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USAGE OF DECISION SUPPORT SYSTEMS FOR DIAGNOSTIC PROCESS MANAGEMENT

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ABSTRACT: *This paper deals with process management in the diagnostic science with usage of the Decision Support System (DSS). Unlike the other common processes, diagnostic processes have some specifics. The outputs of diagnostic process can be used again as inputs. These outputs are measured data as well as gained knowledge and experience. Hence we are focused on increase of efficiency of data evaluation, optimizing of diagnostic processes and acceleration of development of new materials. Decision Support Systems are defined as "interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems". Therefore DSSs can be advisable solution for diagnostic processes, which are primarily unstructured. Unstructured problems can be partially supported by standard computerized quantitative methods, but it is necessary to develop customized solutions. This solution may require certain expertise that can be provided by intelligent system. Intuition and judgment may play a large role in this type of decisions. In the scope of development and diagnostic of new materials, DSSs can be used for optimizing of diagnostic processes and reduction of development time following the anterior data, knowledge and experience. DSSs provide new possibilities in discovery of materials and combination of materials with exactly defined properties. In addition, they can reduce related costs.*
KEYWORDS: *diagnostic process, process management, decision support system*

INTRODUCTION

Application of process management in the field of diagnostics is the result of the search for new opportunities to diagnostics development. Process management involves continuous measurement and evaluation of processes as well as decision making about implementation of new, improvement of existing and termination of insufficient processes. Successful implementation of process management also requires the use of appropriate information systems and technologies (IS/IT).

Decision Support Systems are defined as "interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems". In fact, DSSs can be used to solve any type of problems. It means that they can be used to facilitate decision making in both cases, the diagnostic problem solving and diagnostic process management as well.

DIAGNOSTIC PROCESS MANAGEMENT

Diagnostics is a discipline that essentially deals with identifying the root causes of the problem and seeking solutions to the problem. Important attributes, with which the diagnostic processes work, are data, information and knowledge. Knowledge transforming data into information and information (diagnosis) is the output of a process, which should be called a diagnostic process (see Figure 1).

Diagnostic process is effectively planned sequence of activities, which enabling identify the structure or behavior of diagnosed object using information, knowledge, financial, material and human resources in accordance with customer requirements. Diagnostic object should be an element of the system, system or process. Customer is a person who required diagnostics.

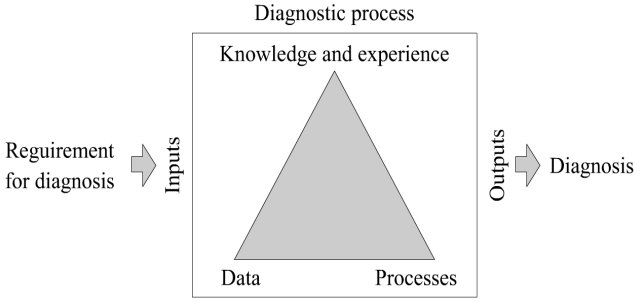

Figure 1 – Process view of diagnostics

Diagnostic process management is not clearly defined as a scientific discipline. Generally, diagnostic process management can be conceived as management of service providing. Nowadays, in terms of scientific focus, this issue can be defined as Service Sciences, Management and Engineering (SSME). It is a multidisciplinary field of research and academic initiative that integrates aspects of the areas of informatics, operational research, technical disciplines of engineering, management sciences, including strategic, social, cognitive and legal sciences. SSME is then defined as a management-engineering discipline focused on providing efficient services.

During implementation of diagnostic process management, following of particular stages of process management life cycle is highly recommended. These stages are:

1. *Determination of management strategy and process objectives defining*
2. *Analysis and processes mapping*
3. *Process modeling*

4. Process optimization
5. Creating of a system for measurement and evaluation of processes

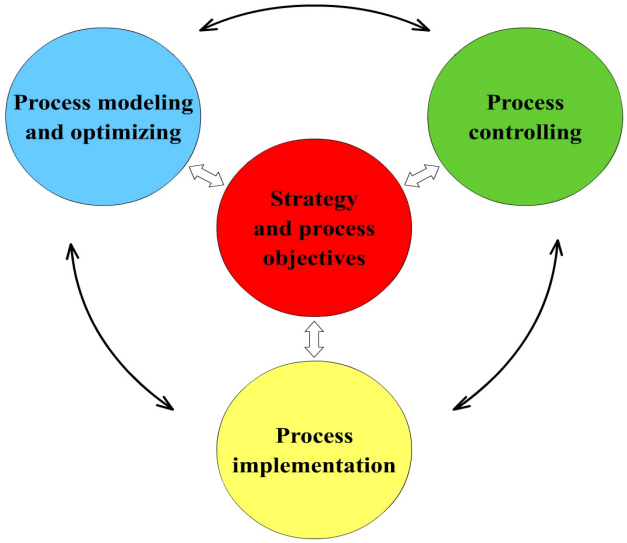

Figure 2 – Process management life cycle

These stages are complemented and extended with appropriate methods and techniques that are used in different areas separately. Then, the proposed methodology determines the order and concept of how to use these methods to create a coherent logical unit.

