business Intelligence technology and its utilisation.

Key words

business intelligence, system architecture, life cycle, analytical methods, data mining

INTRODUCTION

This paper deals with the Business Intelligence technology. A brief overview of its architecture and its most used analytical methods is offered. Every current company or organization has a place for data storage. However, even if the data were collected systematically and structured, they do not have the necessary information value for decision-making process. Therefore, it is necessary to use appropriate extraction tools and analytical methodsto transform information into knowledge. Such knowledge plays an important role in the business decisions. The abilities of Business Intelligence could be also used in the process control with the advantage discussed below.

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BUSINESS INTELLIGENCE

The Business Intelligence (BI) could be defined as a collection of mathematical models and analytical methods which are used to generate the knowledge valuable for the decision-making processes from available data. To highlight the importance of BI in companies and organisations, some fundamental advantages are listed below. The BI:

- helps to direct the organisation towards its main objectives,
- enhances the decision-making ability of analysts and managers,
- enables faster and factual decision making,
- helps to meet or to exceed customer expectations,
- helps to identify competitive advantages,
- combines multiple data sources for the decision-making process,
- ensures efficient acquisition and distribution of essential data and statistics,
- finds hidden problems using information that is not visible,
- provides immediate answers to the questions that arise during the data study.

BUSINESS INTELLIGENCE ARCHITECTURE

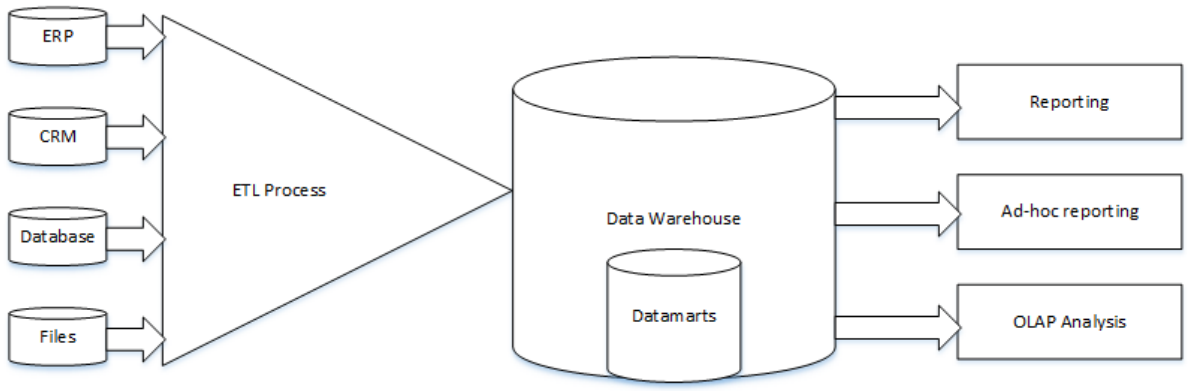

Fig. 1 *Typical architecture of the BI system*

The BI system architecture shown in Fig. 1 consists of three main parts.

The data sources. In the first step, it is necessary to collect and integrate all available data from the primary and secondary sources, which differ in type and origin.

The data warehouses and data stores. Next step is to use the extraction and transformation with the following storage of data from multiple sources (ETL) into the BI supportive databases. These databases are so-called data warehouses and data marts. Bill Inmon defines the data warehouse as a collection of integrated, subject oriented databases designed in support of management decisions. The data marts represent an essential part and form a subset of the whole company data warehouses. The data for data marts is selected to meet the specific requirements of certain part of the organization.

Methodologies of BI. The extracted data serves as inputs of mathematical models and analytical methods. Several applications could be implemented as a support for the decision-making process within the BI system:

- multidimensional cube analysis,

- exploratory data analysis,
- time series analysis,
- inductive learning models for data mining),
- optimization models.

A more detailed description of the components of the BI system architecture described above is provided by a hierarchical (pyramid) model in Fig. 2. The components of the two bottom layers were described above, therefore the next part of this chapter focuses on the description of the remaining model layers.

