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PLANNING SOFTWARE AS A SERVICE - A NEW APPROACH FOR HOLISTIC AND PARTICIPATIVE PRODUCTION PLANNING PROCESSES

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ABSTRACT

The application of planning software for production systems is on the point of changing fundamentally. Technological innovations as Cloud Computing and resulting developments, for instance the rising adaption of Software as a Service license models, offer manifold benefits for enterprises within their software management and establish new possibilities of using software for project driven work. This Paper proceeds from the relation of current software to specific planning phases and processes and reveals possible application scenarios for Planning Software as a Service with a description of the arising chances and risks. On the basis of a modest morphological analysis of software applications, crucial determinants are identified and afterwards valued based on a scenario building. The result is the guidance for adopting Software as a Service in planning phases and processes to support the user effectuating the upcoming change actively with minimized risks.

KEYWORDS

Factory Planning, Cloud Computing, Software as a Service, Web 2.0 Technologies

1. INTRODUCTION

Cloud Computing vendors promise manifold benefits for customers utilising this new technology, although possible users are still uncertain about the chances and security of these innovative services. Research in the field of internet services lack, especially in the field of digital enterprise technologies for planning and controlling production systems.

This article arose from research work within the interdisciplinary project IREKO (Günther and Moch, 2009], which is founded by the European Social Fond and the Free State of Saxony. In this project, researchers of the field of factory planning and management and organizational researchers work on sustainable implementation of innovation in regional work context. This paper will illuminate the occurring innovation Cloud Computing and the effect on planning production systems.

Initially this paper will clarify the objective of research and research questions. After defining the term Cloud Computing and underlying terminologies, the paper will outline the state of the art of factory planning projects. Following the conducted methods will be depicted and the findings and conclusions will be explained.

2. OBJECTIVE

The purpose of this paper is to discuss the advantages of utilizing factory planning software "in the cloud" and give guidance for adopting Cloud Computing technologies to the work context of factory planning issues. The research questions to be answered are the following:

(1) What chances and risks appear through the availability of Cloud Computing for planning factories and production systems?

(2) In which way can these chances be utilized for planning projects?

(3) How can disadvantages and risks in using Cloud Computing technologies for planning production systems be avoided?

3. STATE OF THE ART

3.1. CLOUD COMPUTING TERMINOLOGIES

Cloud Computing is seen to be the new paradigm to provide software and hardware for business and private customers. In a very simplified way, Cloud Computing can be described as a technology, which enables users to access data and software by using a remote station with a display, without the need of having special computing performance on their site. This idea of providing computing power on demand is first mentioned by Parkhill (1966). Irwin (1967, p. 223) describes Parkhills Concept of Computer Utilization as the following:

"This development enables subscribers to have access to and to share simultaneously a centrally-located computer. The user need not be adjacent to the computers site. On the contrary, the trend is for users to be located at some remote station or terminal and through telephone lines gain admittance to the computer's logic and memory."

Still Cloud Computing is a developing technology and various definitions can be found in literature. For this article, the definition of the National Institute of Standards and Technology (NIST) is adopted (Mell and Grance, 2011, pp. 2):

"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, 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 is composed of five ***essential characteristics,*** *three* ***service models****, and four* ***deployment models****."*

The essential characteristics of cloud computing are:

- On-demand self service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured service

The deployment models can be subdivided into: **Private Cloud**, **Community Cloud**, **Public Cloud** and **Hybrid Cloud**. A Private Cloud is a service that is exclusively provided for one enterprise or organisation. This service can be offered by the organisation itself or by third party. The term Community Cloud refers to providing IT performance via internet for a certain group of enterprises and organisations. This service also can be offered by a third party or by one of the organisations itself. The term Public Cloud is understood as a deployment model, which is characterised by one provider and several enterprises or special groups of users as customers. A Hybrid Cloud can be provided private, communal or public. The crucial criterion is the interconnection of several discrete clouds through adjusted and standardized technologies. This deployment model is commonly applied for load balancing between clouds.

