Dashboard User Interface for Measuring Performance Metrics: Concept from Virtual Factory Approach

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Abstract

Dashboard that acts as a user interface is used for the visualization of different processes in an industry. This visualization interface supports the basic purposes of process monitoring, problem identification and solving, communication and consistency, etc. All such purposes are intrinsically related to the performance metrics of a manufacturing organization. Such performance metrics reflect the overall productivity of an organization. This research highlights the design and development of a collaborative dashboard that can be used as the performance monitoring and management of a virtual factory (VF). This VF works as an organization, where small and medium enterprises (SMEs) grouped together with common goals and to achieve specific business opportunities. The collaborative dashboard is presented in this research as an effective tool in performance management, not only measuring the performance metrics of the collaborative business processes but also for other purposes including communication among the partners' organizations. This research highlights and demonstrates critically the implementation issue of business dashboard that is to be used to monitoring and management of virtual factory business processes. In addition to present the basic functionally of a business dashboard an effort is demonstrated how this dashboard can be used to measure the overall performance metrics of virtual factory processes.

Keywords
Dashboard user interface, performance management, performance metrics, process visualization, virtual factory

1. Introduction
To be profitable and competitive in today's market domain manufacturing organizations, especially SMEs are moving towards networked business. In this changed environment, sustainability issues are clearly in the front row of the global SMEs. Promotion of networked business can be an effective solution for the multiple stakeholders' dynamic value chain networks. An up-to-date collaborative system needs to be developed under a well-integrated socio-technical perspective. Collaboration is important to SMEs with the objective to acquire critical mass, acquire new markets, and leverage skills. The collaboration or partnering enhances business organization, especially for SMEs to stay on track, where true synergy or high trust is crucial among partners.

In business collaboration, there needs cooperation through sharing resources and skills among partners rather than compete. In this changed environment, clear needs and open communication channels are important with respect to specific targets or goals. When looking to grow to business, the choices come down to building partnership among organizations, where like-minded entrepreneurs and advisors talk on how to approach collaboration for maximum benefit. The key to a successful collaboration is to make sure that the goals and expectations of both parties are aligned (Almeida et al. 2013). If company want to grow and enhance its business with partners and collaborators, it is critical to keep the lines of communication open.

Collaboration contributes to the recent trends in the business domain such as:

- Focusing on service-enhanced products,

- Addressing the full life cycle of products, including refurbishing / retrofitting and recycling,
- Having a global perspective, and relying on co-innovation and co-evolution,
- Ensuring after sales service on products effectively,
- Supporting knowledge exchange and value creation,
- Taking on board the serious concerns of energy saving and reduction of ecological footprint.

In collaborative business, it is generic trend that partners communicate with each other through common communication platform, which is developed on ICT-based infrastructure. Different information as required to execute the collaborative network is visualized over the user interactive layer known as 'dashboard'. This dashboard interacts with other processes associated to execute the collaborative network. Dashboard presents the critical information related to execute the VF processes and visualize them to its user (Gröger et al. 2013). This visualization process can be used as the performance measures of the VF processes through monitoring and managing them extensively (Shamsuzzoha et al. 2013). In this research, the overall performances of the VF processes are measured with respect to monitoring and measuring them.

2. Literature Review

Dashboard is the tool used for measuring the performance of manufacturing organization is not new but has been widely adopted by businesses. For instance, a survey done in 2004 by The Data Warehousing Institute reported that about half of the 473 business intelligence professionals were using dashboards and that a further 17% of the respondents were in the process of developing a dashboard solution in their organizations (Eckerson 2006). Another report published in 2011 by Gartner Inc. shown that dashboard has been rapidly replacing reporting and ad-hoc analysis in Western organizations (Sallam 2011). Many literatures have been published so far based on the technical design of the dashboard (e.g. Few 2006; Rasmussen et al. 2009), but few are published about use dashboard as the implementations for performance of an organization (Velcu and Yigitbasioglu 2012; DeBusk et al. 2003; Pauwels et al. 2009; Yigitbasioglu and Velcu 2012).