Data exploration. The third layer of the pyramid model provides tools for the passive BI analysis. The methodologies including the query and reporting systems as well as statistical methods are considered passive, because they require prior determination of initial hypotheses and definitions of the data extraction criteria from decision-makers. Subsequently, the answers obtained by analytical means are used to verify the correctness of decision-makers' initial view.

Data mining. The data mining within the introduced model is understood as an equivalent of the term Knowledge Discovery in Databases (KDD), nevertheless, many authors describe it only as a part of the process. It represents the fourth layer of the pyramid model and provides tools for the active BI analysis, which role is to extract information and knowledge from data. Active methodologies do not need the prior definition of hypotheses to be verified;, on the contrary, they serve to expand the decision-makers' knowledge.

Optimisation. It forms the last but one layer of the pyramid model and makes easier the selection of the best or optimal solution from large, often infinite, number of alternatives.

Decisions. The top of the pyramid model is represented by the selection and acceptance of specific decisions, which ends-up the decision-making process. Even if the company has effectively set BI methodologies, the final decision rests on the shoulders of decision-makers who dispose the informal and unstructured information. Therefore, they have an ability to suitably modify the recommendations and outcomes obtained using mathematical models.

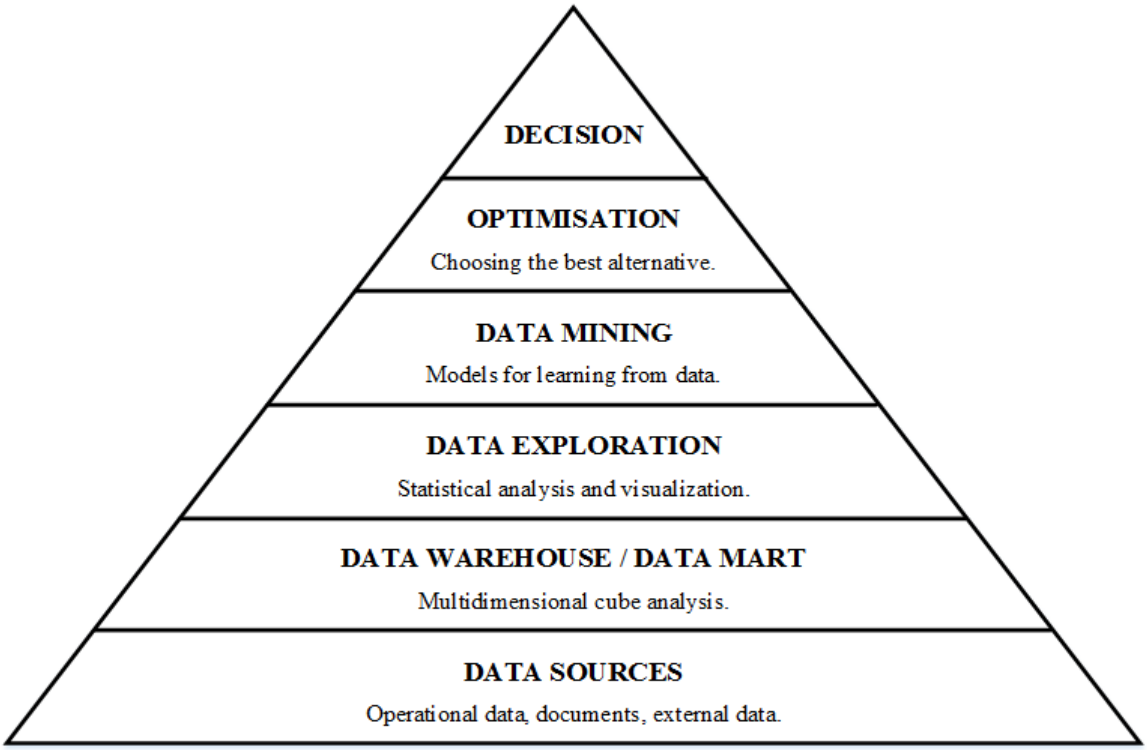

Fig. 2 *Hierarchical model of the BI system (VERCELLIS 2009)*

LIFE CYCLE OF BUSINESS INTELLIGENCE

The life cycle of an analysis within the BI system is depicted in Fig. 3, which reflects the above described architecture of the BI system. Successful operation of the BI system requires four steps mutually interconnected into a ring.