Currently the majority of Cloud Computing services are provided by large-scale companies, like Microsoft, Amazon, IBM or Google as Public Clouds. Though there is a trend of small and medium sized IT vendors offering specific customer driven cloud solutions as Private or Public Clouds. These offers particularly aim customers appreciating regional contiguity and individual support considering regional directives and requirements.

NIST distinguishes three different Cloud Computing service models: **Infrastructure as a Service** (IaaS), **Platform as a Service** (PaaS) und **Software as a Service** (SaaS). IaaS is understood as the deployment of virtual hardware systems via internet. Users can freely install operation system and software. Hence the customer is able to determine the configuration of data storage, applications and network components. The provisioning and allocation of the virtual and physical resources is assumed by the service provider. Hence the customer cannot control the utilised hardware The term PaaS refers to the deployment of hardware and operation system as development platform for applications. Users are able to install, develop and test certain software, without having the relating administration and configuration effort for hardware and middleware. Applications, which are available as SaaS, are complete computer programs supported through browsers or similar thin client systems. The software is not installed on the customer's site, which releases her or him from managing hardware, operation system, drivers and applications. The benefit of all service models is that no asset costs occur; the services are accounted for consumption. (Mell & Grance, 2011)

When discussing Cloud Computing terminologies, Web 2.0 conceptions cannot be ignored. Principally Web 2.0 represents public SaaS applications. Hoegg et al. (2006) state that Web 2.0 is not a specific technology, it is a philosophy of cooperating within open standards and open minded thinking. Web 2.0 is a participatory, user-centric and collaborative way to create and obtain information (Dearstyne, 2007). Web 2.0 enables users to create content by exchanging information and underlies self-regulating evolution processes with embedded or formalized quality assurance mechanisms (Hoegg et al., 2006). Conventional knowledge management systems do not have the performance to create collective intelligence (Grossmann and McCarthy, 2007). Web 2.0 facilitates efficient knowledge creation through intuitive operations for many users (Knights, 2007). Referring to McAffe (2006) and Hinchcliffe (2007) the implementation of Web 2.0 into a company has to be associated with social and organisational innovations to be successful.

3.2. DIGITAL ENTERPRISE TECHNOLOGIES AND CLOUD COMPUTING

Cloud Computing still is a research challenge (Zhang, Q., Cheng, L. and Boutaba, R. (2010). The development of the Cloud Computing industry is seen to be a chance for small and medium sized enterprises (SME) to utilise IT applications not yet implemented because of financial or strategic reasons. For many SME it is not profitable to invest into the acquisition, implementation, administration and maintenance of IT systems. Though they lose possible potential in planning and controlling of processes and furthermore their innovativeness. Through the change of paradigm from IT buying to IT renting, new utilisation strategies are possible. Within very short time, enterprises are able to deploy requested IT, because hard- and software is already pre-installed by the service vendor. Merely the configurations of user-specific settings and access privileges have to be adjusted. Hence, the enterprises gain IT flexibility. Appropriate to the changing requirements, the IT systems are being adapted. If e.g. larger storage capacity is needed, the virtual scaling is possible at the click of a mouse. If new software features are required, they can be booked. No longer needed services can be countermanded not causing costs anymore. A further benefit is the increasing data security. Hence the files are secured by a service vendor, whose core competency is the provision of safe cloud services.

