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Developing Enterprise Dashboards

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Abstract: BPM system is an information system that is introduced to accelerate process cycle time through automation of repetitive organizational tasks. With growing importance of business process management, functionality of BPM systems is now extended to support the design, analysis and optimization of business processes. In particular, BPM brought in new applications related with managing business processes; Business Activity Monitoring (BAM) and Business Process Analysis (BPA). In this study, we raise four issues regarding the successful implementation of BAM and discuss what companies should do to address them. Specifically, we will focus on the identification of Key Performance Indicators (KPIs), mapping the KIPs to the BPM metrics. Designing the analysis methods and building digital dashboards. By linking BPM and BPA, BAM provides the visibility on what goes on with several major business processes and all the related information that will help managers make a well-informed, timely decision, so that it significantly accelerates the enterprise's reaction time.

Key words: Information system, business process re-engineering, business process management system, business activity monitoring, key performance indicators, digital dashboards

INTRODUCTION

Business Process Re-engineering (BPR) is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service and speed (Davenport, 1993; Hammer and Champy, 1993; Srinvasan *et al*., 2005). For the successful implementation of BPR, it is typical for organizations to introduce new information systems. They play, a central role to break down the barrier between different functional units and to reduce unnecessary hands-off and non value-adding works considerably.

Even though, many information systems have been introduced to support particular functional areas of a company, they were not able to have a direct control over the whole business process. That is, information system was indispensable but just a component to implement BPR. In this respect, BPM system, which was originally introduced to accelerate process cycle time through automation of repetitive tasks, may be the first information system to pay attention to all the activities throughout the business process.

BPM software enables the design, analysis, optimization and automation of business processes. In particular, BPM brought in new applications related with managing business processes; Business Activity Monitoring (BAM) and Business Process Analysis (BPA). BAM is about to reporting the status or history or both of processes, activities, research items, documents, participants, etc. (Srinvasan *et al*., 2005). It provides evaluation for business processes, activities, research items, documents, participants and so on. On the other hand, BPA is a set of activities to detect implicit process flow and create explicit process models. It address the following issues, such as, rapid process prototyping, analysis, comparison and optimization of process models in terms of time, cost and other Key Performance Indicator (KPIs), simulation and visualization and use of past data for reality and accuracy.

Importantly, BPM, BAM and BAP are closely related with each other. As shown in the Fig. 1, BPM system itself usually deals with low level data. Its main concern is about how to improve efficiency of doing work. However, to identify and fix the problematic business rules and faulty logics in their business processes, BPA needs high-level knowledge on business process. BAM by combining and analyzing the facts acquired from BPM can generate meaningful information and knowledge to conduct BPA.

In this study, we discuss issues regarding the implementation of BAM that can bridge the gap between BPM and BPA. BAM is in fact a critical link in, oftentimes provides essential information for, the management of the plan-do-check-improve cycle. By linking BPM and BPA, BAM provides the visibility on what goes on with several major business processes and all the related information that will help managers make a well-informed, timely decision, so that it significantly accelerates the enterprise's reaction time.

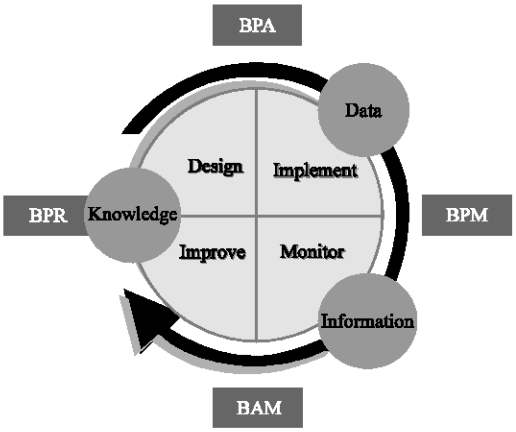

Fig. 1: BPM, BAM and BPA

MATERIALS AND METHODS

BAM should provide such useful functions as real time monitoring, historical analysis, filtering and aggregating information from various sources, automatic detection of anomalies and time-sensitive notification. In this study, we raise four issues regarding the successful implementation of BAM. They include; the identification of the key performance indicators, mapping the KIPs to the BPM metrics, designing the analysis methods and building digital dashboards.

Identifying key performance indicators: The first step for implementing BAM is to identify key performance indicators. KPIs are indicators that can represent how good products and/or services are how much money is spent to produce them and how fast and efficiently they can be delivered to customers. Those indicators are particularly important in that they are related to organization's strategic goals. In this regard, balanced scorecards can be a good starting point to identify critical KPIs to be monitored by BAM (Kung *et al*., 2005).

