A COMPREHENSIVE STUDY OF BUSINESS PROCESS MANAGEMENT IN THE CLOUD

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Abstract: This research paper aims at providing an overview of cloud based business process management systems and its advantages and challenges. It also describes its vitality to the success of an effective IT and Business Environment through inherent prospective of scalability and expenditure reduction. Business Process Management (BPM) on cloud paradigm makes BPM affordable to organizations at minimal cost, thus by allowing Businesses to enhance and develop a customer value propositions. This paper includes fundamentals of BPM, BPM in Cloud Computing, Elements of BPM, Architecture of BPM & its benefits along with its challenges.

Keywords: Business Processing Management, Cloud Computing,Cloud Services

I. INTRODUCTION

Increasing globalization and greater competition has increased the importance of regulated business processes to achieve maximum efficiency. Business Process Management is increasingly being viewed as "The Bridge between Information Technology and Business". It can be considered to be a "Process Optimization Process" with an aim to enhance the overall performance of the company. The concept of Business process is established in the early 20th century when jobs and IT departments came into existence. The prime focus of BPM was to automate the business processes with the integration of technology. However, with time it extended to include human-driven processes as well where humans interact with the technology in series or in parallel. Some of the widely used BPM tools are SIPOCs, process flows, CTQs, RACIs and Histograms.

Implementing BPM into organizations, however, requires high investments since not only the software, but also the hardware needs to be purchased. In addition to that, hiring personnel for setting up and maintaining the system and Scalability can also be a concern for those organizations that use BPM, thus resulting in extra costs. Cloud Computing- often referred to as simply 'Cloud' can be defined as the delivery of computing services- including servers, storage, software, analytics, networking and so on- over the internet in a pay-for-use basis. In simple words, Cloud Computing refers to the delivery of computing services such as storage, database, servers, networking, analytics, and software and so on over the Internet. It also refers to the hardware and the system software in the data centers that provide these services. The Services are generally referred to as Software as a Service (SaaS) while the hardware and the software of the data centers are referred to as the Cloud.

Cloud computing allows the data to be either stored and processed in a privately-owned cloud or on a third party server located in data centers by the users of the cloud and the enterprises with various computing capabilities thus reducing the IT- Infrastructure costs. While there are numerous advantages to using cloud computing, there are certain pitfalls which need to be addressed to make it more reliable. Let us consider the Service Models of Cloud Computing first:
Cloud Computing providers provide their services typically according to the three standard models as per NIST's definition of cloud computing. The three standard models are:

a. IaaS (Infrastructure as a Service): In this case, A Computer Infrastructure, usually in the form of virtualization is provided as a service in cloud hosting. It is the lowest layer in the cloud computing stack combining both hardware layer and Infrastructure layer. The users need to install and configure a virtual machine which actually runs on the hardware of the cloud provider at the data centers. This means that the users are responsible for their virtual machines and the cloud service providers are

responsible for the actual hardware. The advantages of IaaS are Scalable Infrastructure and Portability.

b. PaaS (Platform as a Service): It provides a line of software developers with an integrated platform for development, deployment, testing and support of web applications to manage the computing infrastructure from centralized IT Operations.. The user here has no control over the underlying cloud infrastructure such as the servers or the operating systems, but has control over the deployed applications the application hosting environment configurations. Some of the advantages of PaaS are Provision of development platform and no hardware and server management required.

c. SaaS (Software as a Service): SaaS usually involves the deployment and support of the software vendor. It accesses the web to deliver applications which are managed by a third party vendor whose user interface is only accessible by the client. The provider's applications are running on the cloud infrastructure and the users of SaaS can use it from various client devices through a thin client interface like web browser. Here, the consumers are not responsible for the management of the cloud infrastructure. SaaS provides the cloud providers with the feasibility to manage their software from within their company. Software runs on the servers of the cloud providers rather than being installed individually on each cloud user's computers. In this way, when a fault is detected it can be easily solved by fixing the errors on the software in the server rather than distributing an update to all the users.