The largest obstacle still to conquer for Cloud Computing technologies is the availability of the internet. The potential of the applications is directly correlated to the obtainable bandwidth. For instance complex 3D applications require high data frequencies between the cloud and the user's computer. 3D-CAD (three-dimensional Computer Aided Design) software within the cloud are possible and already developed by several vendors. The benefits of such applications are the elimination of installation and configuration effort, the decrease of computation performance at the user's site and the creation of new possibilities for cooperation. For a inter-company product development project for example, the utilised CAD systems mostly vary. The work with exchange formats is unavoidable, causes extra effort and additional sources of error. Through the possibility of software application on demand, enterprises are able to use common CAD systems with their cooperation partners. By realising a cloud-based Product Lifecycle Management (PLM) even more benefits emerge for cooperating enterprises. Cloud Computing technologies offer the possibility of creating a common database for enterprises of one supply chain to ensure a cross-company PLM. Enterprise Resource Planning (ERP) systems are already successful SaaS applications. Especially SME realize the advantages and chances Cloud-ERP offers compared to traditional ERP systems. Though changing the ERP system vendor is very complex and expensive. Unpredictable efforts and costs may rise and the risk of data loss is high. Through combining SaaS and PaaS approaches, those disadvantages can be avoided and the benefits of Cloud Computing solutions utilised. In this use case, the hardware and operating system is provided as PaaS and the accustomed ERP system is installed by a second service vendor offering the system as a service. Hence the customer enterprise wins resources, because administration of software and scaling of hardware is done by service partners while being able to use the system as usual. Furthermore through cloud-able ERP systems possibilities rise concerning planning and controlling the occupancy of production and order progresses from remote locations, for example by browser based Production Planning and Control (PPC) applications.

A clear cut in the vertical integration of cloud software systems in enterprises emerges between PPC and Manufacturing Execution Systems (MES). Production near systems like factory data capture or production and logistic control centres, or even complete MES contribute essentially to the maintenance of the entire production and are fully integrated. The majority of the MES hardware systems are on the shop floor and cannot be moved into the cloud. Service and troubleshooting require corresponding competencies of the workers on the shop floor, which should be hard to gain by service providers. Only the enforcement of universal standards for MES will bring the possibility and reasonableness of MES software as a internet service.

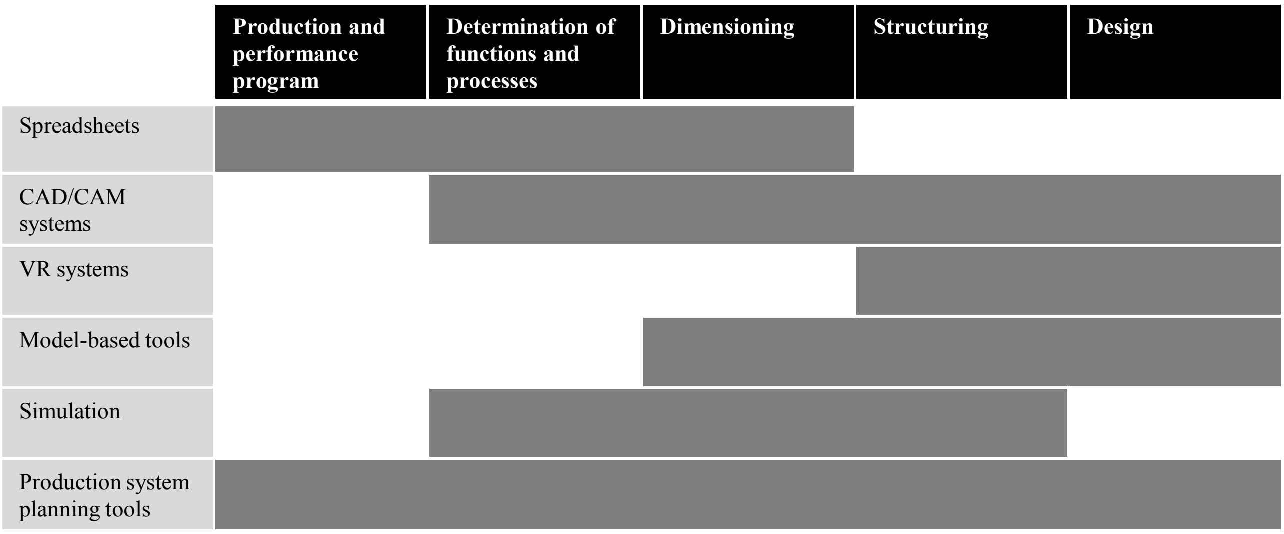

Figure 1 – Production system planning project development and according digital tools

