Optimal Planning Software Platform Development with Cloud Computing Technology

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Abstract

The paper describes research and development of software platform for optimal operation planning of pulp-and-paper and forestry enterprises using cloud computing technology. This work is a part of long-term activity carried out by Petrozavodsk State University (PetrSU) in the field of scientific research, software development and customer projects for enterprises of pulp-and-paper and forestry industry of Russia. The Platform uses advanced mathematical models and optimization algorithms developed by IT-park of PetrSU to create services for solving a series of planning tasks for different industries: production of corrugated packaging, sawmill, plywood production, timber enterprise.

Index Terms: Cloud computing, Mathematical methods, Optimization problems.

I. Introduction

At the present time one of the trends in mining and processing industry (including forestry industry, pulp and paper production, etc.) is the creation of geographically distributed, multi-tier groups, consisting of from 3 to 20 large enterprises (the total number of enterprises being more than 300) which carry out a full cycle of production: logging, its complex processing and transporting the end product to consumers. This allows (and sometimes compels) solving the problem of one large order by several group enterprises (including geographically distributed ones). It may result in the reduction of shared planning and management efficiency.

Increase of production efficiency at such enterprises can be achieved through more effective management of the production process [1]. It's possible due to software based on mathematical models, methods and algorithms of solving management and production planning problems [2, 3]. It results in increased concurrency of work of shops and units, reduction of equipment idle time, improved quality and enterprise load at constant labor and production costs [4, 5].

Similarity between production processes enables development and implementation of typical software solutions at the majority of enterprises. However, the deployment of a large quantity of local software for geographically distributed enterprises leads to significant time and resource expenses to provide customers with timely new versions of software, setup, maintain, update, modify and monitor it.

One of the possible solutions for overcoming the above mentioned difficulties is cloud computing concept, that involves providing end users with remote dynamic access to services, computing resources and applications (including operating systems and infrastructure) via the Internet [6, 7]. Practical implementation of the concept in solving problems of optimal production planning requires development of software solution (platform) with a wide range of functionality, including software implementation and maintenance provision as well as solutions to optimization problems arising at pulp and paper and timber industry complex enterprises.

The importance of web interfaces of cloud services is increasing also because of the growing number of users who run the services via mobile devices to get access to plant data use it in making management decisions.

II. OPTIMAL PLANNING SOFTWARE PLATFORM DEVELOPMENT

A. Platform description

Cloud computing technology is an alternative to using a large quantity of local software in geographically distributed enterprises. This concept provides end users with remote dynamic access to services, computing resources and applications including operating systems and infrastructure via the Internet. Practical implementation of cloud computing in solving problems of optimal production planning requires development of program platform. The cloud platform has a wide range of functionality, including software implementation and maintenance provision as well as solutions to optimization problems that arise at pulp and paper and timber industry complex enterprises.

The cloud platform developed in IT-Park of PetrSU consists of the following basic components:

- library of standard software modules implementing basic optimization algorithms;
- optimal planning and management cloud services for complex production processes of industrial enterprises;
- auxiliary services.

The library of standard software modules is powered by previously developed in PetrSU mathematical models and methods for solving optimization problems arising in the planning and management of pulp and paper and timber industry complex production, including the tasks of cutting, collecting and transporting materials [8]. A wide range of optimality criteria is used when solving optimization problems. Basically it is the profit maximization, minimization of the production costs and resource consumption, etc.

Cloud services of optimal planning include the following decisions:

- Corrugated packaging service – for optimal planning and management of corrugated cardboard production involving several enterprises as well, with transportation being taken into consideration.
- Sawmill service – for optimal planning and management of sawmill involving several enterprises as well, with transportation being taken into consideration.
- Loading service – for optimal planning and management of shipping involving several enterprises as well.
- Plywood production service – for optimal planning and management of plywood production involving several enterprises as well, with transportation being taken into consideration.
- Timber enterprise service – for optimal planning and management of wood enterprise, engaged in harvesting, hauling, severing and shipment of wood,

which includes forest resources, production facilities, transport, forest roads and warehouses.

In many cases in spite of the difference between the listed services optimization problems of each service can be formulated and solved as special cases of multiproduct transport problem (MPTP). The list of services is not finalized, other production services can be added to the list hereafter.

B. Platform architecture

Data storage and processing center (CSDP) is the hardware component of the Platform. It includes a set of hardware and software tools for storing, processing and transmitting data via external data channels as well as the infrastructure to provide uninterrupted operation of the equipment. CSDP consists of the following components:

– information infrastructure – includes servers, disk arrays and other equipment, providing information content;
– telecommunication infrastructure – provides interconnection of Platform components, as well as connection with the system end-users;
– engineering infrastructure – includes uninterrupted power supply system for CSDP autonomous work, air conditioning and ventilation systems, security and fire alarm systems.

