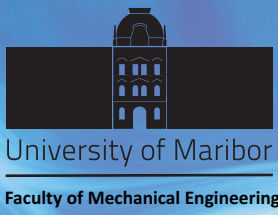

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DEVELOPMENT OF INTELLIGENT AND INNOVATIVE TOOLS FOR PRODUCTION PROCESS ENGINEERING AND SUSTAINABLE MANAGEMENT

MARIBOR - SLOVENIA

2013

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The Institute of Production Engineering and Management from the Faculty of Mechanical Engineering in Skopje, at the Ss. Cyril and Methodius University in Skopje, Republic of Macedonia, and The Institute of Production Engineering and Management from the Faculty of Mechanical Engineering in Maribor, at the University in Maribor, Republic of Slovenia.

This scientific monograph offers comprehensive chapter series from scientific researches conducted by regional authors, authorities in the fields, and summarizes the principal scientific contributions. The chapters deal with range from technology management topics and production process issues to manufacturing technology aspects with intelligent and innovation fields. Edited by two authors with contributions from chapters' authors, this monograph presents advanced topics for students, educators and practitioners.

The compilation of scientific contributions comes out how the growing complexity of industry places increasingly greater emphasis on artificial systems and intelligent cells which can deal with technological needs of production processes. The challenge is to extend engineering methods to handle open-ended and frequently changing real industrial operating conditions. The primary aim is to develop innovatory capabilities to respond intelligently to gaps in engineering knowledge.

To meet this challenge, a mix of scientific theory and technology is investigated, based on natural and artificial cognition in conjunction with novel systems design, production and industrial engineering principles. Implementations of new advanced processes and technology management tools are robust enough to cope with true industrial operative circumstances and to behave in a user-friendly and useful way in relation to engineers and managers in working situations.

The editors of the contents of this scientific monograph would like to express acknowledgement to the Ministry for Science of the Republic of Slovenia and the Ministry for Education and Science of the Republic of Macedonia for their support during the realization of the scientific and research bilateral project, out of which this scientific monograph raised.

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VALUATION OF THE PRODUCTION PROCESSES PERFORMANCES

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CLOUD COMPUTING AS BUSINEES PERSPECTIVES FOR PRODUCT LIFECYCLE MANAGEMENT SYSTEMS

Emilija RISTOVA, Valentina GECEVSKA, Mikolaj KUZINOVSKI, Dejan MIRAKOVSKI

14.1 INTRODUCTION

In a dynamic economic environment, the company's survival may depend on the ability to focus on core business and quick adaptation. Yesterday's profitable business model can't be counted on to translate into future growth and profits. As the business adapts to changing government and industry regulations, evaluates new business partnerships and anticipates competitive threats, IT needs to help the business find new ways to respond of such of fast changes. At the same time, plans for change must often be made in the context of limited resources for finances, people, technology, and power [1].

The evolution of Cloud computing over the past few years is potentially one of the major advances in the history of computing. Cloud computing represents a convergence of two major trends in information technology. The first one is the IT efficiency, whereby the power of modern computers is utilized more efficiently through highly scalable hardware and software resources and secondly the business agility, whereby IT can be used as a competitive tool through rapid deployment, parallel batch processing, use of compute-intensive business analytics and mobile interactive applications that respond in real time to user requirements [2, 3].

The National Institute of Standards and Technology (NIST) in October of 2009 released a formal definition of cloud computing that has become very soon an accepted standard by many in the field including European Network and Information Security Agency. The current version (v26) follows: "Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers,

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storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and it is composed of five essential characteristics, three service models, and four deployment models [4]."

There is no doubt about the paramount potential of Cloud computing, but it is yet to cross its stage of infancy, with only a limited number of takers currently, owing to some of the challenges of its widespread adoption such as security, trust, and vendor lock-in [5, 6]. It is estimated that 71 % of companies believe that cloud computing is a real technology option, 70 % hold that it would make their business more flexible, 62 % think that it would help them react quickly to market conditions and 65 % that it would help increase focus on core business [7]. Below are given some indicators about readiness for adoption of the Cloud by SME's based on research conducted by Opinion Matters, an independent pan-European market research company. The Easynet Connect commissioned research in UK to determine how seriously SME's were taking the Cloud at 2010 compared to the end of 2008. A trend of steady interest in cloud computing in the end of 2008 (but still 53 % said they would never adopt the cloud), was significantly changed by the end of 2010 when half of SME's in the UK confirmed that they will be using cloud computing in some form or another [8].