3.3. PRODUCTION SYSTEM PLANNING

In the research field of planning production systems, the Department for Factory Planning and Factory Management of the Chemnitz University of Technology has developed an essential contribution to the structuring and execution of factory planning projects. Schenk et al. (2010) evolved the "0 +5 +X Planning Model". This planning model describes the line of actions necessary to process a factory planning project, consisting of three complexes "0", "5" and "X". The first complex "0" is the *project definition*. The second complex, *project development* has a high intense in software usage. The third and last complex is called *project implementation.* In this research article, the focus lies on the second complex, hence the high intense of software usage. This complex holds five sub-complexes:

- *Determination of the Production and Performance Program*
- *Determination of Functions*
- *Dimensioning*
- *Structuring*
- *Design*

Furthermore, all production system planning projects can be associated with one or more of these four basic cases:

- Basic case A – The *new development* of production facilities
- Basic case B – The *reconfiguration* of existing production facilities
- Basic case C – *Expansion* of existing production facilities
- Basic case D – The *Decommissioning* of existing production facilities, also called revitalization

For all basic cases, the above mentioned planning model can be applied. For the second planning complex the assignment of digital factory planning tools to the sub-complexes referring to Günther (2005) is shown in Figure 1. Spreadsheets and calculation software is commonly utilized to determine the production and performance of a factory and to specify and quantify the functions und processes. Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) systems are also used to determine certain processes and to support quantitative decisions. Virtual Reality (VR) systems are utilized to support planning projects in very detailed phases of structuring and designing plant systems. Model-based tools, such as visTABLE® (Plavis, 2010), conduce dimensioning, structuring and designing tasks. Simulation tools are also deployed to dimension and structure plant systems, and to determine functions and processes. Holistic production system planning tools can be utilized for entire planning projects, though they mostly consist of several of the above mentioned tools.

Through moving these tools from several planning service companies and institutes to the internet and offering them as SaaS applications, manifold benefits are expected. Two anticipated very relevant advantages are improved participation and holistic and continuous planning processes; hence all stakeholders are able to operate with the same systems and databases. Especially participative planning processes are seen to be the key for long-termed success.

4. METHODS

4.1. MORPHOLOGICAL ANALYSIS

After this paper related current software to specific planning phases and processes, it will reveal

Characteristics	Attributes				
Procedure	Initial	Corrective			
Type	Analog	Digital			
Type of model	Formal	Analog	Pictorial		
Depiction	2D	3D	VR		
Operation	Multi-user	Apportioned	Intuitive	Specialist	Planning Support
Compatibility	CAD	Database			
Modelling	Development	Changes	Library		
Scope	Rough Layout	Detailed Layout			
Evaluation	Flow intensities				

Figure 2 – Modest morphology of digital planning tools

possible application scenarios for Planning Software as a Service with a description of the arising chances and risks. Beginning with a modest morphological analysis of software applications for production planning projects, crucial benefits are identified and valued based on Cloud Computing application scenarios.

The modest morphological analysis is a method of the morphologic research (Zwicky, 1989). To reach the morphology of an object, Schlicksupp (1989) suggests 5 steps:

(1) Analyses, definition and generalization of the object.

(2) Definition of all characteristics of the research object

(3) Arrangement of all characteristics in one column of the morphological table

(4) Definition of all Attributes (practical and theoretical) belonging to the characteristics and assignment to the lines of the morphological table

(5) Combination of all possible attributes, to figure out all varieties of the research object