- Acquiring the huge amount of precise data from databases, data warehouses and another data sources.
- Analysis of the obtained data using BI methodologies, while complex elements are extracted into smaller segments for better understanding and discovering of new knowledge. Solutions to business problems are obtained using the business needs identification and reports are prepared (graphs, diagrams, annual reports, etc.).
- Trends identification using predictive analysis and identification of business threats and opportunities using complex mathematical methods.
- Simulation and acquisition of new knowledge about business problems, threats and opportunities, and application of the obtained knowledge by means of decisions. Consequently, the accuracy of the taken decisions is evaluated in a new cycle of extraction and analysis of ongoing processes.

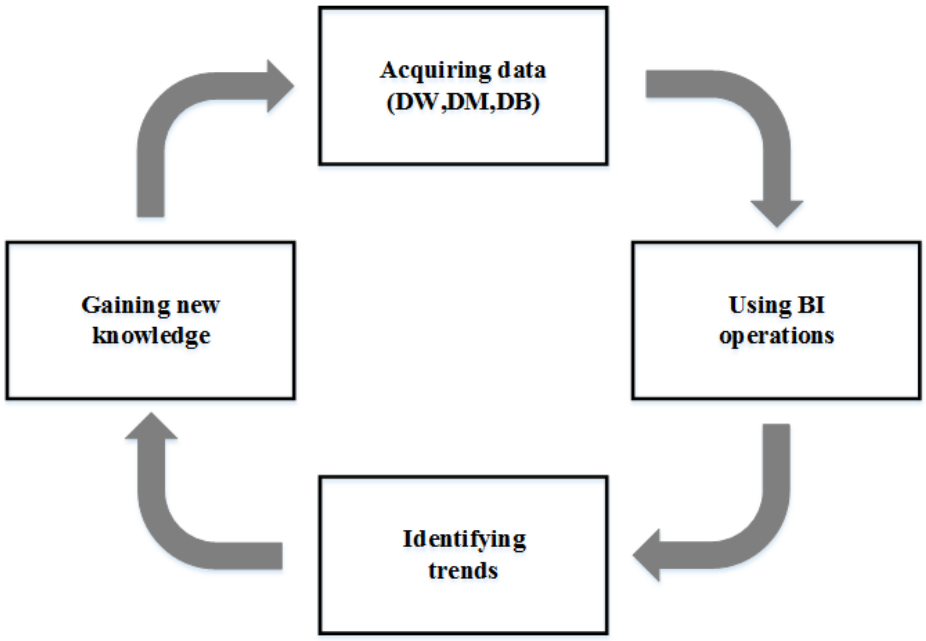

Fig. 3 *Life cycle of analysis within the BI (KOCBEK 2010)*

ANALYTICAL METHODS IN THE BUSINESS INTELLIGENCE SYSTEM

The basic division of analytical methods into methods, which serves for hypotheses verification and methods for knowledge expansion, was made within the BI system architecture description. Some specific methods are briefly introduced in this chapter.

OLAP – OnLine Analytical Processing

Online Analytical Processing or OLAP is a technology of data storage in databases, which allows organizing large amount of data so that the data is accessible and understandable to users engaged in analysing business trends and results. (LIŠKA 2008) The method of data storage differs by its focus from the more commonly used OLTP (Online Transaction

Processing), where the emphasis is primarily on the simple and secure storage of data changes in the competitive (multiuser) environment.
Basic differences between OLAP and OLTP arise from the different applications. In the OLAP, it comes to the one-time recorded data, over which complex queries are implemented. In the OLTP, data is continuously and frequently modified and inserted, and usually simultaneously by many users. (OLAP 2013)
The OLAP tools are widely used also within the data mining. The main objective of the process is to gather knowledge from the existing data set and transform it to the structures, which are easily understandable to the user for further application.