14.2 CLOUDS COMPUTING MODEL

The evolution of Cloud Computing over the past few years is potentially one of the major advances in the history of computing. Cloud Computing might be one of the alternatives for strategic investments in information technology and infrastructure due to the PLM software adoption having in mind the following: companies have to increase innovation and flexibility in meeting the requirements of the market/customers (so they should focus on innovation, not solving problems associated with the infrastructure implementation and its maintenance), „start-up" companies as well as small and medium enterprises cannot afford large investments in information technology and infrastructure, greater flexibility and speed up launching new products on the market offering the opportunity to access and use of already defined data, etc. [15, 16, 17].

Cloud Computing is transfer of information infrastructure in the network, in order to optimize the load in terms of storage space and connection to the different number of users and reduce costs for managing these resources (hardware, software, networking). Resources are virtually interrelated and have a dynamic provisioning (under so called Service Level Agreement contracts (SLA) concluded between users and providers) to ensure uniformity [18, 19].

Three basic categories of Cloud Computing services are identified [17]: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). Software as a service (SaaS) means software deployed as a hosted service and accessed over the Internet. Platform as a service (PaaS)

means platforms that can be used to deploy applications provided by customers or partners of the PaaS provider. Infrastructure as a service (IaaS) means computing infrastructure, such as servers, storage, and network, delivered as a cloud service, typically through virtualization.

Some advantages of Cloud Computing concept are: basically cost savings; scalability; „pay-per-use“ model; independence from devices and location; efficiency; providing space for storage and control; probability and transparency of the processes; optimal utilization of resources, etc. [18, 20].

Below are given some of its disadvantages: currently undefined standards between Cloud Computing providers, not techno-economic analysis of costs that will arise in case the company discontinued the use of web based services; the security of data is still not guaranteed by providers with certain regulations/standards, users become dependent of providers, or lose control over the management of information resources and services, etc. [18, 20].

According to the latest Forrester research, increasing customer demand for software-as-a-service (SaaS) applications has already convinced 50 % of software vendors to deploy some of their business applications via SaaS. The approach is turning out to be major technology challenge, as it re-opens the fundamental platform discussion. A new set of functionality in the form of platform-as-a-service (PaaS) offerings is leading to a new software product and services category. Worldwide cloud services revenue is on pace to surpass $56.3 billion in 2009, a 21,3 % increase from 2008 revenue of $46,4 billion, according to Gartner, Inc. [15, 16].

14.2.1 Potential benefits of CC

Clearly, business management is under a lot of pressure to reduce costs while providing a sophisticated level of service to internal and external customers. Customers might want to add a new business application, but lack the money. They might need to increase the amount of storage for various departments. Cloud service providers offer this type of capability at a prorated basis. A cloud service vendor might rent storage on a per-gigabyte basis.

Specifically, Cloud computing offers the following key advantages:

- ***Reduced costs, both capital and operating, through economies of scale***. It dramatically lowers the initial cost for the smaller firms trying to benefit from compute-intensive business analytics that were hitherto available only to the largest corporations. These computational exercises typically involve large amounts of computing power for relatively short amounts of time, and cloud computing makes such dynamic provisioning of resources possible. Companies are often challenged to increase the functionality of IT while minimizing capital expenditures. CC can provide an almost immediate access to hardware resources, with no upfront capital investments for users, leading to a faster time to market in many businesses. Treating IT as an operational expense (in industry-speak, employing an ‘Op-

ex' as opposed to a 'Cap-ex' model) also helps in dramatically reducing the upfront costs in corporate computing.