Modest morphology means, that not all characteristics exclude themselves and are independent on each other, which would be the case of an exact morphology. The modest morphology of planning tools is shown in Figure 2 referring to a characterization of Günther (2005). The grey fields of the attributes in this figure highlight the strengths gained by the utilisation of planning tools through Cloud Computing technology. On the other hand, the white cells in this figure represent weaknesses for Cloud Computing technologies. Through applying the procedure of morphological analyses, the main benefits of planning tools “in the cloud” appear to be among others the multi-user application for a collaborative work and fast planning support especially being locally independent from the planning team. The compatibility with CAD-systems and databases can also be assured by cloud computing and enhanced by inter-company data management systems. The morphology further indicates that the procedure of utilising planning software as an internet service should start with the beginning of the project. The application of such software in hindsight may cause more effort than benefit. An additional indication through the morphology is the performance of the planning tool concerning depiction and scope. For 2D-applications and rough layouts the performance of cloud services, which mainly depends on bandwidth, suffices. 3D and VR systems for detailed layouts generate enormous data rates. Hence these services are difficult to “put into the cloud”. Therefore the development and changing of complex models in the cloud is a challenge from present view. The application of a model library or a data management tool has most realization possibilities.

4.2. SCENARIO METHOD

Scenario method, scenario building or scenario technique are methodical research approaches to prognosticate future situations (Mietzner, 2009). All scenario research methods have one in common: they are generated on basis of present developments (Lippold and Welters, 1976). Referring to Slaughter (2000), scenarios are exerted to reveal trends and alternative developments. To Porter (1999) scenarios are especially useful for young industries with high uncertainties, to expose different possible situations of the future. These images of the future are the basis for planning processes, testing ideas and inspiring new developments (Ratcliffe, 1999).

For the case of factory planning and the emerging new technology of Cloud Computing, two scenarios were developed to describe possible future trends, concerning service and deployment models.

The first scenario is shown in Figure 3. In this case scenario a Cloud Computing software vendor

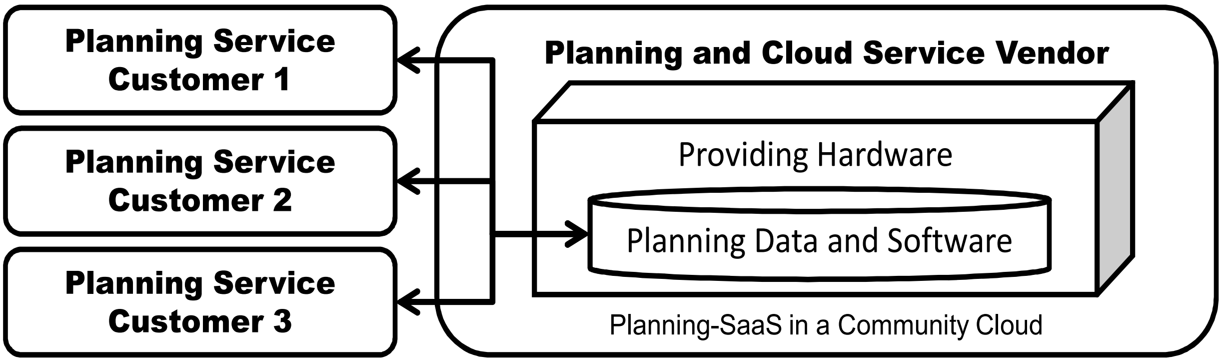

Figure 3 – Future case scenario 1

offers planning software as a service to customers. The benefit for customers is that they do not have to buy planning software and purchase licenses. They are able to rent the software only for the life span of a project. A further advantage is the facilitation of collaborative work on data in a community cloud, whilst being independent on the local site.

Within the second scenario, shown in Figure 4, the SaaS vendor is also an IaaS customer. That offers the possibility of rapidly adjusting computing performance to the customer needs, without having the adjustment of hardware on the planning service vendor's site. For the planning service customers apparently no difference to scenario 1 occurs, but their risks change.

The main risk for customers in both scenarios is their dependence on the cloud service vendors. Especially data security and the persistence of the service are important risk factors. In scenario 1 the risk of data piracy is lowered, because only one vendor processes the data in a community cloud, where exclusively enterprises operating in one project access them. In scenario 2, the risk of dependence on one vendor is lowered by splitting up the two core services: application and infrastructure. If one of the vendors vanishes, the remaining vendor deputizes on an interim basis. Another benefit for the vendors is the opportunity to concentrate on their core business, such as cloud software or cloud infrastructure.