The implementation of dashboard can facilitates as a valuable insight for companies through exchanging information among different parties. This management of information supports to measure the performances of the employees of an organization with respect to problem solving, work integration and customer service (Doll and Torkzadeh 1998). Wiersma (2009) and Pauwels et al. (2009) identified three purposes of dashboard as (a) decision making and decision rationalizing, (b) communication and consistency and (c) self-monitoring. Dashboard communicates necessary data or information to the decision maker through visualization process. This process focuses on the decision making process through presenting the information in different formats such as graphical, symbolic or tables that provides useful guidelines to the organizational managers (Vessey and Galletta 1991).

There is concern about the quality of information or data as visualized over the dashboard user interface. The quality of data can be referred as the information content displayed on the dashboard's screen (Clark et al. 2006). Often this quality concern as related to data or information may be an issue of managerial preference in an organization (Gorla, et al. 2010). Complete and high quality up-to-date data may fulfill all the user requirements to perform their various tasks and perceptions. Under time pressure, organizational managers or decision makers may prefer to use sources of data or information and its quality in terms of accuracy, reliability and timeliness that provides better accessibility to information (Reilly 1982). By implementing ICT driven dashboard user interface, users would be able to fast accessibility of information with relatively low effort (Nelson et al. 2005; Pauwels et al. 2009).

In the literature, dashboard is seen as collaborative tool rather than individual decision support system that help to communicate the values and objectives of the organization (Velcu and Yigitbasioglu 2012). Due to rapid growth of data as well as reporting needs in organizations, the dashboard can be considered as the new highly relevant promising tool for data mining and continuous auditing in future (Vasarhelyi and Halper 1991). It is pointed out by previous researcher (e.g. Pauwels et al. 2009; Yigitbasioglu and Velcu 2012) that there is a lack of knowledge related to the usefulness and implementation of dashboard in the data monitoring and management in an organization, which is taken as the primary concern for this research stream. This study reports the special use of dashboard in the collaborative business domain, where the partners are joined to form a virtual factory and operate it through the ICT-based architectural framework. It is believed that the presented work will be an added value to the area of monitoring and managing the collaborative business effectively and efficiently.

3. ADVENTURE Project and Its Framework

ADVENTURE (Adaptive Virtual Enterprise Manufacturing Environment) is a Research project sponsored under the Europeans Commission's 7th Framework programme as well as by the projects members (www.fp7-adventure.eu). The goal of this project is the creation of a framework that provides the tools to combine factories in a 'plugable' way to manufacture a particular product. In order to fulfill such objective, the project will utilize and combine Service Technologies, devices from the 'Internet of Things' and Process Control to bring enterprise to the level of 'Factory of the Future'. ADVENTURE aims to promote the European SMEs to be collaborative through sharing costing resources and valuable knowledge and expertise. This collaborative environment supports SMEs to achieving more bargaining power over the larger companies in general. It promotes to develop solutions to enable virtual factories and cross enterprises information exchange – the so-called 'Plug-and-Play factory'. This project will support virtual factories and enterprises to move beyond existing operational boundaries by developing specific tools and solutions for facilitating the information exchange between partner factories.

ADVENTURE Framework contains 13 components that are arranged in three layers as, User Interface Layer, Process Management Layer and Data Management Layer as depicted in Figure 1. The user interface layer provides the required GUI (Graphical User Interface) – called 'Dashboard' – to the virtual factory partners. This layer primarily includes process visualization and configuration that supports by the process designer, message exchange and information management with defined user role. In the data management layer all data is collected and stored which is needed across component and factory borders in a cloud-based data storage system and is responsible for data exchange and data search between virtual factory partners. In the process management layer, various processes related requirements such as process execution, adaptation, forecasting and simulation, monitoring and optimization are done actively.

