Cloud-Enabled Business Process Management

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Abstract—In today's highly competitive business environments reducing costs, accelerating business processes and simplifying management are all vital to the success of an effective IT infrastructure. Companies are increasingly turning to more flexible IT environments to help them realize these goals. Cloud Computing is such a paradigm which involves provisioning of dynamically scalable and virtualized resources over the internet as a service on monthly pay-by-use basis of IT resources like paying for the usage of water or electricity from hosting company. Accordingly, delivery Business Process Management (BPM) on this paradigm will make the power of BPM available and affordable to every organization with minimal or non-existent start-up costs with low monthly subscription pricing and libraries of pre-built applications. Hence, this paper describes cloud computing fundamentals, proposed cloud-enabled BPM architecture, motivation for cloud-enabled BPM development, and gives future research directions.

Index Terms—Cloud computing, business process management, service oriented architecture, on-premises, cloud-based.

I. INTRODUCTION

Every few years we come across a new wave in technology which either reshapes the direction of the technology landscape or enhances substantially the application of existing technologies. For instance, Opportunities for improving IT efficiency and performance through centralization of resources have increased dramatically in the last few years with the maturation of technologies such as Service-Oriented Architecture (SOA), virtualization, grid computing, and management automation. A natural outcome of this is what has become increasingly referred to as "cloud computing", where a consumer of computational capabilities sets up or makes use of computing "in the cloud" (i.e. over an internet) in a self-service manner, without direct involvement in how that computing is resourced [1].

Cloud computing, involves provisioning of dynamically scalable and virtualized resources over the internet as a service. It encompasses any subscription-based or pay-per-use service that, in real time over the Internet, extends its existing capabilities. This could be offered as Infrastructure or Platform or Software as a service [2]. It also presents a significant technology trends, and it is already obvious that it is reshaping information technology processes and the IT marketplace.

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On the other hand, Business process management (BPM) is a holistic management approach that promotes business effectiveness and efficiency while striving for innovation, flexibility, and integration with technology. In other words, it refers to activities performed by organizations to design (capture processes and document their design in terms of process maps), model (define business processes in a computer language), execute (develop software that enables the process), monitor (track individual processes for performance measurement), and optimize (retrieve process performance for improvement) operational business processes by using a combination of models, methods, techniques, and tools [3], [4].

Today optimized business processes are the foundation of every successful enterprise. Increased globalization, greater competition, and stricter regulation drive the need to further optimize processes in order to achieve operational efficiency .Competitive advantage lies in the ability for enterprise to be agile and flexible in order to adapt business processes to changing market conditions quickly and efficiently [5]. However, small and medium enterprises in many cases cannot able to comply with these situations.

Cloud Computing is a compelling and high performance multitenant environment that promises to be an aggregator and delivery system for business processes, business services and business content in an environment that should foster innovation. Hence, combining BPM with a Cloud delivery mechanism provides a flexible and affordable environment for modern enterprise application development. With Cloud-delivered BPM software and applications, organizations receive all the benefits of a typical subscription Internet application together with the power and flexibility of a BPM software ecosystem. BPM as a SaaS offering in the Cloud will forever change the way businesses view the cost structure of application creation and maintenance.

Furthermore, BPM system running on the appropriate Cloud-connected hardware configuration makes the ideal Platform-as-a-Service ecosystem because the BPM system itself provides structure, security and consistent rules across process, user, geographic and organizational boundaries less Wild West and more civilization. As a result, cloud-delivered BPM with minimal or non-existent start-up costs coupled with low monthly subscription pricing and libraries of pre-built applications will make the power of Business Process Management available and affordable to every organization. It will also allow organizations and individuals to begin learning about and working with process modeling and process discovery in an inexpensive, risk-free and productive environment.

The remaining section of the paper discusses cloud computing fundamentals, Cloud-enabled BPM architecture, motivation for cloud-enabled BPM development, and conclusions and future research directions.