5. FINDINGS

Summarizing the results of the morphological analyses and the scenario method, the chances and risks of digital factory planning tools utilized by Cloud Computing technology are unveiled and the research questions can be answered. The chances of planning systems as an internet service are:

- more opportunities for collaborative planning projects
- less exchange formats for files
- consistent data stock
- involvement of all stakeholders in the complexes of the planning processes
- holistic planning through all planning levels

Risks of the investigated tools are:

- rising dependence on service vendor's persistence
- data security risks
- lower performance through bandwidth dependence

To utilize the chances, two possible future scenarios were developed, based on present trends and knowledge. Those scenarios show that in future planning software vendors offer their digital tools for a certain span of time to their customers with different business models. To avoid the risk of vendor dependence, a splitting of core functions can be launched. To avoid the risk of data piracy, the vendor should offer only community services to a

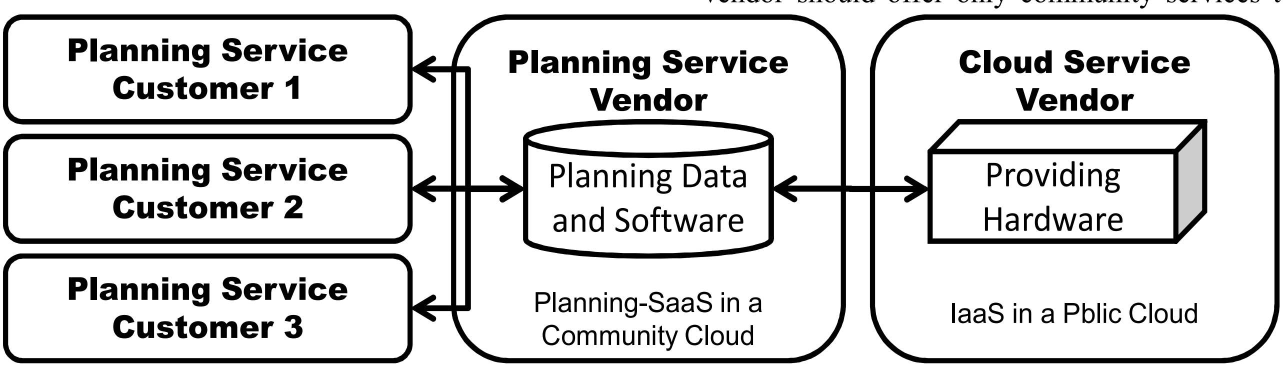

Figure 4 – Future case scenario 2

certain group of customers.

As guidance for the project management of a factory planning project the following considerations can be stated in addition to Schenk et al.'s (2010) planning model:

I) Project definition: The planner needs to define the types of data, files and models to be used in the project and consider how and where they can be stored in due consideration of collaborative chances and security risks.

II) Project development: The required software functions according to the sub-complexes have to be stated and corresponding Cloud Computing services have to be chosen or developed considering emerging risks and chances.

III) Project implementation: The project planner needs to assure, that corresponding data of the planning outcomes are available for the stakeholder realizing their share of the project. In this complex the benefits of Cloud Computing services like having one data base, no redundancies and a flexible data access management show enormous facilitation.

6. CONCLUSION

The debate in this articles shows, that Cloud Computing facilitates participative and holistic planning processes. Still these new approaches have to be successfully applied to become innovations (O'Sullivan and Dooley, 2008). Global cooperating enterprises continue to challenge the proper development of digital enterprise technologies (Wiendahl, 2009). Also regional production networks seek for the adequate support by IT systems (Moch and Müller, 2010). Cloud Computing can contribute to solving these problems in a manner of Teich's (2002) Extended Value Chain Managements (EVCM), which describes the enterprise-overreaching production planning and controlling and proposes the support by an Application Service Provider (APS) that is similar to SaaS.

Therefore more research is required especially investigating the technological and organisational limits of Cloud Computing technologies.