CSDP consumers may be for-profit and non-profit organizations and individuals.

The platform software architecture is divided into the following main layers (see Fig.1):

– database management system;
– application server;
– web server;
– customer layer.

Database management system (DBMS) is responsible for storing, filling and changing data, as well as for providing information in response to the application server requests. The Platform provides work with several different databases and Microsoft SQL Server or Oracle Database can be used in addition. The main DBMS requirement is reliability and resilience, since the amount of stored data increases during the Platform operation process resulting in hardware load growth. Reliability, production and resilience problems can be solved be means of cluster of database servers with hardware mirroring and data backup functions.

Application server (service layer) is logically located between the database and the web server. Its main part is business logic of different program systems describing relevant subject areas. Application business logic combines data and scripts and is designed in the form of a network of interconnected objects. All algorithms and mathematical models are implemented in the form of software modules with explicitly specified and documented access interface for providing usage of various software systems.

In particular, application server includes a module (versatile solver) for solution of complicated optimization problems related to production planning [8]. Algorithms for effective solution of complicated cutting problems, including linear and nonlinear optimization problems, high-dimension problems, problems with combined criteria, etc. are implemented based on the versatile solver. The algorithms utilize a wide range of linear, dynamic, convex and discrete programming methods and decomposition schemes,

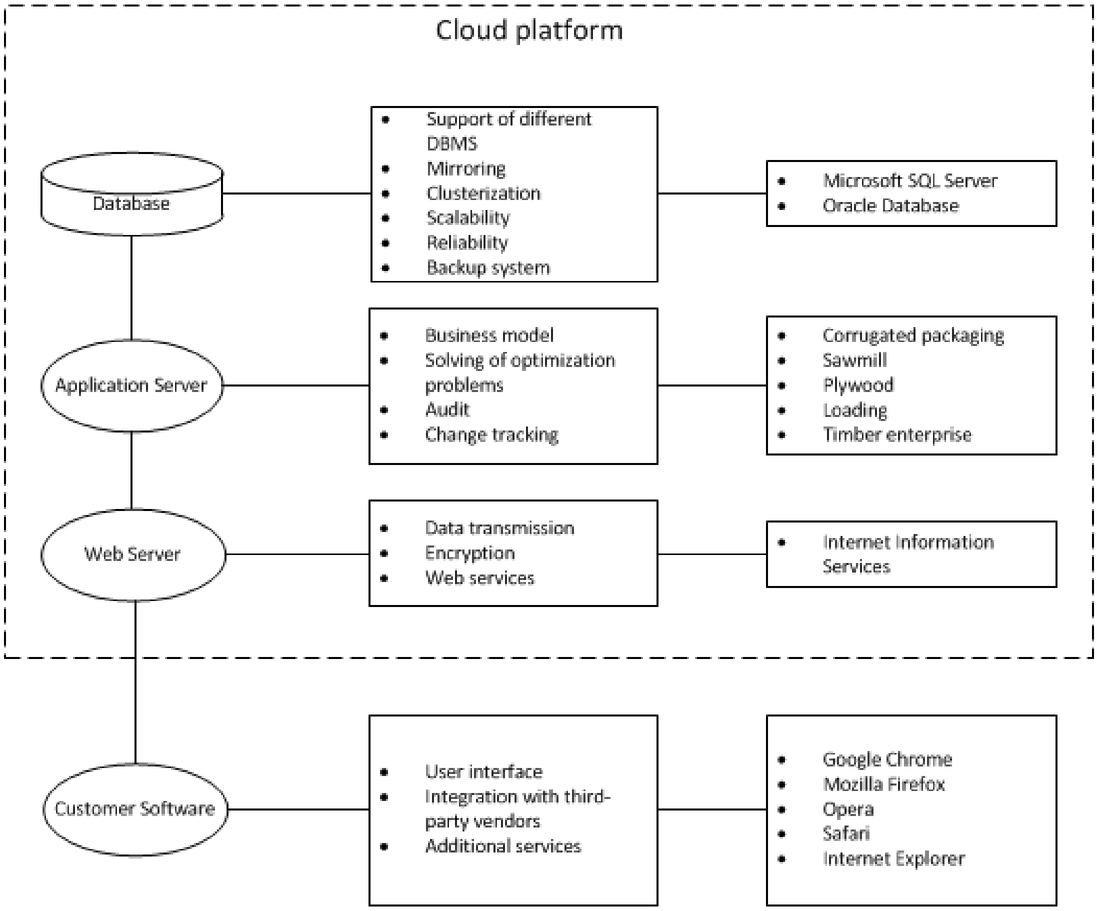

Fig. 1. Platform architecture

which enables to solve a broad array of optimization problems in the area of industrial production planning and scheduling [9].