II. Cloud Computing Fundamentals

A. Definitions and Key Features

A number of computing researchers and practitioners have attempted to define Cloud Computing in various ways. Here are some definitions that we think are generic enough to describe cloud computing. Wikipedia and National Institute of Standards and Technology (NIST) define as follows: According to NIST [6], "Cloud computing is a model for enabling 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".

Wikipedia defines as: "Cloud computing describes systems that provide computation, software, and data access services without requiring end-user knowledge of or dependence on the system's physical location and configuration. It describes a new supplement, consumption, and delivery model for IT services based on the Internet, and it typically involves over-the-Internet provision of dynamically scalable and often virtualized resources".

From above two definitions we draw cloud computing as an emerging paradigm that provides centralized on-demand, scalable, pay-per-use and virtualized computing services over internet to enhance enterprises capabilities to cope with flexible and highly competitive business environments.

Cloud computing allows you to expand and contract your costs in direct proportion to your needs. Moreover, it shifts some of the risk around expanding your IT resources from the enterprise to the cloud computing provider. It is any IT resource, including storage, database, application development, application services, and so on, that exists outside of the firewall that may be leveraged by enterprise IT over the Internet. The core idea behind cloud computing is that it is much cheaper to leverage these resources as services, paying as you go and as you need them, than it is to buy more hardware and software for the data centre.

Accordingly, on-demand self-service (without requiring human interaction with each service's provider), agility (ability to rapidly and inexpensively re-provision technological infrastructure resource) ,ubiquitous network access, Location-independent resource pooling(multitenant model to assign resources based on customer demand)and pay-per-use(on usage charge) are key characteristics of cloud computing [6],[7].

B. Layers of Cloud Computing

Cloud computing can be viewed as a collection of services, which can be presented as a layered cloud computing architecture.

1) Cloud applications services

It is also known as Software as a Service (SaaS) deliver software as a service over the Internet, eliminating the need to install and run the application on the customer's own computers and simplifying maintenance and support.

2) Cloud infrastructure services (IaaS)

It is also known as Infrastructure as a Service (IaaS).It delivers computer infrastructure - typically a platform virtualization environment - as a service. Rather than purchasing servers, software, data-centre space or network equipment, clients instead buy those resources as a fully outsourced service.
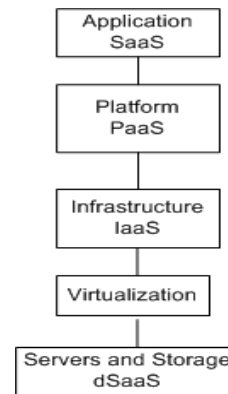

Fig. 1. Layered architecture of cloud computing (adapted from Jones) [8].

3) Platform-as-a-service (PaaS)

It is a complete platform, including application development, interface development, database development, storage, testing, and so on, delivered through a remotely hosted platform to subscribers. Based on the traditional time-sharing model, modern platform-as-a service providers provide the ability to create enterprise-class applications for use locally or on demand for a small subscription price or for free. Platform-as-a-service provides self-contained platforms with everything you need for application development and operational hosting. An example of Platform-as-a Service (PaaS) cloud computing is shown in Fig1.2: ["Platform as a Service," http://www.zoho.com/creator/paas.html].
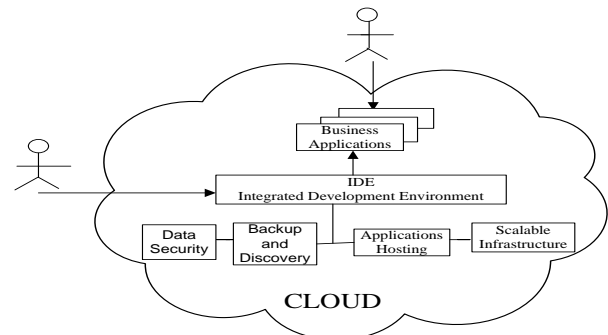

Fig. 2. Platform as a service (adapted from Zoho) [9].