Usually, the diagnostic process should be easy described, surveyed, quantified by real metrics, and its added value can be evaluated easily. For these reasons, process controlling can be easy implemented and advantageously used in the field of diagnostics.

A prerequisite for the successful diagnostic process management is monitoring of real-time run of processes and recording of their attributes. These data could be stored in database or data warehouse and used by analytical tools, such as reporting tools, OLAP or other Business Intelligent (BI) tools. It provides continuous evaluating and measuring of the key attributes of diagnostic processes. It can leads to find process bottleneck and enables continuous optimizing of processes.

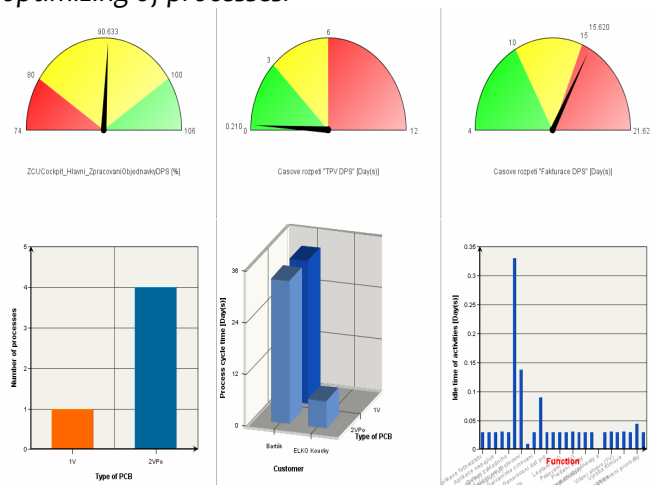

Figure 3 – Example of graphical outputs of queries in the analytical process controlling using ARIS PPM [5]

One of the promising tools which allow above mentioned functions is ARIS Process Performance Manager (PPM). It measures the real-time performance of process by calculation of selected key performance indicators, such as the duration of the process, the process rate, error rate, the process cost, a number of actors involved in the process, and other indicators as desired by the user.

DSSs SUITABLE FOR DIAGNOSTIC PURPOSES

As was already mentioned, DSS are interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems. DSS is an approach, a methodology for supporting decision making [2]. It uses specially developed interactive, flexible and adaptable computer-based information systems.

Generally, a common DSS application consists of four basic components: the data management subsystem, the model management subsystem, a knowledge-based management subsystem and the user interface subsystem.

The data management subsystem is basically a database. This database contains relevant data and is managed by database management system (DBMS). This subsystem is usually interconnected with data warehouse, a repository for relevant decision-making data.

The model management subsystem is a software package that includes quantitative models that provide the system's analytical capabilities, appropriate software management and modeling languages for building custom models.

The knowledge-based management subsystem is optional, but it provides many benefits by providing intelligence into the system. This component can supply the required expertise for solving some aspects of the problem and provide knowledge that can enhance operation of other DSS components [2].

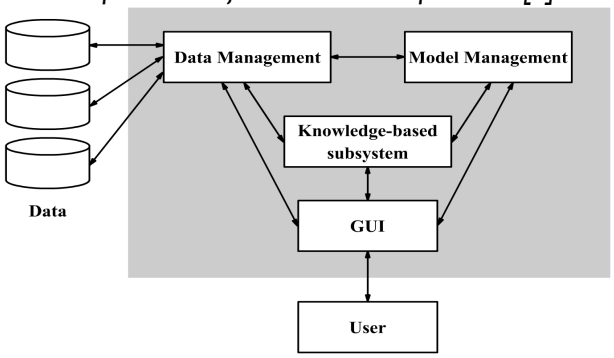

Figure 4 – A schematic view of Decision Support System

The user interface subsystem serves to facilitate user's communicating with and operating the DSS. Because the user is a fundamental part of the system, consistent, familiar and easy to use graphical user interface (GUI) application is highly recommended. GUI is advantageously provided by Web browser.