In typical implementations of BSC, four perspectives of organizational performance, finance, customer, internal processes and learning, are considered. Among them, internal process and customer are well supported by BPM. For instance, BPM can obtain actual data on performance of internal processes by automating order fulfillment processes. The indicators shown in the Table 1 are such indicators that can be measured by using the data that BPM produces. Furthermore, these indicators are linked with the indicators of customer support presented in the right column. Establishing the linkage between these two types of indicators are primary activity of designing BSC. In this way, BPM can support the complete materialization of BSC.

Table 1: Example of KPIs

No.	Perspectives
Customer perspectives	
1	Number of customers
2	Annual sales per customer
3	Customers lost
4	Average time spent on customer relations
5	Customers per employee
6	Sales closed/sales contacts
7	Satisfied-customer index
8	Customer-loyalty index
9	Cost per customer
10	Number of visits to customers
11	Number of complaints
12	Marketing expenses
13	Average duration of customer relationship
14	Customer rating
15	Customer visits to the company
16	Average time from customer contact to sales
17	Service expense/customer/year
Internal process perspectives	
18	Administrative expense/total revenues
19	Processing time, out payments
20	On-time delivery
21	Average lead time
22	Lead time, product development
23	Lead time, from order to delivery
24	Lead time, suppliers
25	Lead time, production
26	Average time for decision-making
27	Inventory turnover
28	Improvement in productivity
29	IT capacity/employee IT
30	IT expense/administrative expense
31	Contract field without error
32	Administrative expense/employee

Mapping BPM metrics to KPI: The second step is to map the KPIs identified in the previous step to the metrics obtained from a BPM system. As mentioned before, conceptual mapping between KPIs at the different levels are usually done in the middle of developing BSCs. However, actual calculation of those indicators cannot be performed without systematic support form sophisticated IT/IS infrastructures like BPM systems. In particular, BPM systems can provide many useful metrics that can be easily mapped to the indicators of BSC. In general, BPM systems provide two types of metrics; process-centric metrics and application-centric metrics.

Process-centric metrics: Basically, the on-time delivery, which means completion of business process by the predefined due date is the key metric that any BPM system has a direct control (Thomas *et al*., 2005). To gain insight into, which data can be obtained from BPM system, we have investigated the traditional areas related with manufacturing processes, such as simulation, scheduling and dispatching rules. In those areas, as listed in Table 2, optimizing the time-related metrics has been of great concern. For instances, the metrics that simulation usually looks at include process completion time, number of completed process instances, queue length, waiting

Table 2: Process-centric metrics

No.	Traditional areas
1	Processing time
2	Waiting time and pure working time of processes and activities
4	idle time, slack time
5	Urgency
6	Utilization
7	No. of completed (failed, delayed, aborted) process/activity instances
8	Process lead time
9	Process velocity- the number of activities in a process/process lead time
10	Process delay
11	Makespan
12	Flow time-time spent in the shop
13	Lateness-the amount of time by which the completion time of a job exceeds its due date.
14	Tardiness-the lateness of a job if it fails to meet its due date, or zero otherwise
15	The number of tardy jobs

time, utilization, etc. Similarly, the metrics related with developing dispatching rules for optimal job scheduling are flow time, lateness, tardiness, make span, etc.

Undoubtedly, such indices are also important in terms of organization performance. They are related with the issues that managers in organizations are interested in. In effect, managers are expected to have concerns, on which process is being delayed, which activity is bottleneck, or which department shows the highest performance. In other words, the performance indices above (completion time, lateness and tardiness, queue length, workload balance and utilization) are also, important in the context of BPM and BPM has a good ability of gathering and controlling process-centric data related with these indices.

Application-centric metrics: In addition to the process-centric metrics, how to monitor application data is also an important issue. A typical example of application data is various forms and documents used to perform business activities. The contents in those forms and documents, by themselves are very important performance metrics. Most of BPM users would be very much interested in monitoring such application domain specific measures that can show directly the business achievement, together with some of the process-related measures.

However, most BPM systems do not have a direct control over them. That information is mostly dealt within the other applications interacting with the BPM system. Instead in many commercial BPM systems, users can define and use a variable whose value is not internally available from process definition or BPM database, but can be obtained from external sources. An application data object can be thought of as a variable that cannot be determined or may not be available until a certain point of time, while a process instance is actually being executed. The BPM system allows fetching the variable value from participants through applications or other external application systems when business processes are initiated. BPM systems are usually integrated with the legacy systems in this way. So, we may say that there is a chance that we can take advantage of the fact that we have a running BPM system. By combining company's application data coming from their legacy systems together with the process data, we can produce value added information for customers.