The PaaS provides Integrated Development Environment (IDE) including data security, backup and recovery, application hosting, and scalable architecture

4) Servers and storage (dSaaS)

The servers' layer consists of computer hardware and/or computer software products that are specifically designed for the delivery of cloud services, including multi-core processors, cloud-specific operating systems and combined offerings.

5) Types of cloud computing

All cloud computing approaches are not the same, and several deployment models, while different, is still considered cloud computing:

- Private cloud. The cloud infrastructure is owned or leased by a single organization and is operated solely for that organization.
- Community cloud. The cloud infrastructure is shared by several organizations and supports a specific

community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations).

- Public cloud. The cloud infrastructure is owned by an organization selling cloud services to the general public or to a large industry group.
- Hybrid cloud. The cloud infrastructure is a composition of two or more clouds (internal, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting).
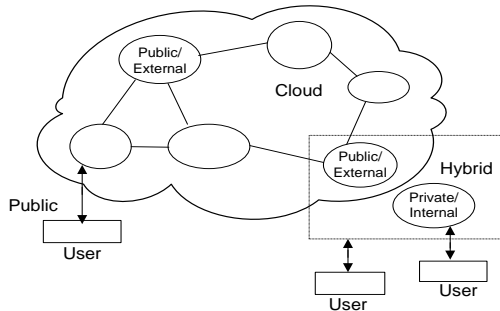

Fig. 3. The three types of cloud computing (adapted from Wikipedia).

Many businesses will find that private clouds are a better solution for their situation, leveraging the benefits of cloud computing but within their firewall. Or, they may choose to leverage a mixture of public and private clouds, or a hybrid cloud. Finally, some may create semiprivate or community clouds, which are public clouds leveraged only by a closed group of companies or government agencies [2].

III. CLOUD-ENABLED BPM ARCHITECTURE

The cloud-delivered BPM architecture is shown in fig.4. Except the physical hardware layer at the bottom, the system architecture from down to up includes infrastructure as service (IaaS), platform as service (PaaS) and BPM as Platform and software as service (SaaS). By adding additional functions into the three-layer model of Cloud Computing, the framework can enable companies to customize BPM design based on their requirements on.
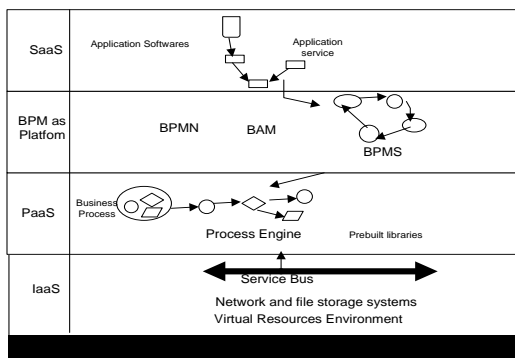

Fig. 4. Cloud-enabled BPM framework.

1) Infrastructure service layer

This layer consists of virtual resources environment, network and file storage system, and service bus. Above the hardware layer, it provides virtual abstract for the traditional physical hardware and support the dynamic configuration of the virtualized hardware facility. Besides, it realizes a distributed file storage system on the basis of virtual resources and forms an abstract file system on various distributed physical machines through local area network, including such functions as load balancing, fault tolerance treatment, dynamic node configuration and concurrent treatment. Service bus is at the top part of IaaS layer, including the exterior services to be used, and the function service released by the existing system. The service bus uniformly manages, inquires and arranges these services through Web Service, WSDL, SOAP, and UDDI technologies. Therefore, the function service in PaaS can be realized under the uniform bus, increasing the transparency and making maintenance much easier.

2) Platform service layer

This layer includes business process engine and business process prebuilt libraries and other middleware. This layer provides a mechanism to obtain the services at the bottom layer released by other systems from the service bus in IaaS, and can also independently realize them. As a service component, the function service can be provided for business process or the application service in SaaS. The business process engine is the execution environment for business process, and prebuilt libraries, and business rule library are also available in the engine. Business rule library is used by the business analyst and designer. Since independent to any realization, the business rule library can dynamically change any rule standard during operation. Business process is a simulation of the traditional enterprise businesses. The result and process after the establishment of model can be described by BPEL. The process logic can be realized by adopting different service components and rules.