To help users to decide which type of DSS is the best solution for their specifications and requirements, several classifications of DSS applications had been create. Today most DSSs fit into the classification provided by the Association for Information Systems Special Interest Group on Decision Support Systems (AIS SIGDSS) [2]. This concise classification includes the following categories:

- Data-Driven DSS
- Model-Driven DSS
- Knowledge-driven DSS, data mining and ES (Expert System) applications
- Document-Driven DSS
- Communications-Driven and group DSS

To include the categorization in terms of functions and technology, Power extends these five major categories of DSSs by two more:

- Spreadsheet-Based DSS
- Web-Based DSS

Hybrid, or so called compound DSS, may also be creates as combination of two or more major categories.

In the field of diagnostics the DSS should be able to manage large amount of measured data as well as knowledge and experience gained in the past. To easy share the information and functions of such a system, using of network technologies is useful. To reach these characteristics, design of the Web-Based Data/ Knowledge-Driven compound DSS should be the best approach. Therefore we are closely focused on the three mentioned categories of DSSs.

WEB-BASED DSS

Web-Based DSS gives decision support information or decision support tools to users using a "thin-client" Web browser like Internet Explorer or Mozilla Firefox that is accessing the Internet or an intranet. The computer server that is hosting the DSS application is linked to the user's computer by a network with the TCP/IP protocol. Web technologies can be used to implement any of DSS main categories.

Web-Based means the whole application is implemented using Web technologies. In some cases key parts of application remain on a legacy system, but the application is accessed from a Web-based component and displayed in a browser. These types of applications are so called Web-Enabled.

DATA-DRIVEN DSS

A Data-Driven Decision Support System is an interactive computer-based system that helps decision-makers use a large amount of data. Users of the system can perform unplanned or ad hoc analyses and requests for data, process data to identify facts and to draw conclusions about data patterns and trends. Data-Driven DSS help users retrieve, display, and analyze historical data.

The elementary level of functionality is provided by simple file system accessed by query and retrieval tools. The additional functionality is represented by Data warehouse system. It allows the manipulation of data by computerized tools. The highest level of functionality and decision support is represented by Data-driven DSS with On-line Analytical Processing (OLAP).

This category of DSS is determined to help users "drill down" for more detailed information, "drill up" to see a broader, more summarized view, and "slice and dice" to change the dimensions they are viewing. The results of "drilling" and "slicing and dicing" are presented in tables and charts [3].

KNOWLEDGE-DRIVEN DSS

Knowledge-Driven Decision Support Systems store and apply knowledge for specific problems. They are computer programs that ask questions and reason with the stored knowledge about a narrow, specialized subject. This type of programs attempt to solve a problem or give advice.

In general, Knowledge-Driven DSS is a program with specialized problem-solving expertise. The "expertise" consists of three components: 1) knowledge of symptoms related to a particular domain, 2) understanding of the relations among symptoms, problems and solutions, and 3) "skill" or methods for solving some of the problems. It is knowledge-intensive program that captures the expertise of a human in a limited domain of knowledge and experience [3].

USAGE OF DECISION SUPPORT SYSTEMS FOR DIAGNOSTIC PROCESS MANAGEMENT

There are many different ways to use Decision Support Systems. It always depends on their purpose and user requirements. In the field of diagnostics we can profitably use the best practices from published case studies of implementation of maintenance and medical applications of DSS. The maintenance DSSs are generally more focused on the data which represents measured values of the key parameters of reference object. On the other side, medical DSSs are mostly designed to use and dissemination of knowledge.

In the field of general diagnostics we can find both of these mentioned approaches. In the next two subsections we will try to outline the possible application of both approaches on examples of diagnostic processes performed in our research team workplace. These diagnostic processes are diagnostics of solderability and diagnostics of organic polymers.

EXAMPLE 1 – PROCESS OF SOLDERABILITY DIAGNOSTICS

The aim of this diagnostic process is to evaluate solderability of electronic device leads or parts of printed circuit boards. Solderability consists of 3

aspects – wettability, temperature requirement and resistance to soldering heat. Diagnosed object can be solder, flux, sample of one of the connected materials, or even the soldering process settings. For diagnostic itself, equipment for solderability testing using wetting balance test is used.

Process of solderability testing strictly follows relevant standards. Therefore all evaluated parameters of soldering test are well known and defined. This knowledge, if necessary, can be with advantage used to build a knowledge-driven DSS based on well defined rules such as expert system (ES). For these purposes several free tools, so called expert system shells, are available. The most common ES shells include CLIPS, Jess, Jena and e2go.