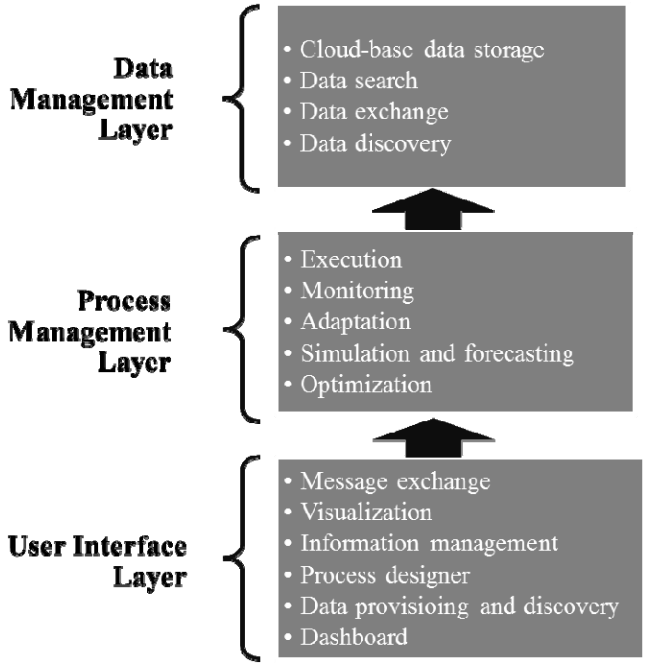

Figure 1: ADVENTURE Framework overview

ADVENTURE aims at simplifying the establishment, management, adaptation, and monitoring of dynamic manufacturing processes in virtual factories. Various technologies from the field of Ubiquitous Computing and 'the Internet of Things', e.g., wireless sensors, will be adopted in order to support the monitoring and governance of processes, i.e., to give information about the current status of manufacturing and delivery.

4. Dashboard User Interface: Business Process Monitoring and Management

The dashboard user interface enables process improvements within VF through visual performance indicators. It acts as a diagnostic tool designed to provide organization managers with a quick overview of a company's performance. Through visualization managers used the dashboard for the purposes of process monitoring and management. This monitoring process enables useful communication and consistency, problem solving and rationalizing among the VF operational activities. The data or information as monitored through the dashboard is considered as an effective activity in performance monitoring and management process for its user. The quality of the data in the dashboard is a critical driver for its use. Furthermore, there is a high correlation between the dashboard uses and user productivity indicating that it serves other purposes such as decision rationalization and communication.

The motivation of using visualization in dashboard focuses on the correlation between decision making process and information presentation format that provide useful guidelines to organizational monitoring. For instance, graphical representation of tasks monitors the spatial tasks that involves process monitoring such as forecasting and simulation, whereas, tabular information is more suitable for symbolic tasks such as accounting and financial analysis of an organization (Vessey and Galletta 1991).

Monitoring through dashboard refers to the day to day evaluation of key performance metrics (KPIs) that should result in a way to advocate various corrective measures. Monitoring and communication can be considered as the major concern and functionality of the dashboard. Dashboard also can be used as the planning tool for executing the virtual factory and maintaining consistency among the collaborative processes within VF. The characteristics of the dashboard are to self-monitoring, communication and consistency that contribute VF partners to decision making and decision rationalizing process. When integrated with collaborative processes, dashboard enables of displaying status of the work in process to different partners. This work in process visibility brings an opportunity to the VF partners to monitor their own performances in real-time and to coordinate the required actions with other partners in the process (Wiersma 2009; Pauwels et al. 2009).

Dashboard as acts a business activity monitoring or business process measurement enables the organization to measure the VF's performance in terms of improved customer satisfaction, return on investment and increase in cash flow. Through data visualization, it drill downs to the data warehouse to see what the possible causes of problems were and then look at the dashboard to see the current operational status of the problem area. From literature survey it is concluded that desired functional features of dashboard includes (i) real-time notifications and alerts, (ii) drill down capabilities, (iii) scenario analysis, (iv) presentation flexibility, and (v) external benchmarking, (Pauwels et al. 2009; Ying et al. 2009, Yigitbasioglu and Velcu 2012).