3) BPM as a platform layer

It has a business process management system (BPMS) at its heart. This is similar to PaaS, but rather than programming tools being accessed, the BPMS is being accessed for full process lifecycle management and specific process services such as process modeling with BPMN and business activity monitoring (BAM). This layer added to help companies to build and visualize their business needs on cloud delivered BPM.

4) Software and service layer

This is a top layer of Cloud Computing that contains application service and application software. The application service is transparent to realize whether users and application software requirements achieve or not. It provides the concrete process information and function realization obtained from the business process and function service in BPM platform and PaaS for the application software at the upper layer or directly provides them for the users through Internet service. Through three-layer model of Cloud Computing and adding one layer to enable companies to visualize their BPM requirements through BPMS we add BPM platform in which they can model their business for example by BPMN and use BAM to monitor business activity. The core system of BPM resides in PaaS. This enables BPM management software to conveniently collect the information of business process and then develop, optimize and monitor the information.

IV. MOTIVATION FOR CLOUD-ENABLED BPM DEVELOPMENT

BPM is an aggregation of business process modeling, business process automation, and workflow. Its approach implements and manages transactions and real-time business processes that span multiple applications, providing a layer to create common processes that span many processes in integrated systems [4]. It can strengthen organization's ability to interact with any number of systems—inside or outside the organization, on-premise or cloud-based—by integrating entire business processes both within and among enterprises or from on-premise to cloud delivered processes.

Processes can span any number of complex systems within the same company or among companies, and can exist and leverage resources that are locally hosted (on-premise) or cloud computing based. This functionality exists to bind services together to create solutions that are easy to create and change. Thus, BPM technology must be flexible, providing a translation layer between the services and the BPM engine.

Hence, the central concepts of BPM, and the use of BPM within cloud computing, is to automate services invocation and process flow so that another layer of processes will exist over and above the processes encapsulated in existing systems. In other words, BPM completes application binding, allowing the integration of systems by readily sharing information and services and by managing the sharing of that information and services with easy-to-use tools. This enables the process architect to create and re-create processes to solve business problems and adjust processes as needed, as the business changes. It also creates an opportunity for small to medium scaled companies to adapt BPM and this in turn will foster easy development of collaborative BPM by simplifying complexity.

The other motivation for cloud-enabled BPM is the advantages of using BPM. The following are some basic advantages:

- A single instance of BPM typically spans many instances of systems, on-premise or cloud-based.
- BPM defines a master application (or applications) that have visibility into many encapsulated services and information.
- BPM leads with a process model, moves information among applications, and invokes internal services in support of that model.
- BPM is independent of the services. Changes can be made to the processes without having to change the source or target systems, on-premise or cloud-based.
- BPM is strategic, leveraging business rules to determine how systems should interact and better leverage the business value from each system through a common abstract business model.

In general, BPM is the science and mechanism of managing the movement of data and the invocation of services in the correct and proper order to support the management and execution of common processes that exist in and between organizations and internal applications. BPM provides another layer of easily defined and centrally managed processes that exist on top of an existing set of processes, application services, and data within any set of applications.

V. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

In this paper we covered the fundamentals concept of cloud computing, BPM and We proposed a cloud-enabled BPM framework and motivations for consider BPM in Cloud. Cloud computing allows the company or customers to expand and contract their costs in direct proportion to their needs. It's high performance multitenant environment that promises to be an aggregator and delivery system for business processes, business services and business content in an environment that should foster innovation. As today's business process development seeks a continuous improvement due to ever changing business world, combining BPM with cloud is a promising approach to enable small and medium scaled companies to remain competitive and effective in their business.

As cloud computing is new emerging paradigm, work for future at most aiming at building a better generic architecture for cloud-enabled business process management and implement to enhance process execution tracking to monitor business performance, security and the overall business process deliver on cloud computing technology paradigm.

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