DATA MINING
There exist many different definitions of the data analysis technology known as data mining. Most of them involve a procedure of searching and discovery of useful relationships in large databases. As the personal computers became more effective and user friendly, the new data mining tools were developed to get an advantage from the growing power of computer technology. Procedures for data mining are designed in response to the new and increasingly expressed needs of management decisions. Some definitions of data mining are anchored in specific analytical methods, like neural networks, genetic algorithms, etc. Other definitions of data mining are sometimes confused with the definitions of data warehousing. Building the data warehouses and data mining are complements. The data warehouse serves as data storage, but not to transform the data into information. Data mining transforms the data into information and information into knowledge (KEBÍSEK 2010).

The most common data mining tasks comprise:
- classification,
- prediction,
- association rules.

Classification is a method used to divide data into groups according to specific criteria. If the criteria are known in advance, at least for a data sample, a model may be developed using predictive modelling methods, the output of which is a classification variable. If the resulting criteria are not known in advance and the classification task is to find them, an unguided classification occurs. The technique used in such cases is a cluster analysis. A prime example of cluster analysis is e. g. finding the groups of markets based on their turnover, product range and customer type. The found groups (clusters) are consequently used e. g. as a specification for an advertising campaign aimed at different groups of stores. (LIŠKA 2008)
The basic methods of classification are (PARALIČ 2003):
- Decision trees - Classification using the decision trees method is the most often used to determine the target attribute having discrete values. The method belongs to the inductive learning methods and has been successfully applied in many fields such as classification of patients according to diagnosis or prediction of credit and insurance frauds (classification according to the risk of credit or insurance frauds).
- Bayesian classification - Bayesian classifiers classify the given examples into different classes according to the predicted probability of attribute values. (PARALIČ 2003)
- Classifiers based on k-nearest neighbours – Classes are represented by their typical representatives in the method. A new example is assigned into the class on the basis of similarity during the qualification process (minimum distance to the representative from some class). (LIŠKA 2008)

Prediction is used to forecast a value of continuous (numeric) target attribute. A typical example is a model of behaviour of loan applicants. On the basis of the previous borrowers and theirs loan repayment, bank can build a classification model using data mining techniques, which is used to place new borrowers into one of the predefined categories (e.g. allocate the loan or not) based on the data contained in the loan application. (PARALIČ 2003)
The basic methods of prediction are (PARALIČ 2003):

- Regression – The linear regression is the simplest regression method which models the data using lines. The two dimensional linear regression method models the target attribute Y (predicted variable - regressand) as a linear function of another known attribute X (predictor variable - regressor). Regression coefficients α, β could be calculated by the least squares method, which minimises the error between the actual data and the approximation line.
- Model trees – In the case of prediction tasks, where the transformation of the linear model is not possible, it is useful to use e.g. M5 algorithm that generates predictive models in the form of a tree structure, which is much like decision trees.
- Predictors based on k-nearest neighbours – The final prediction is made on the basis of the values of the target attribute of k-nearest examples from the training set of the just solved example. The difference compared to classification is that the resulting predicted value is calculated as the average value of k-nearest neighbours in the training set. (PARALIČ 2003)

Association rules are used to describe the categories or classes and to reflect the connection between objects. The rules very often use the IF-THEN construction and logical operators AND, OR, and their reliability is determined using probability. (MAGYAROVA 2008)
The association rules are (PARALIČ 2003):

- simple association rules,
- hierarchical association rules,
- quantitative association rules.

Methodologies of knowledge discovery in databases
There are methodologies the aim of which is to provide a uniform framework for the solution of data mining tasks. Some were developed by software producers e.g. methodologies 5A and SEMMA, others arisen from the cooperation of research and commercial institutions e.g. CRISP-DM, which is shown in Fig. 5.