- ***Scalability*.** Cloud computing makes it easier for enterprises to scale their services which are increasingly reliant on accurate information, according to the client demand. Since the computing resources are managed through software, they can be deployed very fast as new requirements arise. In fact, the goal of CC is to scale resources up or down dynamically through software API's depending on client load with minimal service provider interaction.
- ***Device and location independence*.** The Cloud becomes an adaptive infrastructure that can be shared by different end users, each of whom might use it in very different ways. The users are completely separated from each other and the flexibility of the infrastructure allows for computing loads to be balanced on the fly as more users join the system (the process of setting up the infrastructure has become so standardized that adding computing capacity has become almost as simple as adding building blocks to an existing grid). Cloud computing also makes possible new classes of applications and delivers services that were not possible before. The mobile interactive applications that are location-environment- and context-aware and that respond in real time to information provided by human users, nonhuman sensors (e.g. humidity and stress sensors within a shipping container) or even from independent information services (e.g. worldwide weather data).
- ***Cloud computing uses a pay-per-use billing model*.** Cloud billing model is very different when compared to traditional IT billing techniques. Typical billing models include per user billing, per GB billing or per-use billing (i.e. an organization is billed on each usage of the computing service).

14.3 PLM FOR THE SME'S

PLM is the strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life – is now clearly recognized by many companies as fundamental to the product innovation process, and a businesses' top and bottom line performance. The most recent market research figures that the worldwide PLM market achieved overall growth of 4 % during an economically tough 2003, and the investments in both new and expanded PLM solutions continue to grow at a solid pace over the next five years and exceed to $20 billion by 2008 [12].

Historically, Product Data Management (PDM) and more recently PLM solutions were only practical for large enterprises, which had the extensive resources required to deploy and maintain them. The latest PLM solutions are

designed not only for large companies, but also for SME's in multiple industrial sectors. Some PLM solutions now deliver pre-packaged functionality that is easy to acquire, implement and support at a reasonable price point for mid-size enterprises. Unfortunately, because these systems are typically built on their legacy foundations, their heredity does not allow them to adapt easily to the evolving needs of the smaller enterprises. Moreover, these systems still require lengthy (and costly) implementation phases [10, 13].

Implementation time and costs are critical factors for the SME's to consider when selecting a PLM system. SME's cannot afford to reassign their valuable resources to long PLM implementation projects. Most software designed for the large enterprises have considerably lengthy implementation processes of more than six months. Alternatively, striped down software designed for the SME's has a quicker implementation process and can have the company up and running within days or weeks, depending upon the vendor and level of integration with other systems [13]. At the same time, smaller enterprises are also accepting the need to improve their management of intellectual assets, and are more clearly of their need to become better integrated with customers and suppliers address cost, quality, and delivery [12, 14].

Life is going to be different in the next ten years in everything that related to business models. PLM will not be able to continue existing business model with mostly direct sales, heavy reliance on the service offering by partners and marathon of new product releases with new features, or expect always that SME's will accept "PLM Light" products. So, new approaches should be searching for.

Majority of PLM systems was created based on previously available EDM/PDM and CAD products. Some of the products related to ERP offering inherited lots of ERP technologies. However, nature of PLM products drives Product Lifecycle Management into areas where Internet technologies demonstrated clear differentiation – scale of data management, integration, collaboration, information sharing. PLM needs to stand in front of complicated decisions about how to adopt various internet technologies to keep technological leadership.

14.4 PLM AND CLOUD COMPUTING

SME's often have a competitive advantage over their larger competitors when it comes to customer support and responsiveness. SME's can react quicker to the evolving needs of their customers and target market, with intimate support and new or enhanced products. This should also be an important consideration for the SME when choosing a PLM system. SME's should consider such purchases to be a "partnership" with the vendor. For the SME's, their PLM system needs to be easy to use, have a low total cost of ownership (TCO), and be from a vendor who is dedicated to the success of that SME [12]. Not constantly small-to-medium enterprises need stripped-down versions that work for large corporations. What when the SME's wants a robust solution

quickly, something that is not normally associated with PLM? When it's about smaller business, with big aspirations, which has need of implementation PLM to streamline the product development process between engineering, manufacturing, sales and quality assurance departments [12, 14].

Hence, Cloud computing might be one of the alternatives for strategic investments in information technology and infrastructure and there is a high importance of the comparative study of conventional PLM models and Cloud PLM.

Cloud computing is a paradigm appropriate in all economic situations. When the economy picks up, the flexibility it provides can help in coping with growth, complexity and globalization; in a recession, costs are lowered, liquidity created and flexibility rose [21]. Cloud computing is a topic of discussion even in the traditionally conservative Product Lifecycle Management (PLM) segment. CIOs and business managers also see possibilities here for reducing costs significantly and greatly speeding up the usually slow processes connected with the introduction and maintenance of PLM solutions. Companies are less and less willing to tie up developer resources in PLM projects for months on end – their employees are simply too valuable. Developers should, after all, be concentrating on product development and IT employees on creating an efficient work environment in order to get the most out of business processes [21, 22].