Designing analysis methods: As mentioned earlier, a BPM system can deal with many informative data related with performance evaluation from the various perspectives. Having identified the metrics and the categories, we now need to consider analysis methods to manipulate related data and calculate target metrics.

Independent variables: So far, we have identified the elements on the Y-axis of monitoring dimensions, say, dependent variables. Now, we need to consider the X-axis, let us say independent variable, of the monitoring dimensions. The X-axis can be thought of as the categories, over which a user puts a metric that the user wants to compare. The customers of BAM software may want to compare the performances of different processes, people, activities and periods. Sometimes, these categories may be combined so that three or more dimensional analysis may be carried out. The bases that can be used to compare the performance metrics of business processes may include.

- Employee/department/group/role/level
- Daily/weekly/monthly/quarterly/yearly
- Category of application data
- Process types
- Category of length of activity processing time

Analysis methods: For an effective deployment of useful monitoring service, a crucial element would be identifying useful analyses. There are many different types of analyses. One of the classifications would be:

Descriptive statistics: Maximum, minimum, average, variance, mode, best, worst, range, etc.

Trend: Descriptive statistics with upper and lower bound and/or±n.

Cause-and-effect: ANOVA, Regression, Correlation, etc.

Analysis to support management: Six-sigma, TPM/TQM, SPC, BSC, TOC, ABC, etc.

Relational operations: Select, filter, group-by, project, union, etc.

Process-specific analysis: PERT/CPM, Bottleneck (critical path), slack time, gantt chart, workload, etc.

Comparison: ANOVA, Multi-variable analysis methods

- User-defined analysis

As shown in Fig. 2, in fact, many well-known management frameworks, like 6-sigma and Total Quality Management (TQM), use some of the combinations of the methods above. If we have well-designed BAM applications that can perform the analysis methods above by using the process-related data in BPM database, such BAM applications can systematically and efficiently support the required activities of the management frameworks in the Fig. 2.

Six-sigma, for example, could be one of such frameworks that can be assisted by integrating BPM and BAM. The 6-sigma procedure is composed of DMAIC (define-measure-analyze-improve-control) cycles. Most of the phases use some analysis tools and/or formats to carry out the activities. Figure 3 shows, a classification of the tools (or called charts or analyses) often used in the 6σ procedure. Some of those are Run chart, Control chart, Cp and Cpk (Process capability), Gage R and R (repeatability and reproducibility), histograms, regression, hypothesis test, ANOVA, etc.

BPM system can deal with most of data objects required to perform those analyses. Once, we have defined and implemented the analysis methods in BAM application, it becomes straightforward to support the tools in the second column of the Table 2 as has been described. The same approach can be applied to support those analyses in the advanced column. For those in the first column, we need some process-specific analysis algorithms like Critical Path Method (CPM).

Now, by placing the data objects from both X and Y axe over the tools in the table, we can easily define an analysis report like the one shown in Fig. 3. This may be presented in various formats. In this way, a number of reports can be defined. Useful analyses are a subset of the possible reports.

Building dashboards: So far, we have identified various metrics and analysis methods required to implement useful BAM applications. Now, we need to organize those elements into a consolidated view. There can be many different ways to do that. Enterprise dashboard is a term used to describe a monitoring view designed to monitor a particular metric of a company. Just as we understand the overall status and performance of a device by looking at the Fig. 3, on its dashboard, we grasp the current status and evaluate performance of a company by the enterprise dashboard.

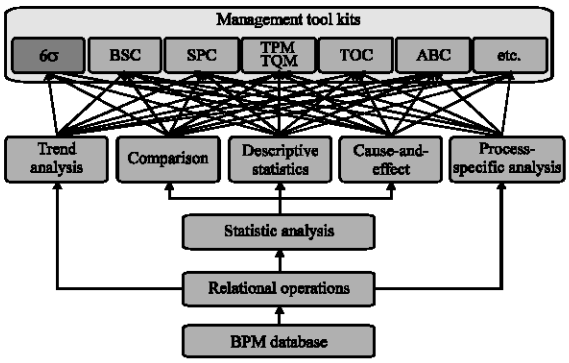

Fig. 2: Useful analyses for management toolkit

	Individual instance	Group of instances	
		Simple	Advanced
On-line	▪ PERT/CPM ▪ Gantt chart ▪ Individual status report	▪ Process flow ▪ Prediction and precaution ▪ Something unusual in off-line analysis	▪ Event-based monitoring ▪ Real-time analysis
Off-line	▪ Comparison with best, worst, average and standard cases ▪ Provision of past knowledge	▪ Run chart ▪ Control chart ▪ Cp and Cpk ▪ Gage R and R ▪ Histograms ▪ Box (Scatter) plots ▪ C and E analysis ▪ Regression ▪ Hypothesis test ▪ ANOVA	▪ Some in the left column are packed together ▪ Pareto chart ▪ Pie chart ▪ Multi-variant analysis ▪ Hypothesis test ▪ ANOVA