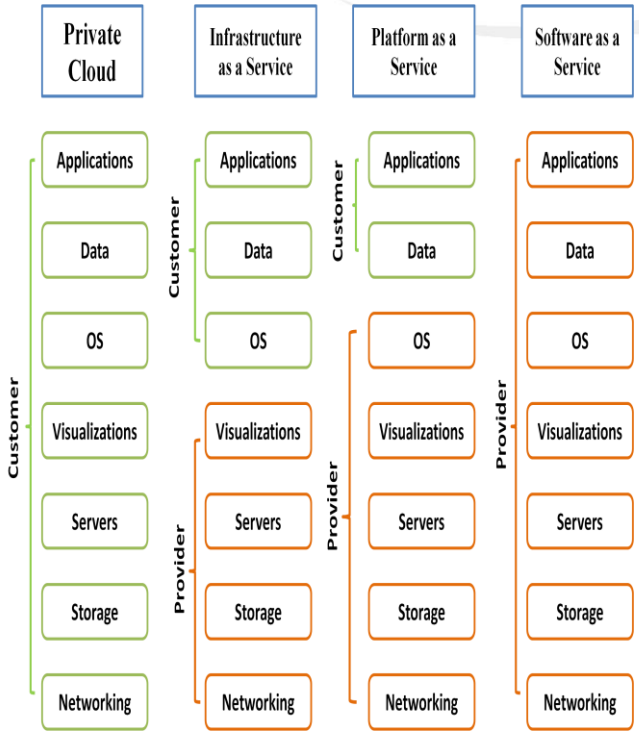

Figure 1: Cloud Service Models- Delineation of Responsibility

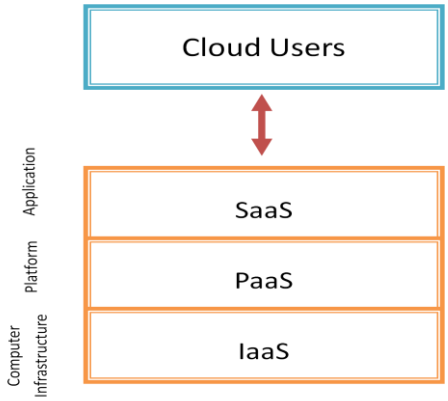

Figure 2: Cloud Service Model types

II.TYPES OF CLOUD

a. Private Cloud: In this case, the cloud infrastructure is operated exclusively for an organization. It can exist inside or outside the cloud user's organization and can be managed by the same or by a third party provider. This is useful for situations where security is the most prominent concern and the data has to be hosted inside the organization itself.

b. Public Cloud: Here, the cloud infrastructure is made available to the general public or a broader range of audience such as a large industry group and is owned by an organization selling cloud services. The cloud users can access the cloud through the internet. Companies like Google, Amazon and Microsoft offer public cloud computing services

c. Hybrid Cloud: Hybrid Cloud combines the benefits of both Public Cloud and Private Cloud. Here, the organization can choose which data and services can be stored in the public cloud and which critical data needs to be kept inside the organization in the private cloud. Thus, in hybrid cloud, we have the advantage of both Scalability and Data Security.

d. Community Cloud: Community cloud is exclusive to a specific community. Two or more organizations can mutually decide to host their services together since they have the same concerns in order to collaborate. Community cloud can be managed by one or more organizations within the community or it can be hosted by a third party provider.

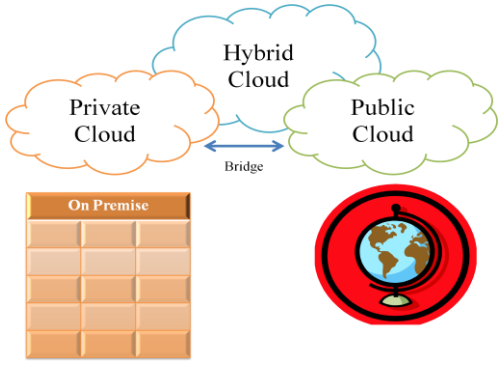

Figure 3: Cloud Deployment Model types

The various services have been provided by Cloud with numerous advantages that allows the organizations to use the BPM Applications in a pay-for-use manner, thus saving them the extravagant investment costs of implementing and maintaining the BPM Application. The provision of elastic resources also allows the organizations to scale up and down in a feasible manner to meet the ever changing demands.

III.BUSINESS PROCESS MANAGEMENT

Business Process Management is defined by the BPM Institute (Gregg Rock, Tom Dwyer. What is BPM anyways? Business process management explained.) as follows

"The definition, improvement and management of a firm's end-to-end enterprise business processes in order to achieve three outcomes crucial to a performance-based, customer-driven firm: 1) clarity on strategic direction, 2) alignment of the firm's resources, and 3) increased discipline in daily operations."

