Developing cloud-based Business Process Management (BPM): a survey

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Abstract. In today's highly competitive business environment, modern enterprises are dealing difficulties to cut unnecessary costs, eliminate wastes and deliver huge benefits for the organization. Companies are increasingly turning to a more flexible IT environment to help them realize this goal. For this reason, the article applies cloud based Business Process Management (BPM) that enables to focus on modeling, monitoring and process management. Cloud based BPM consists of business processes, business information and IT resources, which help build real-time intelligence systems, based on business management and cloud technology. Cloud computing is a paradigm that involves procuring dynamically measurable resources over the internet as an IT resource service. Cloud based BPM service enables to address common problems faced by traditional BPM, especially in promoting flexibility, event-driven business process to exploit opportunities in the marketplace.

1. Introduction

Since its introduction more than 20 years ago, Michael Hammer (1) and Thomas Davenport (2) initiated the term business process management (BPM) to illustrate the entire stream of activity that every organisation carries out. BPM has substantially matured over the last two decades and provided an effective way to monitor and improve business efficiency (1). With the increase of globalization, business management and the process becomes big challenges for all enterprises. Modern enterprises are dealing difficulties to cut unnecessary costs, eliminate wastes, streamline and automate their business processes to deliver huge gains (3) (4). BPM is expected to help the enterprise be both competitively agile and cost efficient, promote flexibility, event-driven business processes to exploit opportunities in the marketplace (5). To address these challenges, IT is used to manage business processes and eventually evolved into what is known as BPM today (6). BPM acts as a "business process advocate" using methods, techniques & software to design, implement, control & analyze operational processes involving people, organizations, applications, documents & other sources of information (7).

BPM takes data from various business enterprise applications in the form of data presentation, and then does the following two things (8): (1) to track how information is used to complete a business, so as to accurately locate and understand existing business processes; (2) to track the flow of information in various operations, to ensure business processes run well. BPM software was introduced along with the aim to provide solution that enables to integrate existing applications without additional technology investment. Even with limited investment, companies can further improve their work efficiency.

The article applies BPM method in cloud computing (CC) environment. Nowadays, CC has emerged as an attractive, high-performing multi-tenant environment that promises aggregator systems and business process delivery, business services and business content in an environment that drives innovation. Therefore, combining BPM with the cloud will produce a flexible and affordable
environment for development of modern enterprise applications (3). With BPM software and applications connected with the cloud, the company receives all the benefits of internet applications along with the power and flexibility of the BPM software ecosystem. BPM located as Software as a Service (SaaS) bidding in the cloud that changes the way businesses view of cost structure of application creation and maintenance (9). By connecting BPM applications with the cloud, companies can handle large number of business processes at the same time and software development efforts become easier. The application of BPM in CC environment is expected to provide insight of BPM application in modern enterprises.

2. Theoretical Foundation
2.1. Business Process Management (BPM)
BPM refers to discipline that enables to combine knowledge from IT and knowledge from management sciences, and applies them into operational business processes (7). BPM focuses on improving organization, integration, optimization, implementation, monitoring and process management. With the increasing needs of customers and dealing with competitors have made business process become more complex, heavily rely on information systems and may span multiple organizations (10).

Business processes in general can be classified into: human centric and system centric with combination of: person-to-person (P2P), person-to-application (P2A), and application-to-application (A2A) (11). The article examines the A2A processes in software systems that cover: transaction processing systems, enterprise architecture integration (EAI) platforms, and web-based integration servers. This software architecture enables all different business processes can be accessed dynamically through a protocol, known as service oriented architecture (SOA) and tailored to business needs of the company. The use of web-based SOA in BPM includes (12): (1) developing tools for users to personally define models with basic components; (2) business performance management tools to manage all functions as different processes and to monitor IT systems and business process operations. The architecture of web services technology that enables to link BPM are illustrated in the following:

![Figure 1. Web services technology that enables to link business process modeling.](image)