14.4.1 PLM as Software-as-a-Service (SaaS) vice versa PLM conventional model

When considering PLM SaaS, then we are talking about software application in the Clouds that is delivered as a service, renting out and paying monthly subscription, as easy as login and logout, as it shown on Figure 1 (PLM Users in interactions with the Cloud services).

PLM data are heavy and complex. Those can run remotely on Cloud servers and to be delivered over the Internet. The usage is in the same way that would be if they were installed on the conventional system. Thus, PLM SaaS allows focus on the product innovation, not implementation and infrastructure issues characteristics for conventional PLM models.

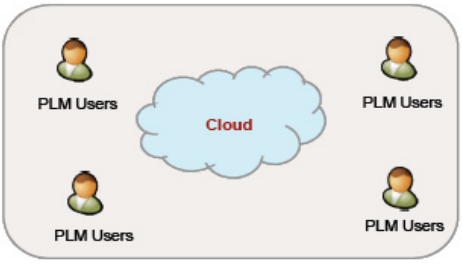

Figure 1. Software as a Service

The comparison between Conventional PLM model and SaaS PLM shows that the “old - fashioned model” in-house PLM software requires company to spend on servers, networks and software licenses and to run the PLM applications, but at the SaaS PLM model there is no software or hardware to buy, install, maintain, or upgrade. Hence, the benefits of using SaaS PLM are the following: no software licenses to be purchased, no middleware, database or hardware to buy, fast and easy automatic upgrades, no customization and re-customization, instant access (anytime and anywhere), pay-by-the-meter, etc.

The current situation regarding usage of Clouds into the market is that, vendors like Arena Solutions, PTC PLM On Demand, PLM+, Autodesk Labs Project Twitch already made some attempts in that way, offering on-demand advantages.

14.4.2 PLM as Platform-as-a-Service (PaaS) vice versa PLM conventional model

When considering PLM PaaS, then we are talking about the platform resides in the Clouds. As it shown on Figure 2, renting programming tools, subscribing and building apps and uploading in the Clouds, as well as a database, security, workflow, user interface and other are tools that step through the process of building powerful business applications.

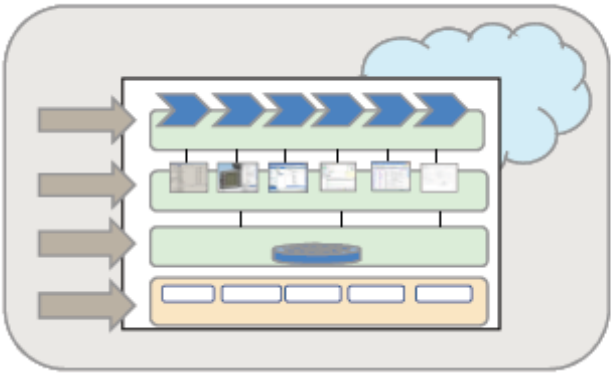

Figure 2. Platform as a Service

PLM data are rich and deep in term of size, proprietary file formats and etc. The cost of rendering is high in the sense every time we work with the data we need to download the whole file. Rest based API’s can provide access to partial contents so we can downloaded and work on relevant pieces. PLM PaaS allows working between PLM tools. With software oriented architecture (SOA), companies can wave together various PLM tools like CAD, CAM, CAE and PDM and make them more interoperable. And again, the most important, PLM PaaS allows focus on the product innovation, not implementation and infrastructure issues.

The comparison between Conventional PLM model and PaaS PLM shows that the "old - fashioned model" requires too many moving parts to be bought, installed, configured and maintained, then the PaaS PLM model allows application development and all application to be run entirely on the web. Hence, the benefits of using PaaS PLM model are the following: custom application development possible without the pain and expense of buying, configuring and managing development stack, developing, parcelling and instantly deploying of applications without any infrastructure, no need of hardware procurement, etc.

What's the current situation on the market regarding PaaS advantages usage – still no PLM vendors players, none so far; just few of them, which are non PLM vendors already offer on demand platform advantages, like Force.com IDE, Google App Engine SDK, Windows Azure SDK, etc.

