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ADVANCED TECHNOLOGIES IN DEVELOPING WEB-BASED DECISION SUPPORT SYSTEMS FOR AGRICULTURE

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ABSTRACT A need for prompt and reliable information dedicated to farmers and institutions involved in the agriculture and food sector results in enhancing Web-based decision support systems with new advanced technologies. Implementation of such advanced and effective technologies is important for a software developer to support software quality standards. Emerging technologies and environments related to the recent version of Microsoft .NET Framework were analyzed and applied to develop several Web applications for the agri-food sector. The methods were based on ASP.NET (versions 3.5 and 4), C++/CLI and C# (versions 3.0 and 4.0) available in Microsoft Visual Studio 2008 and 2010. The approach was enhanced with: AJAX to make Web applications more interactive, LINQ to work with data, CSS to build attractive and consistent web sites, WPF, including Silverlight, to develop and distribute rich Web applications, and WCF for implementing services. The technologies were exemplified with several original web applications selected from a vast ICT repository of information systems developed within Master's and doctoral theses in the Department of Applied Informatics, Institute of Agricultural Engineering, Poznan University of Life Sciences.

Keywords: Web applications, Decision support, ASP.NET technology, Rapeseed plantation protection, Cereal grain drying, Research and education management.

INTRODUCTION Prompt and reliable information available on the Web is essential for farmers, companies and institutions to make better decisions on operating the agribusiness and maintaining quality standards. New advanced technologies available for developing Web-based decision support applications can increase substantially the functionality, reliability, usability, maintainability and performance of such applications in the agri-food sector.

The objective of the paper was to indicate, implement and analyze emerging technologies useful for developing Web-based decision support systems for agriculture. The technologies comprised selected approaches to knowledge representation, software engineering, project management, UML diagramming, and the recent Microsoft application development framework.

METHODS AND RESULTS

Knowledge representation In order to develop decision support systems several approaches were used. In an exemplary Web application "Rzepinfo" (Figure 1), developed to support protection of winter oilseed rape plantations (Kozłowski and Weres, 2008), problems were analyzed with decision trees (Adam and Humphreys, 2008). PC-Shell (AITech, 2010), the domain-independent shell for building expert systems was implemented in a Web decision support system "Ziarbit" (Figure 2), to support design and management of cereal grain drying and storage. Another interesting approach was also analyzed in case of the "Ziarbit" system, based on NxBRE - an open-source rule engine for the .NET software framework (SourceForge, 2010). The Expert Module, built as an implementation of NxBRE engine, is the main part of the solution. It contains two software engines – the Flow Engine and the Inference Engine. The Flow Engine uses XML to control process flow for the application. It is a wrapper on C#, it offers all its flow control commands plus a context of business objects and results. The Inference Engine is a forward-chaining, data driven deduction engine. It supports Facts, Queries and Implications concepts, and Rule Priority, Mutual Exclusion and Precondition concepts. It encourages separation of roles between an expert and a developer. A process of decision making is preceded with data transformation to a form of knowledge: data are acquired from the Database Module and processed by the Knowledge Representation Module. Then the data are tested against the set of rules that apply to a particular step in the process of the decision support. Rules are contained within an XML file. It is possible to tailor the rule container, and one of the AI key-features for an expert system, the "goal trace" feature is enabled. Due to that it is possible to develop an information system that can answer questions about its own behavior. The Expert Module of that DSS application is also responsible for supplying answers provided by the inference process to business objects implemented within the Web-based decision support system.

Software engineering, project management and UML diagramming Development of information systems in the Department of Applied Informatics, Institute of Agricultural Engineering, Poznan University of Life Sciences, in cooperation with students, was based on standards of software engineering (Sommerville, 2007) at all phases of the development process. Functional requirements and UML 2.2 diagrams (OMG, 2009, Visual Paradigm, 2010) were designed to represent functionality, structure and behavior corresponding to the problem domains. The code was implemented, and test cases were designed to cover all functional requirements. The results of testing were used to improve the software. Several approaches to project management were examined, they were based on ISO/IEC 9126 standards, agile approach with the Scrum method (Schwaber, 2004), and Microsoft Solutions Framework for Agile Software Development (MSDN Library, 2010).