Service layer can be physically separated from the web server for remote operation via internal or external channels of data transmission including the Internet. It enables relocating a part of computing cost to a remote server thus shortening problem solution time, as well as reducing equipment purchase costs. This structure implements the concept of cloud computing in case Internet servers are used. In addition, the service level provides a number of resources to simplify implementation and audit of software products, to obtain current information on the state of important parts of products, to track changes, etc.

The main purpose of a web server is to send data to customer software, which can be presented in HTML, XML (generated by web services) and other data formats that are used for processing by customer software. Furthermore, the web server encrypts data transmission channel to protect the customer and the Platform from unauthorized access. Internet Information Services application is used as basic implementation of the web server.

Customer software can be roughly described as a combination of 3 components: user interface, integration with third-party software products and additional services.

The main component of user interface is a web browser, which generates visual representation of the product and transmits data via encrypted channel. The most current versions of Google Chrome, Mozilla Firefox, Opera, Safari and Internet Explorer are mainly used in Platform. Integration with third-party software products is due to modules, implementing interaction between the program shell and the web server. Additional services component represents services that use the Platform resources to solve applied complex-structured problems.

III. SOFTWARE IMPLEMENTATON

The following technologies and components are used for the Platform development:

- Microsoft .NET ver. 4.0 – basic operating platform the source code is directed to, main programming language – C#;
- Software implementation of database servers – Microsoft SQL Server 2008 R2, Oracle Database 11g, SQLite;
- Object-relational mapping (ORM) library – NHibernate 3;
- Castle Windsor library is used for providing dependencies between the components of the Platform;
- Graphic interface of the Platform is implemented with ASP.NET MVC 3.0;
- Subsystem for building graphical templates - Razor;
- The graphical subsystem generates views in HTML format (ver. 4/ver.5);
- Application interactivity is provided by JQuery library;
- Complex management elements are created with Telerik MVC Extensions library;
- Report generation library – StimulSoft Reports;
- To integrate application modules in the third-party software Windows Communication Foundation is used.

Software modules of the Platform can be divided into two main classes: the first module contains all general libraries for all cloud services – Platform core, the second one – modules of specific service implementations.

The main task of Platform core is to create agile, adjustable and scalable software environment for implementing cloud software. Service oriented architecture is used for the purpose.

The core contains the following modules:

- a module comprising basic classes for defining business logic of applications;
- a module utilizing ORM library NHibernate in the implemented software;
- general classes and libraries;
- modules providing interaction between modules and classes;
- modules that are required to support Castle Windsor library;
- application for generating database schemes according to application business logic;
- modules for view generation;
- complex visual components based on Telerik library.

Business objects of the Platform are implemented as classes, where each object feature corresponds to some database table column. Object relational view libraries are used for interaction of object oriented application structure with relational database data thus providing independence of business logic from specific database server implementation.

Business methods of the Platform are implemented as services, accepting as parameters and returning business objects that enables easy scaling and changing output software implementations.

View system is designed according to Model View ViewModel (MVVM) concept, according to which the system is divided into three main layers: Model, View and View model [10].

Model represents fundamental data and it is not intended for direct using in View design. The Platform defines Model as a set of entities and services to work with them.

View is a visual interface, pages, windows, buttons, etc. It’s a software agent between user and View model. In response to user actions it makes a request and triggers corresponding View model operations.

On the one hand the View model is View abstraction, on the other hand it is Model data wrapper entitled to binding to graphical interface, also containing operations the View can use.

IV. CONCLUSION

Developed Platform uses advanced mathematical models and optimization algorithms to create services for solving a series of planning tasks for different industries. The usage of cloud platform and cloud services for optimal planning provides the following benefits for enterprises:

- Increased equipment uptime by 3-4%.
- Increased profitability by 3-5%.
- Very fast planning and replanning (under 10 sec.).
- Reduced time for order fulfillment.
- Increased production output by 1-2%.
- Decreased raw materials consumption by 1-3%.

The use of Sawmill service as well as Corrugated packaging service already allows enterprises to save about 300 thousand euro annually. For other services the effect is expected to be at about the same level. Moreover, the use of cloud services for optimal planning and management of production provides additional considerable reduction of financial expenses related to deploying, maintaining and updating both software and hardware for geographically distributed enterprises.

The number of successfully implemented the cloud projects for small, medium and large businesses is steadily growing. Cloud services are offered by many IT companies, including Microsoft (Dynamics AX), 1C, SAP, Oracle thus acknowledging the appropriateness and relevance of research and development in this area.

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