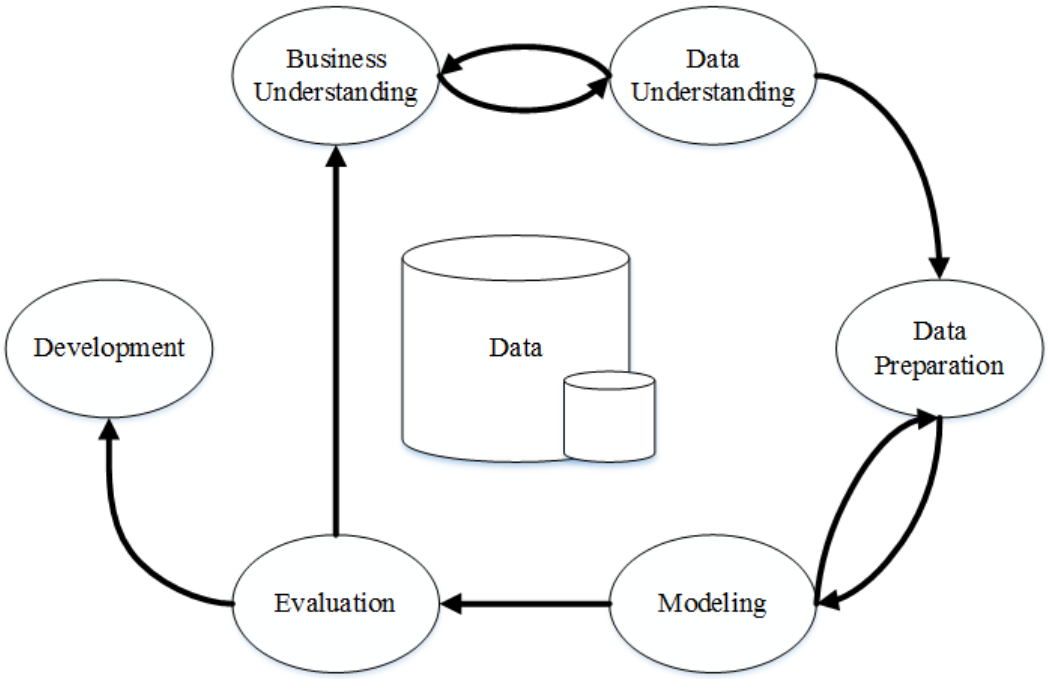

Fig. 5 *Phases of the CRISP-DM reference model (MIRABADI 2010)*

The common essence of all methodologies is the following steps:

- Business/practical - the formulation of the task and understanding of the problem.
- Data - search and preparation of data for analysis.
- Analytical - finding information in the data and creating statistical models.
- Application - acquired knowledge and models are necessary to e.g. launch an advertising campaign or reorganize Website.
- Revisory - the need to ensure feedback and for long-term deployed models to check, whether the model has not become obsolete and still retains its effectiveness.

Applications of data mining

- Relational marketing:
  - identification of customer segments that are most likely to respond to the targeted marketing campaigns, such as cross-selling and up-selling,
  - prediction of the rate of positive responses to marketing campaigns,
  - interpretation and understanding of the buying behaviour of the customers,
  - market basket analysis,
- fraud detection,
- risk evaluation,
- image recognition,
- medical diagnosis.

KNOWLEDGE DISCOVERY IN HIERARCHICAL PROCESS CONTROL

Before submitting a proposal for the knowledge discovery for hierarchical process control, the following stages should be implemented:

- Analysis of data at all levels of the pyramid model of process control and subsequent design of the functions and structure of specialised data storage.
- Verification and validation of data storage design in accordance to the existing international standards and guidelines.

- Proposal of transformation subsystem of heterogeneous data structures into a single structure, which is given by the proposal of data storage.

Mastering the three stages is a prerequisite for achieving the defined objective, i.e. to use the data warehouses for process control by using the system with hierarchical (multilevel) structure.

The aim can be formulated as a comprehensive approach to solving problems which relate to the processing of extreme amount of data for the control purposes of complex systems.