Microsoft application development framework At present, with respect to Web-based decision support systems, Microsoft Visual Studio (formerly VS 2008, and now VS 2010) is the most effective framework for developing software (Mackey, 2010). The applications depicted in this paper were developed within this framework, with the use of the ASP.NET technology, versions 3.5 and 4 (Esposito, 2008, Evjen et al., 2010), C++/CLI and C#, versions 3.0 and 4.0 (Nagel et al., 2010). Some elements of AJAX were examined to make Web applications more interactive, LINQ - to work with data, CSS - to build attractive and consistent web sites, Windows Presentation Foundation (WPF),

including Silverlight - to develop and distribute rich Web applications, and Windows Communication Foundation (WCF) – to implement services.

Exemplification of Web-based decision support systems for agriculture The technologies indicated in the paper were exemplified with several original Web applications, developed within Master's and doctoral theses in the Department of Applied Informatics, Institute of Agricultural Engineering, Poznan University of Life Sciences.

A Web-based decision support system for protecting winter oilseed rape plantations The functionality and structure of the DSS "Rzepinfo" is depicted in Figure 1. The client-server decision support system provides information about pests and diseases of winter oilseed rape and the methods of combating them. The decision support algorithms make it possible to identify the pests and diseases on the basis of morphology or characteristic damage to plants, and select the best methods of eliminating these threats.

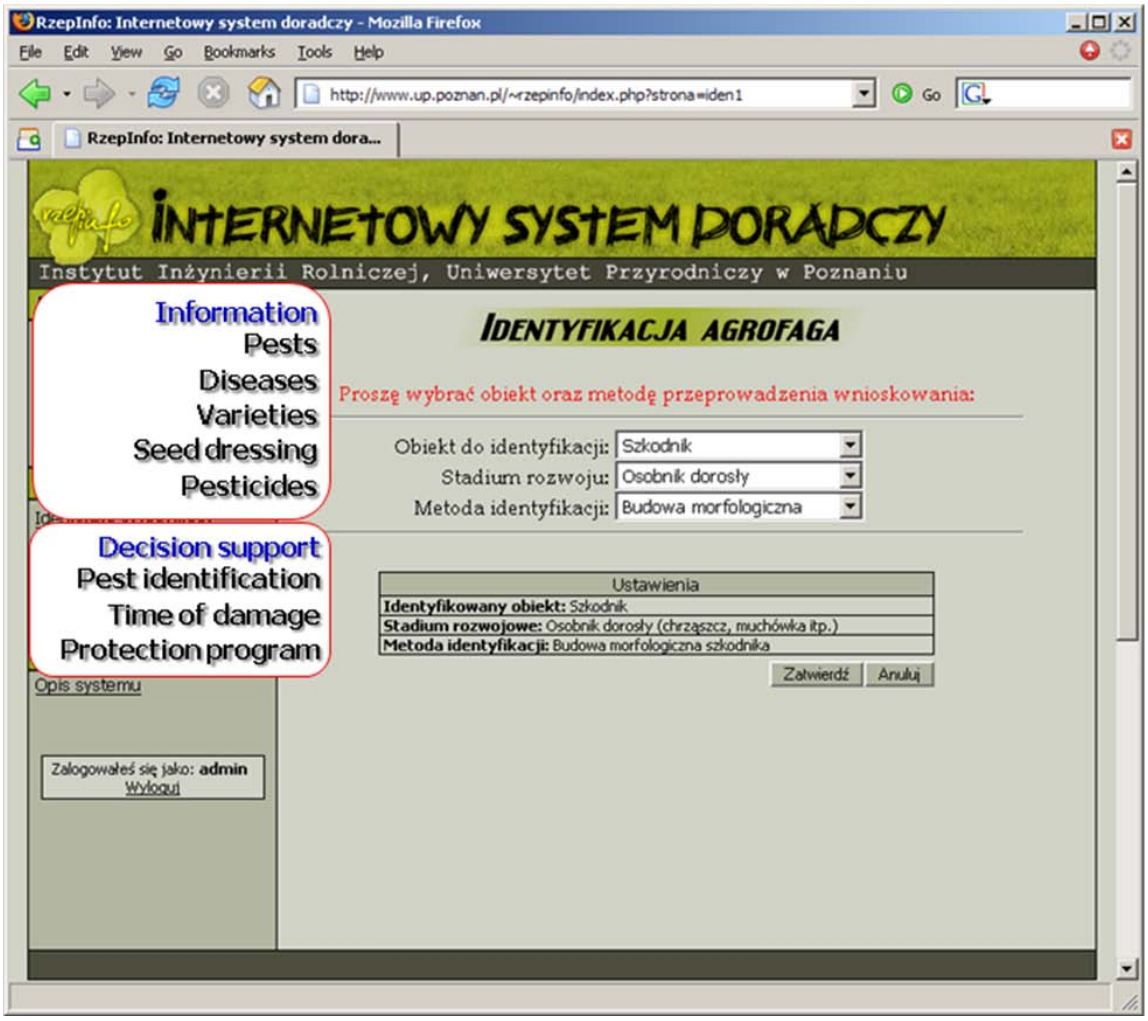

Figure 1. Web-based decision support system for protecting winter oilseed rape plantations