Another definition of BPM is given by the Association of Business Process Management Professionals in "Guide to the Business Process Management Common Body of Knowledge" (Benedict et al., 2013) as "Business process management (BPM) is a disciplined approach to identify, design, execute, document, measure, monitor, and control both automated and non-automated business processes to achieve consistent, targeted results aligned with an organization's strategic goals. BPM involves the deliberate, collaborative and increasingly technology-aided definition, improvement, innovation, and management of end-to-end business processes that drive business results, create value, and enable an organization to meet its business objectives with more agility. BPM enables an enterprise to align its business processes to its business strategy, leading to effective overall company performance through improvements of specific work activities either within a specific department, across the enterprise, or between organizations."

A Business Process Management lifecycle can be broadly divided into five categories, namely, Design, Modelling, Execution, Monitoring and Optimization. It is an iterative process where all the BPM aspects are covered.

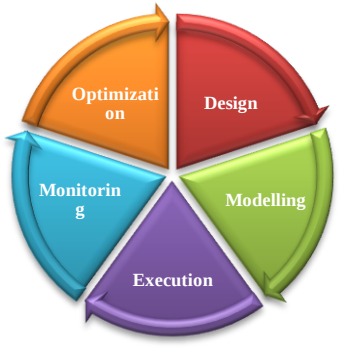

Figure 4: Phases of Business Process Management

Design: The design phase is related to identifying the business processes within the company and the designing of the to-be processes. The main focus of the design phase is to capture the business processes within an organization in a business process model and to depict these models using graphical notations. Business Process Model and Notation (BPMN) is the most widely used graphical language for capturing and defining the business process models. This allows the stakeholders to understand the processes and models relatively easily and recommend any changes if required. The proposed improvement can be in human-to-human, human-to-system or system-to-system workflow. Good design is very crucial to the smooth functioning and overall performance of the organization as it will reduce the number of problems over the lifetime of the processes.

Modelling: In the modelling phase, theoretical design from the previous phase is introduced to a combination of variables. Different variables and factors are considered along with the effect on the functioning of the processes when these combinations of variables are changed. For example, how will a process be affected when we vary the material cost or change the capacity of the resources. Thus, here the design phase is updated to accommodate the various changes which might affect the functioning of the processes.

Execution: Execution and Implementation are carried out in co-ordination with each other. While automating the processes, we can either develop or buy an application which will execute the necessary steps of the process. However, in doing so, it is not guaranteed that all the steps of the process will be executed efficiently. Another approach is rather complex involving a combination of software and human interaction. A better way to address these problems is to develop a software which allows the complete business processes to be defined in a computer language which can be then executed by the computer. Thus, in this phase, all the business processes are implemented and executed accurately and completely. Also, instances of the processes are launched and allow interactions with the end-users.

Monitoring: This phase is the understanding of where inefficiencies lie in the business processes. It is associated with measuring the key performance indicators and process performance. It gives an overview of the currently running and completed business process instances so that it will be easier to detect problems within them. Graphical dashboards as well as textual and statistical reports help in determining how the process is performing. Degree of monitoring depends on how the organizations need the business processes to be monitored. Business Activity Monitoring (BAM) is used to extend the monitoring tools generally provided by the Business Process Management.

Optimization: Optimization phase is associated with identifying the underlying inefficiencies in the modelling or monitoring phase and improving them thus retrieving process performance. It also determines the changes which can provide maximum benefit by identifying opportunities such as cost savings or any other improvements and incorporates these enhancements in the design phase. It helps in creating a greater business value.

As the firm, technology and environment changes, the processes need to be changed or upgraded as well. This is where the importance of BPM- Continuous Improvement, comes into play.

IV.CORE ELEMENTS OF BUSINESS PROCESS MANAGEMENT

There are six core elements essential to Business Process Management. Each of the organizations striving for success with BPM needs to consider each of these six core element sooner or later. Each of the core elements and their capability areas are shown in Figure 5.

Strategic Alignment: Strategic alignment can be defined as the tight linkage of organizational priorities and enterprise processes resulting in overall business processes. It is very important that BPM is aligned with the overall strategy of the organization. This means that the design, modeling, execution, monitoring and optimization of business processes should be carried out in accordance with the strategic priorities and specific situations.