However, the key role in this diagnostic process play obtained data and their evaluation. This is a typical example of the use of data-driven diagnostic decision support system. The obtained data should be shown as charts and graphs, with ability to be investigated from several angles of view, such as solder type, flux type, soldering process parameters etc. Whereas, the solderability testing does not produce a large amount of data so the suitable data-driven DSS could be built using common spreadsheet processors.

EXAMPLE 2 – PROCESS OF ORGANIC POLYMERS DIAGNOSTICS

The aim of this diagnostic process is the assessment of selected parameters of organic polymers that are used for the construction of sensors. Diagnosed object is composed of the substrate, the electrode system and a layer of organic polymer. For this sample changes in several electrical properties, such as complex impedance, permittivity, resistivity and loss angle, depending on changes in the environment, especially humidity, temperature, steam, are examined. For the deposition of organic polymer layer different technologies may be used, such as dip coating, spin coating, vapor plating, sputtering and electrochemical processes such as electric polymerization.

Besides the measured data, this diagnostic process produces a large amount of knowledge and experience. These knowledge contain information about the type of used material, used selected polymer coating technology, design layout of the measured samples, processes used for sample preparation, measurement conditions and used equipment, etc. Furthermore, the knowledge about influence of one process condition on another is also very important.

Characteristics of organic polymer diagnostics process show the key role of knowledge and experience. This is a typical example of the use of knowledge-driven diagnostic decision support system. Such a system could be built using intelligent techniques and tools like expert system technologies and data mining. Especially Artificial Neural Networks (ANN) are very promising technology for building knowledge-driven DSS. Neural networks attempt to learn patterns from the data directly by repeatedly examining the data to identify relationships and build a model [3]. They can be used to classify the data, to discover hidden knowledge, or to make predictions based on already learned knowledge. There are many free, mainly Java-based ANN tools that provide building, training and implementing of neural networks. The most popular are Joone, Encog and Neuroph.

WIDER USE OF DECISION SUPPORT SYSTEM

Apart from measured data and gained knowledge and experience, decision support system should be able to obtain, use and manage additional attributes of diagnostics processes. These attributes, such as duration of the process, utilization of key resources, costs, etc., are the key elements of diagnostic process management. Based on such attributes, the diagnostics processes could be controlled and optimized.

Usage of decision support systems for diagnostic process management provides significant advantages like sharing of information, knowledge and experiences, optimization of diagnostic processes in terms of time and costs, continuous improvement of diagnostics quality, coordination and planning of tests, risks elimination, etc.

SUMMARY / CONCLUSIONS

Process management is the set of activities for planning and monitoring the performance of a process. It includes the application of knowledge, skills, tools, techniques and systems to define, visualize, measure, control, report and improve processes. In the field of diagnostics, process management brings the possibility of optimization of diagnostic processes and therefore the acceleration of diagnostics, research and development of new materials, technologies and techniques. It eventually also leads to reduction of costs.

Usage of Decision Support Systems for the diagnostic process management seems to be a good opportunity for achieving the above mentioned goals. Especially the Data-Driven and Knowledge-Driven DSS, both developed as a Web-Based system, or their combinations, are suitable tools for diagnostic purposes.

This article deals with the process management in the field of technical diagnostics using Decision Support Systems. It brings the brief overview of diagnostic process management and the suitable types of DSS. The usage of Decision support systems for diagnostic process management is described and demonstrated on two process examples – Diagnostics of solderability and Diagnostics of organic polymers.

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REFERENCES

[1] TUPA, J.: Řízení diagnostických procesů, ZČU, Plzeň 2008.

[2] TURBAN, E., ARONSON, J. A., LIANG, T., SHARDA, R.: Decision support and business intelligence systems, Parson Education, Inc., Upper Saddle River, New Jersey 2008.

[3] POWER, D.: Decision Support Systems Hyperbook, http://dssresources.com (accessed January 2010).

[4] ZHANG, GODDARD: A software architecture and framework for Web-based distributed Decision Support System, Decision Support Systems, Volume 43, Issue 4, Special Issue Clusters, August 2007, Pages 1133-1150, ISSN 0167 9236, DOI: 10.1016/j.dss. 2005.06.001.

[5] TUPA, J., STEINER, F., BASL, J.: Business Intelligence pro řízení diagnostických procesů, In Diagnostika '07. Plzeň : Západočeská univerzita, 2007. pp. 259-263.

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