A Web-based decision support system for designing and managing cereal grain drying and storage The system was composed of three subsystems: 1) Databases for cereal grain drying, 2) Simulation and performance analysis (calculation of drying air

properties, simulation of the moisture content changes in thin/thick layers of grain, performance computation for drying systems), 3) Decision support for selecting appropriate equipment and conditions for drying cereal grains (Figures 2-4). More details on developing the system will be given in the poster presentation.

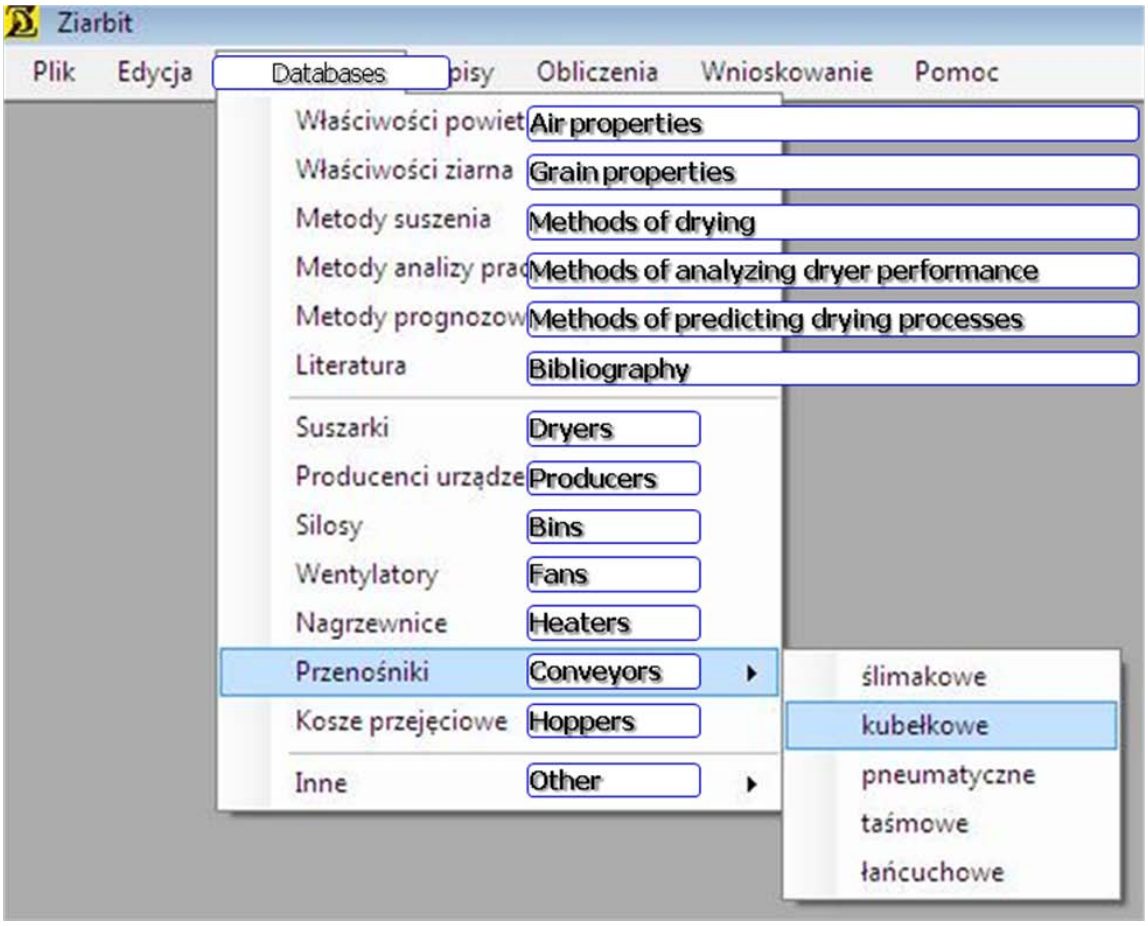

Figure 2. Web-based decision support system for designing and managing cereal grain drying and storage – databases