Real time notifications and alerts are helpful for the VF partners to initiative immediate corrective actions. Some dashboard user interface displays the alerts by following different standard color codes, while notifications are sent through mobile SMS or electronic mail. The drill down approach analyzes each of the data or information based on its importance or urgency level (Bariff and Lusk 1977; Benbasat and Dexter 1979). In case of scenario analysis, the dashboard can be used as a decision support tool, where each of the presented scenarios is dissected to see how changes in certain scenario effects on the others scenarios. The presentation flexibly concerns with the nature of data displaying, whether it is graphical, tabular or textual format (Huber 1983; Velcu-Laitinen and Yigitbasioglu 2012). An external benchmarking feature focuses to the dashboard user about how well the VF is performing in compare to its competitors.

5. Dashboard User Interface: Performance Metrics and Management

A large number of different types of performance measures have been used for business network (Beamon 1999; Jufer et al. 2012). Many researches about performance measurement focus on analyzing performance measurement systems, categorizing the metrics, and build rules of thumb or frameworks (Beamon 1999). The issue is that most of this works have been focus on the single enterprise point of view. When measuring the performance across enterprises, they measurement is different. It is very difficult to select suitable metrics to measure the performance of collaboration in form of Virtual Factory since it includes many parties and activates. In order to measure VF performance, all pertinent aspects of the VF must be measured. It is a fact that competition will be between value-chains, which integrate their competencies and resources to compete in a global economy (Bititci et al. 2005).

Beamon (1999) summaries four important questions to be addressed to create an adequate measurement system, namely: what to measure? How are multiple individual measures integrated into a measurement system? How often to measure? How and when are measures re-evaluated? Normally, the performance is measured from four aspects: Quality, Time, Flexibility and Cost (Beamon 1999). Gunasekaran et al. (2001) propose performance metrics for supply chains' performance. There are three levels and five elements, respectively: strategic, tactical and operational levels, and plan performance, source performance, production performance, deliver performance and customer satisfaction. Besides, in Bititci et al. (2005) research, they develop the extended enterprise performance measurement model with similar elements.

One efficient way to satisfy customer needs and be competitive is to collaborate with qualified partners with the necessary physical resources and capabilities (Cao and Dowlatshahi 2005; Sarkis et al. 2007). From this point of view, it implies that optimize manufacturing process with most suitable partners is the most fundamental and important decision. Therefore, the evaluation of partners' capabilities, description and resource is important criteria for measuring the Virtual Factory performance. Bititci et al. (2005) point out that the Performance measurement systems should be balanced, be integrated, inform strategy, deploy strategy, focus on business processes that deliver value, specific to business units, include competencies and include stakeholder contribution. Based on these requirements and standard, we will develop an integrated Dashboard to display all required functionality to users in order to fulfill Virtual Factory in reality.

6. Use of Dashboard to Measure Business Performance: An Example from a VF Approach

The overall approach for dashboard user interface as the tool for performance monitoring and management of a virtual factory can be illustrated through the following demonstration. Figure 2 displays a sample dashboard, where high level performance measurement indicators of each of the VF processes are shown exclusively. From Figure 2, it is seen that high level status information of all the VF related processes such as overall status, orders status, stock level, processes, notifications, etc., are presented in order to monitor them. After clicked each of the individual processes will display more detailed information of the process. High level status information of the processes is displayed in Figure 2. For instance, orders management process shows the order summary and order forecasting, while stock level process management highlights the graphical display of VF's suppliers current stock levels. Brief information of other associated processes such as production status, environment and OEE (overall equipment efficiency) summary is also highlighted in Figure 2 too.