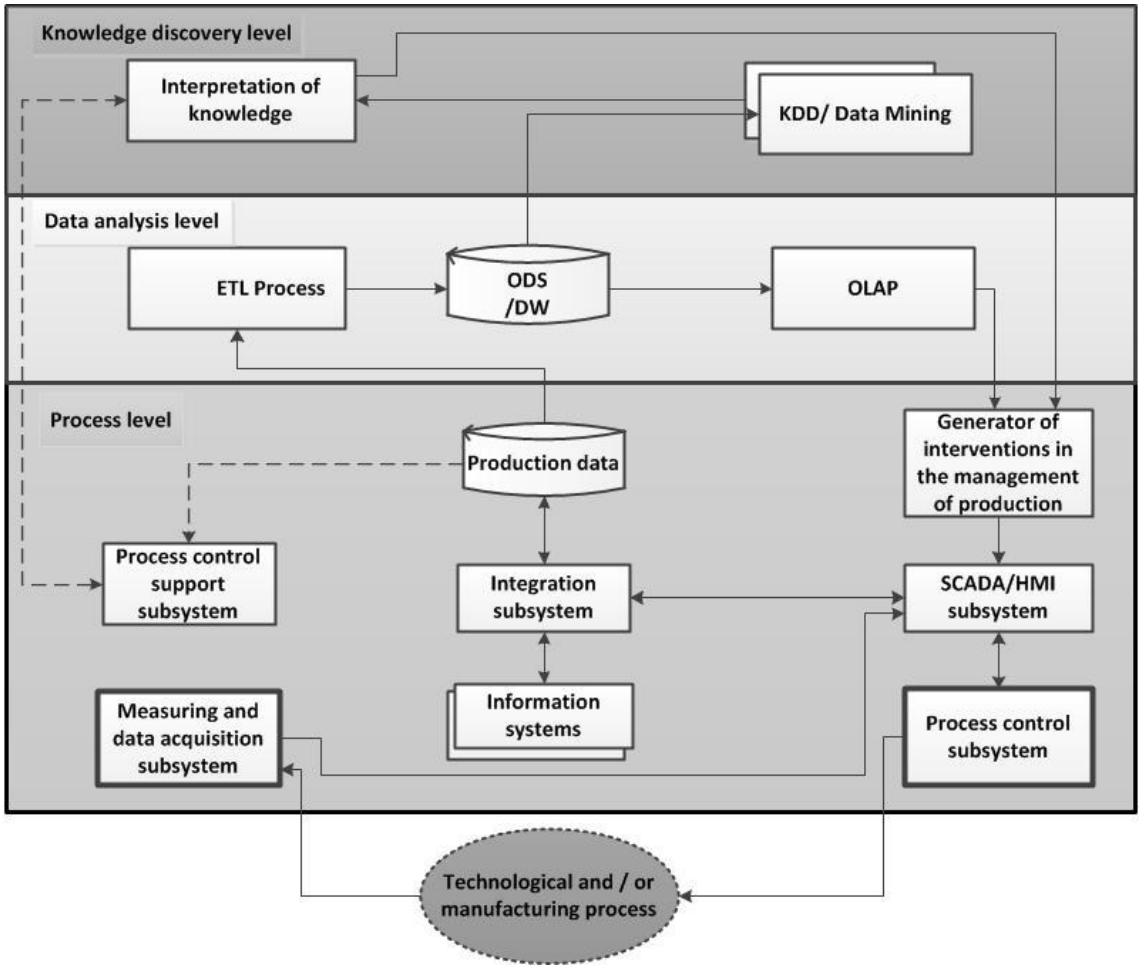

Fig. 6 *The conceptual scheme of proposal of the knowledge discovery system*

The overall solution is divided into three levels as shown in Fig. 6. The basic level, so called process level, is the information related to the technological and/or manufacturing process. It is based on the standard pyramid model.

It contains all the relevant elements and subsystems which are essential for the process control of any industrial enterprise and provide, among others, the functions such as measurement of the instantaneous values of variables, monitoring parameters (e.g. thresholds, trends, etc..), actuating of the actuators, manual operation, setting the setpoint of controllers and logic control, data visualisation, archiving the process data, the transfer of information to the superior level, etc.

The next level is the level of data analysis and it should be understood as the superior one. It includes subsystems for the acquisition, extraction, transformation and integration of data, including the data warehouse itself or operational data store. The system also includes OLAP tools and technologies.

The fundamental requirement for the extraction and processing of data from production databases is to maintain data integrity. It is in many cases difficult to solve and extremely complicated requirement due to the transformation and processing of data into different data structures within the data storage. Potential knowledge hidden in a huge amount of data, is necessary to prepare in several steps for processing and yet not to violate the relations and linkages in these data.