REFERENCES

Dearstyne BW, "Blogs, mashups & wikis, oh my!", *Information Management Journal*, Vol. 41, No. 4, 2007, pp. 24-33

Grossman M and McCarthy RV, "Web 2.0: Is the enterprise ready for the adventure" *Issues in Information Systems*, Vol. 8, No. 2, 2007

Günther L and Moch R "IREKO – Sustainable Implementation of Innovation in Regional Workcontext", TU Chemnitz, 2009, Retrieved: 30/06/2011, <http://ireko.tu-chemnitz.de/index.html.en>

Günther U, "Methodik zur Struktur- und Layoutplanung wandlungsfähiger Produktionssysteme", IBF TU Chemnitz, Chemnitz, 2005

Hinchcliffe D, "The state of Enterprise 2.0", ZDNet, 2007, Retrieved: 30/06/2011, <http://www.zdnet.com/blog/hinchcliffe/the-state-of-enterprise-20/143>

Hoegg R. et al., "Overview of business models for Web 2.0 communities", Paper Presented at the GeNeMe, Dresden, 2006

Irwin MR, "The Regulatory Status of the Computer Utility", *Land Economics*, Vol. 43, No. 2, 1967, pp. 223-227

Knights M, "Web 2.0", *Communication Engineer*, Vol. 5, No. 1, 2007, pp. 30-35

Murugesan S, "Understanding Web 2.0", *IT Professional*, Vol. 9, No. 4, 2007, pp. 34-41

McAffe AP, "Enterprise 2.0: The Dawn of Emergent Collaboration", *Sloan Management Review*, Vol. 47 No. 3, 2006, pp.20-29

Mell P and Grance T, "NIST Definition of Cloud Computing v15", NIST, 2011, Retrieved: 30/6/2011, <http://csrc.nist.gov/publications/drafts/800-145/Draft-SP-800-145_cloud-definition.pdf>

Mietzner D, "Strategische Vorausschau und Szenarioanalysen – Methodenevaluation und neue Ansätze", Reger, G. and Wagner, D. (eds.), Gabler Research, Wiesbaden, 2009

Moch R and Müller E, "Digital Enterprise Technologies in Regional SME Production Networks", Book of abstracts of the CENTERIS 2010 - Conference on ENTERprise Information Systems, Quintela Varajao JE, Cruz Cunha MM, Putnik GP, Trigo Ribeiro A (eds.), UTAD & IPCA, Portugal, 2010, pp. 19

Plavis, "visTABLE – innovative Planungswerkzeuge", 2010, Retrieved: 30/06/2011, <http://www.vistable.de>

Porter ME, "Wettbewerbsstrategie: Methoden zur Analyse von Branchen und Konkurrenten", Campus Verlag, Frankfurt, 1999

O'Sullivan D and Dooley L, "Applying Innovation", Sage, Thousand Oaks, 2008

Parkhill D, "The challenge of the computer utility", Addison-Wesley, Reading, 1966

Ratcliffe J, "Scenario Building: A Suitable Method For Strategic Property Planning", The Property Research Conference of the RICS St John's Collage, Cambridge, 1999

Schenk M, Wirth S, Müller E, “Factory Planning Manual – Situation-Driven Production Facility Planning”, Springer, Berlin Heidelberg, 2010

Schlicksupp H, “Innovation, Kreativität, Ideenfindung“, Vogel, Würzburg, 1989

Slaughter R, “Futures: Tools and Techniques”, Indooroopilly, Qld., 2000

Teich T, “Extended Value Chain Management – ein Konzept zur Koordination von Wertschöpfungsnetzen“, TU Chemnitz, Chemnitz, 2002

Wiendahl HP, “Global Manufacturing – Challenges and Solutions”, Digital enterprise technology: perspectives and future challenges, Cunha P and Maropoulos P (eds.), Springer, New York, 2009, pp. 15-24

Zhang Q, Cheng L and Boutaba R, “Cloud computing: state-of-the-art and research challenges” *Journal of Internet Services and Applications*, 2010, Vol. 1, No. 1, pp.7-18

Zwicky F, “Morphologische Forschung”, Baeschlin, Glarus, 1989