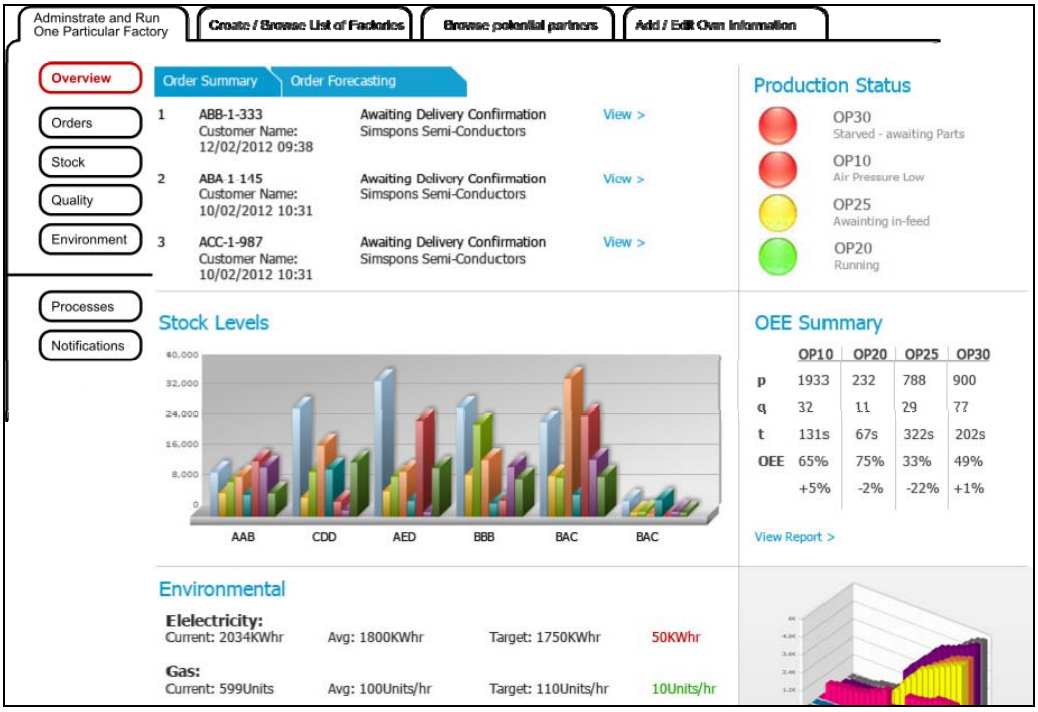

Figure 2: Display of high level status information of VF processes

The status information as displayed in Figure 2 also can be presented through the web-based technology as shown in Figure 3. The associated processes to formation and operation of a VF such as process design, process management, application management and partner management are integrated with this web-based VF monitoring and management system. Within Figure 3, processes related to monitor the VF processes such as order summary, stock level, production status, etc. (as displayed in Figure 2), are interfaced with the web-based system. This system contributes to internet or online-based VF monitoring and management. In this system, VF partners would be able to monitor his/her processes and could initiate necessary actions if any of the processes are not working according to the planned way. Clicking on each of the process button will enable partners to visualize the real-time status information of the processes in questions. For instance, clicking on any specific customer identification (ID) under the 'order summary' button in Figure 3 will opens up a new window to more detailed information about the customer name, order number, order due date, order change, etc.

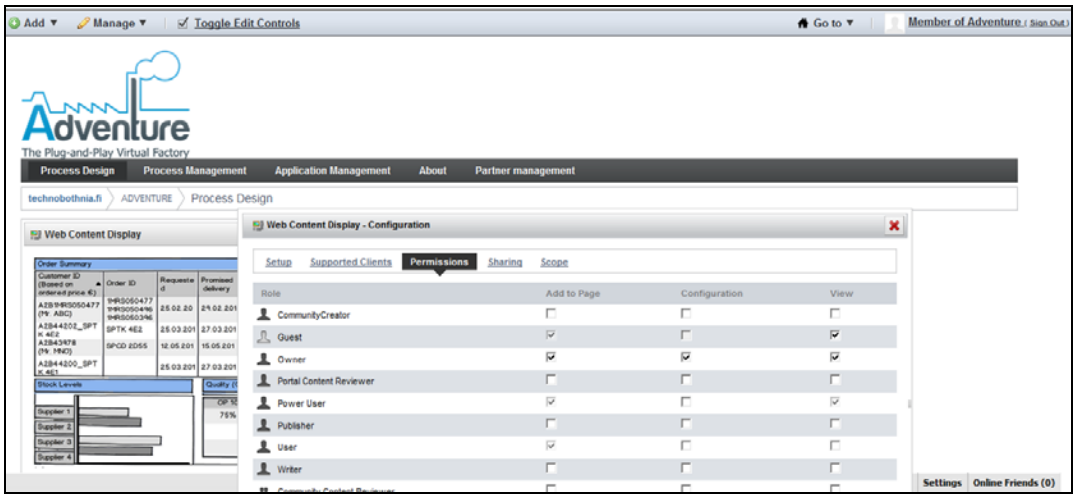

Figure 3: Display of web-based technology for monitoring and management of VF processes