The last and the highest level is the knowledge discovery level which includes KDD subsystem with the subsystem of the knowledge interpretation. Only properly obtained (using methods and techniques of data mining) and interpreted knowledge could be effectively used to improve the quality of process control. Therefore, the most important part of the system is the module for knowledge interpretation. Properly interpreted knowledge is subsequently necessary to be used and ensure its transport back into the production process. This is done through the "Generator of interventions in the management of production" module. The module should be seen as an interface between the level of knowledge discovery and the control level.

The module itself is directly connected to the SCADA/HMI and the interventions to the production process are directly implemented through it. It must be said that the interventions using the acquired and correctly interpreted knowledge may be carried out in the manual or automatic modes.

The information flow from the level of knowledge discovery to the process level itself may include:

- control algorithms parameters,
- balance calculations values,
- static and dynamic parameters of models,
- parameters useful for equipment diagnosis - maintenance support,
- documents to ensure quality of production, etc.

Benefits of the proposed solution

The proposed system of knowledge discovery for the hierarchical process control could help in solving the following issues:

- Prediction of emergency situations in controlled process based on the principle of finding the analogous situations by the processing of large amounts of data in real time.
- Prediction of preventive production equipment checks associated with maintenance.
- Identification of the impact of process parameters on the production process.
- Identification of slightly incorrect information sources (sensors), where conventional techniques for estimation of alarms limits fail.
- Diagnostics of manufacturing systems with respect to the overall service life of these systems.
- Identification and optimisation of relevant control parameters, that affect the safety improvement of process control.
- Defective operations of actuators, such as insufficient implementation of the calculated action.

- Refinement of nonlinear dynamical models of controlled processes focused on optimising the parameters.
- Continuous monitoring of the quality of process of control on the basis of the quality evaluation of the online obtained data.
- Detecting error conditions of production facilities as well as individual products - detection of rejected pieces.
- Identification of various non-standard states, that affect the production process and which the production operator must solve the most commonly by unplanned shutdown of a machine or technology.
- Solution to the problems using the obtained knowledge without pre-specified objectives.
- Prediction for the needs of enterprise management, various ad hoc reports.
- Effective implementation and especially innovation of control systems at all levels.

CONCLUSION AND DISCUSSION

Business Intelligence represents the top of the hierarchical model of the business administration and information system and a strong tool which helps to increase quality, reliability, safety and efficiency of business processes. Knowledge is gained through the Business Intelligence, thus providing the analysts and managers with important information about the activities of the company and the insight into the processes within the company.
Although the Business intelligence technology was originally developed as a support of the decision-making in enterprises, given its nature and the diversity of its tools, it is clear that it has a very big potential and wide application in the areas outside business management. Business intelligence tools could find application e.g. in control parameters optimisation and complex nonlinear technological processes control, in early warning systems, or other systems that uses mass storages for historical data. It is obvious that using the knowledge discovery for the need of hierarchical process control is definitely such type of application.

SUMMARY

The main aim is to give a comprehensive view and to familiarise the reader with the Business Intelligence technology and its utilization, as well as to suggest a new field of application of the progressive technology. The paper points out that the Business Intelligence technology represents a strong tool not only for decision making support, but also has a big potential in other fields of application e.g. medical diagnosis, image recognition, control parameters optimisation and complex nonlinear technological processes control, early warning systems, or other systems that uses mass storages for historical data. Fundamental definitions are offered and explained to better understand the principles and the role of the technology for a company management. Some main identified advantages of the Business Intelligence utilisation are enhancing the decision-making ability, finding and predicting hidden or future problems, etc. The system architecture is hierarchical in nature and consists of six layers from data sources to decision. The life cycle of an analysis within the Business Intelligence system reflects the described system architecture. Successful operation of the Business Intelligence system requires four steps mutually interconnected into a ring to apply Business Intelligence operations, identify trends and finally gain new knowledge. The utilised analytical methods are in general incorporated into online analytical processing and data mining. The data mining methodologies such as 5A, SEMMA and CRISP-DM could be used to simplify the application of Business Intelligence operations. The proposed knowledge discovery system for the need of hierarchical process control was designed in accordance to

the mentioned technology architecture and existing methodologies. Thanks to this a few key benefits were identified.

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