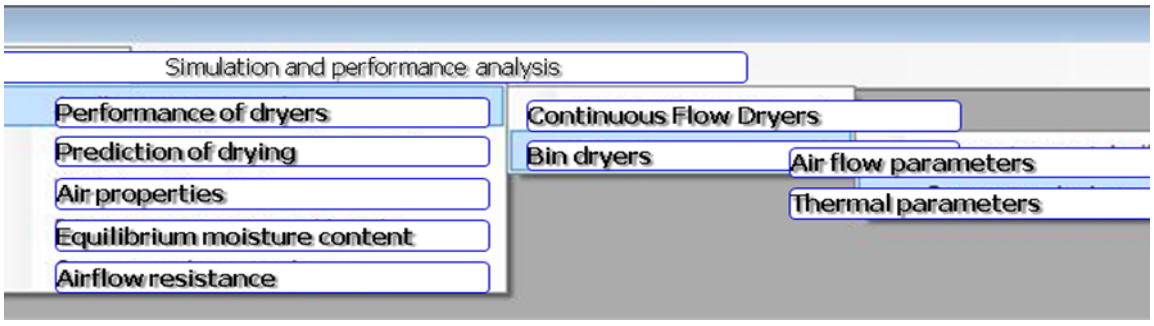

Figure 3. Web-based decision support system for designing and managing cereal grain drying and storage – simulation and performance analysis

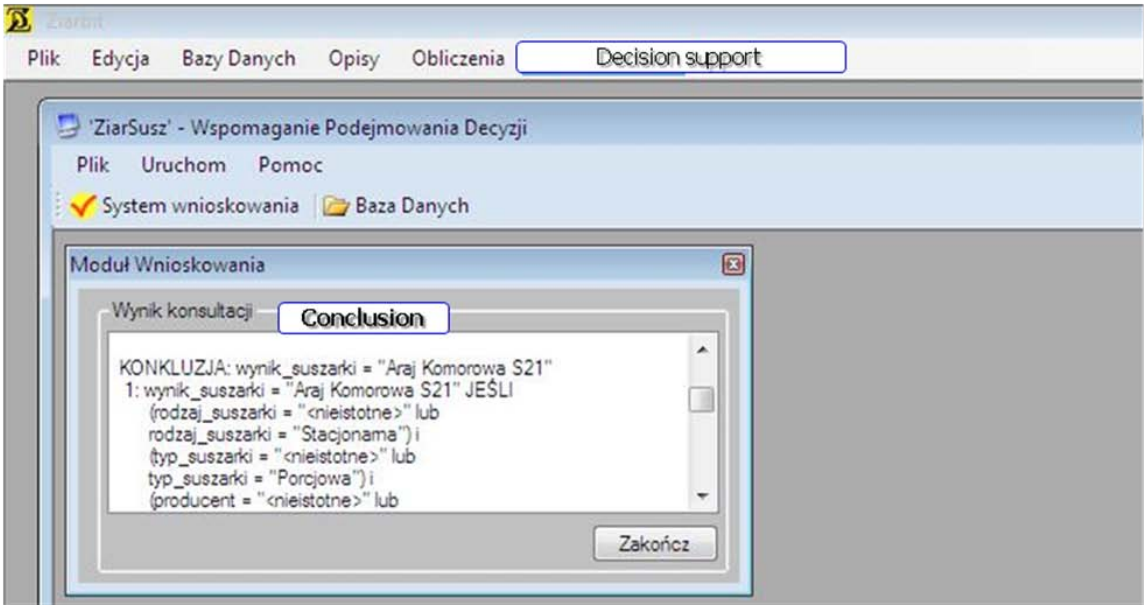

Figure 4. Web-based decision support system for designing and managing cereal grain drying and storage – decision support

A Web-based decision support system for managing Faculty of Agriculture and Bioengineering The system was composed of subsystems for managing research, teaching, knowledge verification, and finances, and was implemented and deployed in the Institute of Agricultural Engineering. Figures and details on developing the system will be given in the poster presentation.

A Web-based application for managing and presenting abstracts and screen shots of all information systems developed in the Institute of Agricultural Engineering, Poznan University of Life Sciences Figures and details on developing the system will be given in the poster presentation.

CONCLUSION Advanced technologies useful for developing Web-based decision support systems for agriculture were indicated, implemented and analyzed. In the area of decision support, several approaches were implemented: a decision tree, an expert system shell and an open-source rule engine NxBRE for the .NET software framework. The ASP.NET (3.5 and 4.0) technology available in Microsoft Visual Studio (2008 and 2010) was a very effective framework for developing Web-based applications. Conformance to software engineering standards during the whole software development process was a critical factor for accepting the developed applications in practice.

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