2.2 Definition of Cloud Computing (CC)
According to National Institute and Standard of Technology NIST (13), CC is a model that allows easy on-demand network access to shared containers of configurable computing resources (eg, networks, servers, storage, applications, and services) that can be set up and released quickly with little or no management effort or service provider interaction. CC has emerged to provide computing services based on demand, measurable, ‘pay-per-us’ and virtual centrally via the internet to improve the company's ability to cope with a flexible and highly competitive business environment.
The cloud technology has evolved through combining the advantages of SOA, virtualization, grid computing, and management automation with the following features (8): (1) virtualization, reuses hardware equipment to provide an expandable system environment with extra flexibility such as the use VMware and Xen that act as a demand-based virtualization IT equipment. Users can configure their personal network and system environment through virtualization network known as VPN; (2) service flow and workflow, provides a complete set of service environment as per demand; (3) web service and SOA, through standard of WSDL, SOAP, and UDDI, and other cloud services can be delivered in the web service; (4) web 2.0, can strengthen information share and interactive cooperation of users; (5) large-scale distributed systems, requires large-scale distributed memory system and computing ability to realize the rental of computing resources and memory spaces by users; (6) programming model, allows user to write application program under cloud environment.

CC involves dynamically measurable resource procurement through internet services. Through elastic and virtualized infrastructures, CC enables to lease and release the needed resources in an on-demand, utility-like fashion, with billing according to use and to scale the computing infrastructure up and down rapidly (rapid elasticity) (14). Cloud Computing also presents a significant technological trend, and has clear that it is reshaping the information technology process and IT market (15).

2.3. BPM in the Cloud Computing.

The cloud based BPM refers to the use of BPM tools that are delivered as software service, Software as a Service (SaaS) over networks. According to Gartner by 2016, there will be more than 20% of all business processes around the world will be supported by cloud based BPM platforms. Cloud based BPM provides cloud users with valuable opportunities to use cloud software based in a pay-per-user manner. The application of cloud service model in organization can be summarized as:

The figure 2 above shows service models of cloud-based BPM comprised of: (1) Infrastructure as a Service (IaaS), is a CC service that provides IT infrastructure of CPU, RAM, storage, bandwidth and other configurations. These components are used to build virtual computers. Virtual computer can be installed operating system and application as needed. The advantage of IaaS service is that it is not necessary to purchase computers so it allows creating cost-effective solution. Configuring a virtual computer can also be changed as needed. Suppose that when the storage is almost full, storage can be added immediately. Common IaaS providers such as: Amazon EC2, TelkomCloud and BizNetCloud; (2) Platform as a Service (PaaS), is a service that provides computing platform. Usually there are operating systems, databases, web servers and application framework for running applications. PaaS service enables developers to focus on the applications they create without thinking about the maintenance of the computing platform itself; (3) Software as a Service (SaaS), is a cloud computing service where applications are provided. The service provider manages the infrastructure and platform that runs the application. Examples of email application services are: Gmail, Yahoo and Outlook,
while examples of social media applications are Twitter, Facebook and Google +. These service enables users to utilize application without must purchase the license. Users only need a CC client device connected to the internet. There are also applications that require users to subscribe in order to access applications such as: Office 365 and Adobe Creative Cloud; (4) cloud clients, cover all important stakeholders of the company. They can be staffs, suppliers, business partners, and customers.

3. Theoretical Model
The article applies literature study method. The results are based on the information reviewed from selected relevant articles. The first step is to search the relevant articles from the last 10 years using a database of journals such as: Google Scholar, EBSCOhost, ProQuest and IEEE. By using the keyword “Business Process Management and Cloud Computing” then got some relevant articles.

The article examines the application of BPM in CC environment (see figure 3) with the following components (16) (8): (1) infrastructure service layer, consists of virtual resource environments, network and file storage systems, and service buses. Above the hardware layer supports dynamic configuration of virtual hardware facilities and enables to create a distributed file storage system. This storage system enables managing virtual resources and forms as separate file system on various physical machines distributed over LAN, including load balancing, fault tolerance treatment, dynamic node configurations, and more; (2) platform service layer, covers business process machines and business process pre-built libraries and other middle-wares. The service bus is in this layer with the function to uniformly manage, request and manage all service through Web Service, WSDL, SOAP, and UDDI services. The PaaS service function enables easy maintenance and improving transparency; (3) BPM as platform layer, has a BPM system built in it. BPM system has full life cycle management and specialized process services such as process modeling with BPM notation (BPMN) and business activity monitoring (BAM) monitoring. This layer provides the added benefits for helping companies to build and visualize their business needs on a cloud-based BPM; (4) software and service layer, sit on the top layer of CC that contains application services and software through internet services.