In order to monitor various operational processes within VF, dashboard displays the status information of the processes as depicted in Figure 4. This process visualization occurs after clicking on the 'processes' button that opens up the process editor, where all the sub-processes can be visualized through flow diagram. The VF partners that are directly involved in each of the sub-processes can be visualized through this dashboard user interface. Various operational sequences of the sub-processes are also displayed in Figure 4.

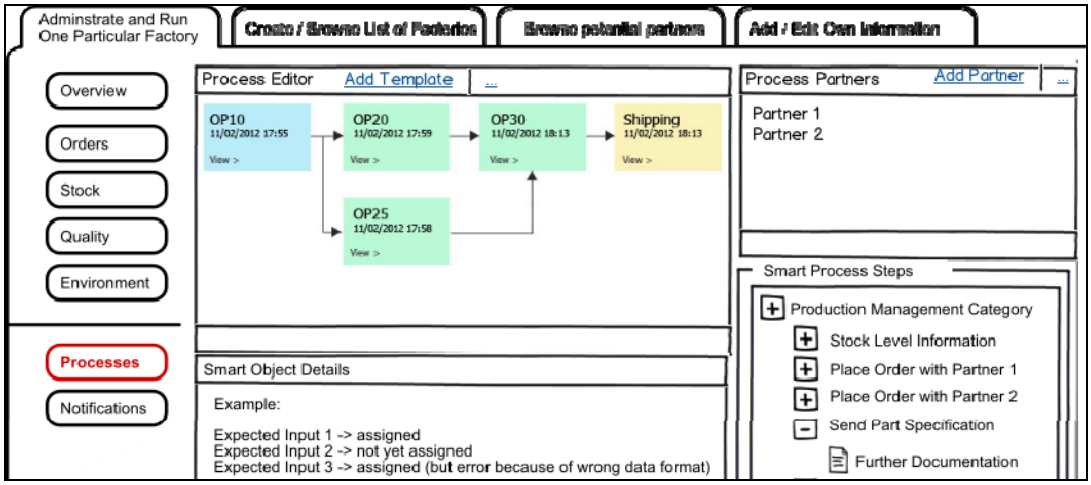

Figure 4: Display of various sub-processes of a specific VF process

Same as before this process flow diagram can be monitored and controlled through web-based technology as displayed in Figure 5. The sub-processes as shown in Figure 5 can be monitored through presenting different color according to current status. For instance, red color on a process might interpret that it is stopped due to some reason, whereas, yellow color might interpret as warning for process delay, while blue color represents as shortage of raw materials, etc. Any notifications and/or alerts with a particular sub-process can also be notified in the dashboard window. Some dashboard user interface even consists of knowledge-based database elaborating different responses or actions necessary in case of problems related to specific process. Moreover, web-enabled dashboard can be smart enough to send short message service (SMS) to VF partners in case of abnormalities in the collaborative sub-processes.