14.4.3 PLM in an Infrastructure-as-a-Service (IaaS) vice versa PLM conventional model

When consider PLM IaaS, and then we are talking about renting computing hardware resources, as it shown on Figure 3. With subscription, it's allowed configuring the computer resources.

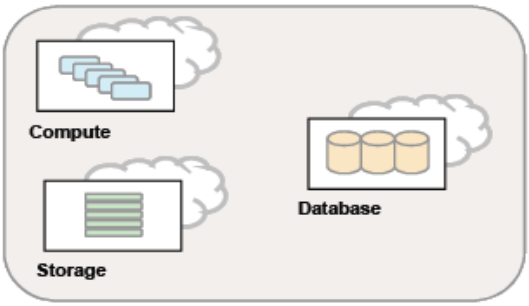

Figure 3. Infrastructure as a Service

Elastic nature of cloud platforms makes it possible to scale up when needed. This can be greatly used by simulation, visualization and computation products. Refresh and rendering time of 3D images are very time and space consuming. Advanced technologies on the Cloud, such as non-relational databases and MapReduce parallel processing capabilities can ease out such of complex rendering of product data.

The comparison between Conventional PLM model and IaaS PLM model shows that the new approach allows configuring and controlling the leased hardware in provider's data centre then the "old - fashioned model" where is necessary company to buy own hardware and manage its own data centre. Hence, the benefits of using IaaS PLM model are the following: no hardware to be bought, scalability (massive compute capacity on the fly), reliability (always

on and self-healing infrastructure), pays and go, meaning no more, no less, acquire resources on demand, release resources when no longer needed, etc.

What's the current situation on the market regarding IaaS advantages usage – very similar to PaaS, none PLM vendors' players so far? Amazon AWS and Force.com on AWS are the only one non PLM Players that offer IaaS on demand advantages.

14.4.4 Cost's comparison about conventional PLM model and Cloud PLM

As it shown in the Table 1, there are significant advantages in using Cloud PLM model despite the conventional PLM model. Perpetual App Licences and large upfront investments characteristically for conventional model are reduced and thus replaced with subscription level at the Cloud PLM model. Costs savings are on the side of the Cloud PLM model also for the maintenance and support/upgrade costs.

Costs	Conventional PLM model	Cloud PLM model
Software cost	• Perpetual App License, • Large upfront investment	• Subscription service • Low upfront investment
Maintenance cost	• Annual fee for the license	• None, included in the subscription
Support/Upgrades costs	• Unpredictable, hidden costs	• None
IT Infrastructure/HW	• Large upfront investment	• Pay-per-use
Facility expense and maintenance	• Comes with the infrastructure cost	• None

Table 1: Cost's comparison about conventional PLM model and Cloud PLM

14.5 CONCLUSION

When it comes to Product Lifecycle Management, in today's complex business environment companies are beginning to focus more and more on the individual productivity, application productivity and IT productivity. These three factors must be balanced and optimized – at moderate cost. This is particularly challenging for small- and medium-sized companies who don't want to tie up their investment resources in major IT systems.

As product designs become more and more complex, businesses require a high-performance Product Lifecycle Management solution. Implementation, integration, rollout and operation of a PLM platform is a significant source of cost and risk, setting a tough challenge to the cost oriented business. While large enterprises have the resources to invest in leading-edge solutions, smaller companies may miss out on the opportunity to unleash the potential of PLM by settling for second-best. In general, companies are facing the challenges given in Table 1 when they operate a PLM system.

SME's which fit one of the following profiles are strongly advised to consider Cloud computing in their business planning:

1. Starting a new company or division
2. Large IT investments in upgrades or new resources
3. Decision to outsource a greater number of tasks or
4. Move towards a decentralized workforce.

Cloud is not so beneficial for SME's which have already made substantial investments in IT in the last 3 years. Cloud is causing an outflow of human capital from the back-offices of SME's to outsourced businesses.

Here are of course some disadvantages too. The cloud computing services needed to deliver the majority of IT services needed by customers do not yet exist. There are still problems and constraints with application offerings, service-level agreements, more importantly security issues. All of the cloud providers do not have the same capability for their technological levels. The fundamental shift is going towards to the collaborative environment of the future – new devices, real time, and social environment.

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