Those 3 layers of CC and BPM layer enable companies to visualize their BPM needs through BPMS. The core system of BPM is in PaaS, that enables companies to model their business processes. It enables to collect information, develop, optimize and monitor information easier. The use of BPM in CC enables to complement application pooling, allows easy system integration, managing sharing of such information and services with convenient tools. This allows the process architects to create and modify processes to solve business problems and adjust the processes needed, as business changes. In addition, cloud-based BPM also creates opportunities for SMEs with ease by simplifying complexity.

![Figure 3. Framework Cloud-based BPM (8).](image)

To maximize the BPM output, the cloud-based BPM framework needs to be supported with the use of data mining and DSS technology. It comprised of components of (17): (1) information sources,
consists of current ERP and legacy system, point of sales (POS), other OLTP/web access, and external data that are fed as input data; (2) data management, consists of metadata, enterprise data-warehouse and replication; (3) information management, processes data marts of each departments into routine business reporting, OLAP, dashboards, intranet search for content; (4) operation management, carries out data and text mining, optimizing and simulating the data, and also automating decision system for board of directors. Data, information and analytical services are enabled through cloud services (see figure 4).

The figure 4 shows internal service oriented BPM enables to assist developing good BPM culture in organization, such as (18): (1) BPM enables important key activities to be managed and continuously improved to ensure consistent ability to deliver high quality standards of products/services; (2) business processes are critical and all-encompassing activities of design, manufacture, marketing, innovation, sales and others which deliver quality to the end customers; (3) process management constantly strive for excellence and how they stimulate innovation and creativity for process improvement and optimization; (4) BPM includes activities which refer to developing supplier quality management issues; (5) the management processes is conducted through performance measurement for setting targets for improvement and also for measuring product/service capability, process capability, supplier capability and efficiency/effeciveness aspects in terms of cycle time, quality standards, costs, etc.; (6) BPM, through continuous measurement and improvement will determine effectiveness of process design for streamlining and simplification. It ensures introducing best practices through benchmarking information and is based on valuable inputs from customers; (7) process management challenges practices (i.e. the dynamic aspects of each process and its behaviour) as much as the performance of each process (its output/metrics). Process management seeks to continuously strengthen all activities through the introduction of best practice, and to ensure that internal standards of performance are competitively acceptable; (8) BPM enables creating a systematic methodology supported by a problem-solving methodology to strengthen newly-designed processes, to reinforce the linkages between various functions and to ensure that optimum performance can be achieved.

![Figure 4. Conceptual architecture of service oriented BPM diagram (adapted from (17)).](image_url)

4. Discussion.
Service oriented cloud based BPM enables to address data process inside organizations in the area of (19): (1) low degree of automation in implementation stage: the actual setup of business processes according to managerial needs is mainly done manually, often involving numerous consultants. The use of cloud BPM enables full degree automation in entire business process; (2) implementation delay: The dynamic composition of business processes is mostly impossible, increasing the time to market and reducing an organization’s agility. Combining with mining technology has enabled to address specific problem and collaboration process to solve the problems; (3) cognitively inadequate complexity: The lack of a clear separation between business goals and implementation details makes the management of business processes overly complex. Cloud BPM enables to simplify the complexity in business processes and easy access for key stakeholders; (4) process blindness: Managers and other business experts cannot quickly determine whether a specific process can be composed out of existing atomic processes, nor can those stakeholders query the process space within their organization by logical expressions. Thus, checks for process feasibility (e.g. prior to the launch of new products or services) or compliance (e.g. ISO, etc.) are still to be done manually by business analysts. Cloud BPM enables fast query process and check process feasibility/compliance;

5. Conclusion.
This article discusses the basic concepts of CC and BPM, and how the cloud-based BPM framework is proposed. Cloud BPM enables easy and affordable cost management according to the needs. Along with the current development of business processes that are constantly changing and improving due to changing business conditions, combining BPM with the cloud is a promising approach to enable enterprises in all sizes to stay competitive and focus to their core business.

Cloud based BPM and supported with mining technology enables to create flexible business process, faster in delivery and provide better service for key stakeholders. CC is an emerging paradigm that enables to develop a better architecture for managing high complexity of business processes in modern enterprises. It involves easy data/information retrieval and processing, guaranteed data availability, fast and flexible information and analytical services.

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