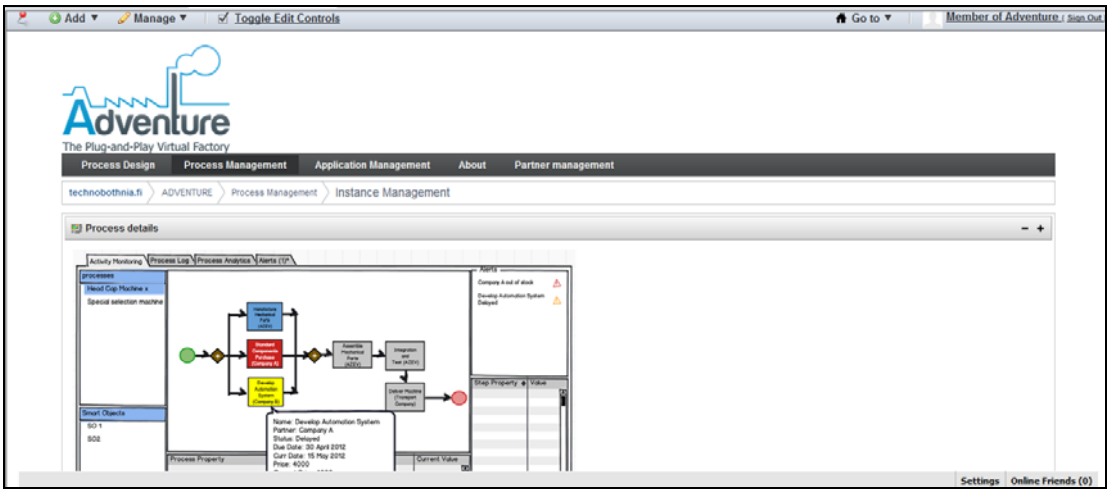

Figure 5: Display of web-based technology for monitoring and management of VF processes

The example dashboard as described above section mentioned various information monitoring related the VF operational processes. All these information contributes to the overall performance measures of the collaborative VF. For instance, if the real-time information is available to all the partners through dashboard visualization, it contributes to take immediate actions in case of abnormalities if there any and affect the overall performances or qualities of the collaborative processes. In such consequence, it can be mentioned clearly that the development of effective and efficient dashboard user interface supports VF performances through on time visualization of each corners of VF processes. This presented example can be elaborated through developing up-to-date web-based communication infrastructure that will ensure real-time information processing and display and consequently contributes towards performance monitoring and management within VF processes.

7. Discussion and Conclusions

Dashboard as works for the visualization purpose for business processes can be used by different users such as front-line workers to process monitoring, inventory management, performance monitoring and measurements, etc. This multipurpose use of dashboard enhances organizational managers to evaluate business process management and strategic performances against the predefined targets or objectives. It incorporates various functional features that help to improve process cognition and interpretation (Yigitbasioglu and Velcu 2012). The advancement of IT provides an important role in development of dashboard that used for cross-department integration in performance reporting, as well as managerial implications in information processing. Dashboard has evolved from the purpose of monitoring and management of business performance in today's dynamic market environment. Its visualization functionality offers to interactive representation of process abstract and scenario analysis (Card et al. 1999).

The application of the dashboard user interface can be successfully extended towards the area of monitoring and managing of the virtual factory, which is defined as the collaborative platform of similar size and capacity companies. The concept of virtual factory is getting increasing popularity within industrial communities, especially within the SMEs. This collaborative platform demands for continuous process visualization as offered by the dashboard component. This component ensures the real-time process visibility as part of its functionality that can also be used as the technique to monitor and measure the performance metrics of VF. In this research paper an

attempt has been carried out and presented to use the dashboard as the source of performance measures for VF network. It is explained within this research how dashboard user interface component can be used as a helpful tool to monitor and manage the VF business processes that how this monitoring process directly contributes to measure the performance metrics of the VF business processes. An example dashboard which is designed and developed under the Web-enabled communication platform is presented in this research paper in order to demonstrate the ability to monitoring and management of business processes performance indices.

There are several limitations of this research. The main limitation of this research study relates to the unavailability of the real case example which will be done after completing this ongoing research. Another limitation might be that this research is not implemented in a real life case company yet which is necessary to generalize any research theme or hypothesis. The prototype version of the web-enabled dashboard user interface as highlighted in this research is the other limitation which needs to be fine-tuned further for its maturity and reliability. Nevertheless, this research shows some pathways to investigate the performance measures of networked business through process visualization component dashboard. It is believed and hoped that the presented approach will be helpful to monitor and manage the performances metrics of collaborative business domain that ultimately benefits to the collaborative partners in a longer run.

Acknowledgements

The authors would like to acknowledge the co-funding of the European Commission in NMP priority of the Seventh RTD Framework Programme (2007-13) for the ADVENTURE project (Adaptive Virtual Enterprise Manufacturing Environment), Ref. 285220. The authors also acknowledge the valuable collaboration provided by the project team during the research work.

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Biography

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