Fig. 3: Six-sigma tools and BAM

As discussed earlier, there are a great variety of things that managers have to monitor in a company and many different ways of analyzing the things that are monitored. The analysis results can be presented in a number of different styles. Moreover, sometimes they need to be monitored continuously and sometimes periodically or intermittently. From the perspective of monitoring users, monitoring requirements usually vary from company to company. Each individual user may require different monitoring depending his/her research scope, roles, responsibility and authority. It can even change over time as the work environment changes.

As shown in the Fig. 4, according to the number of data object (process and activity instance, participants, documents and so on) and the organizational level (individual, department manager, process owner, director, CxO, etc.) of monitoring users, there can be diverse ways of performing a monitoring action. For example, one in high organizational level may want to see a periodic report demonstrating results of long-term historical data analysis. This kind of operation needs to be performed off-line, because it usually involves relatively heavy transactions compared to on-line monitoring.

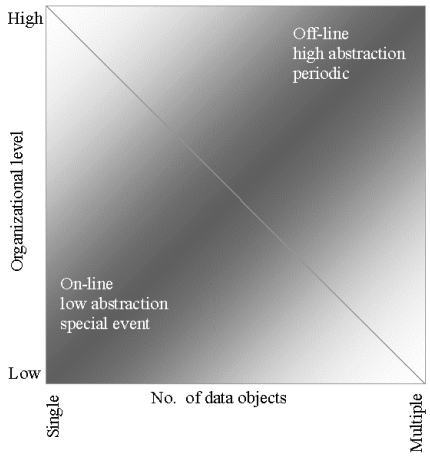

Fig. 4: BAM dimension

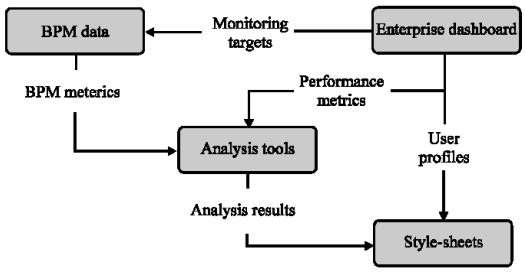

Fig. 5: Architecture for customizable enterprise dashboard (Hur *et al*., 2004)

To resolve this complexity, it is a substantial issue to design a BAM application that can facilitate customizing and personalizing monitoring environments. That is, an enterprise dashboard needs to provide individual users with tailor-made monitoring functions. Figure 5 presents system architecture of enterprise dashboard that supports customizable monitoring service. Enterprise dashboard specifies the components of monitoring into monitoring objects, analysis tools and presentation styles. A monitoring user can select, the indicators or metrics to monitor, the analysis tools to use and the presentation styles to display the analysis results and then by combining them, the user can define and configure his/her own monitoring dashboard.

RESULTS AND DISCUSSION

The steps involved in conducting business activity monitoring resemble those of the PDCA cycle, which was originally developed by Walter Shewhart in the 1930's. The PDCA cycle is a checklist of the four stages, which you must go through to get from problem-faced to problem solved. It was taken up and promoted very effectively from the 1950s on by the famous Quality Management authority, W. Edwards Deming. The PDCA Cycle is used to coordinate your continuous improvement efforts. It both emphasizes and demonstrates that improvement programs must start with careful planning, must result in effective action and must move on again to careful planning in a continuous cycle. Also, use the PDCA Cycle diagram in team meetings to take stock of what stage improvement initiatives are at and to choose the appropriate tools to see each stage through to successful completion.

Similarly, the technologies of BPM-BAM-BPA will be converged to practical support of continuous process improvement. That is, BPM automates the execution and control of the process model designed and tested by BPA, BAM monitors the process model automatically executed and controlled by BPM and BPA designs and tests the process model data collected and analyzed by BAM. Throughout this cycle, data can be transformed to information and information can be transformed to knowledge.

CONCLUSION

In this study, we have investigated several issues related with business activity monitoring. We first took a look at the important metrics that provide meaningful information on the performance of business process. Based on those metrics and the corresponding analysis tools, business processes of company can be analyzed, re-engineered and streamlined to meet the required performance.

We also provided an approach to implement enterprise dashboard that can provide a customizable monitoring service. The proposed approach can increase the flexibility to support various monitoring requirements from different companies and customers. It also, enhances the customizability of products and enables the support of individual users' preference in monitoring.

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