Governance: BPM Governance specifies the appropriate and transparent roles and responsibilities for each level of BPM. It further focuses on decision-making and guiding the process related actions.

Methods: Methods are defined as the set of tools and techniques which facilitates the various phases of the process lifecycle. For example, methods for enabling process analysis or process modelling or process optimization.

Information Technology: IT-based solutions are very import/ant for Business Process Management initiatives. BPM related IT solutions can be considered to be equivalent to process-aware information systems (PAIS) which means that the software system has explicit understanding of all the processes to be executed.

People: People form a core element of BPM. They are the individuals and groups who continuously use their process management skills and knowledge to enhance the business performance. Process skills and expertise, Process management knowledge and process management leaders are some of the capabilities of this core element which are very crucial to be present in individuals or groups of individuals.

Culture: BPM culture is all about creating an environment which supports the business initiatives. It includes the values and beliefs of a process-centered organization. However, it should be noticed that the impact time of culture- related activities is considerably longer than the impact time of any of the other five core elements.

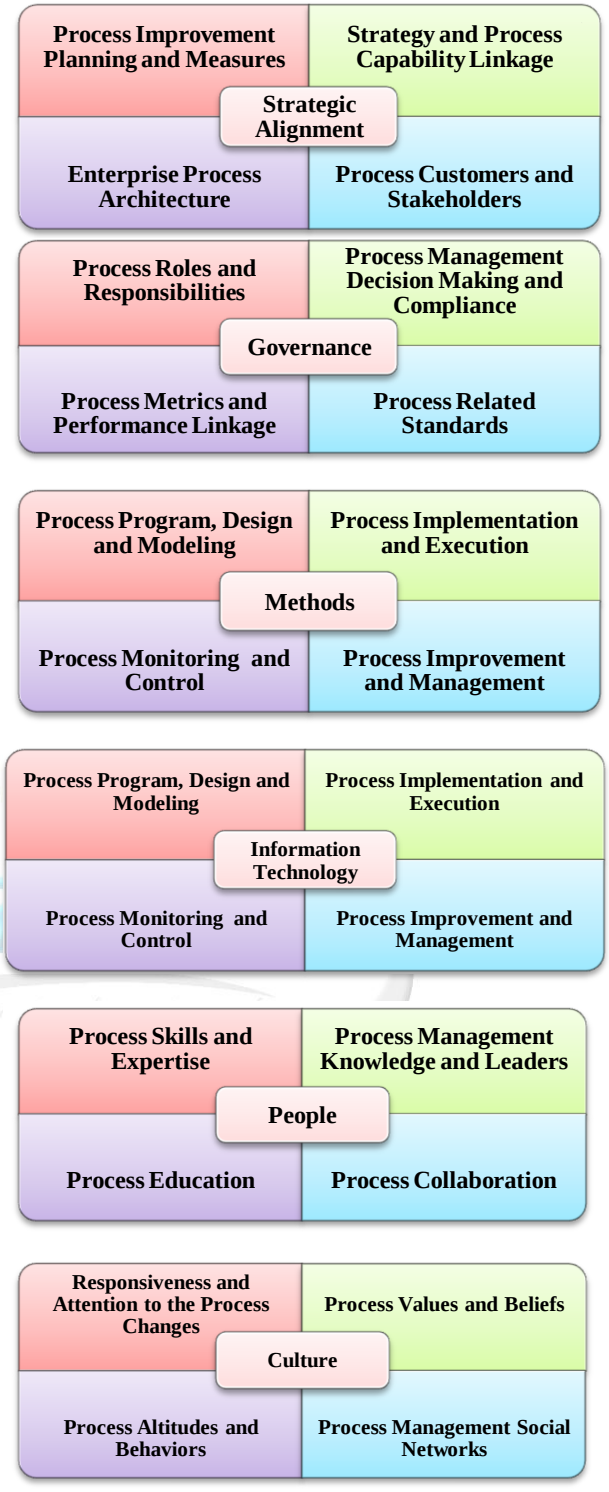

Figure 5: Capability Areas of the core elements of BPM

In spite of the numerous advantages, cloud computing does have some limitations when it comes to security and availability. However, the different models of cloud computing provides solutions to a great extent for such limitations (Private Cloud for Security etc.).

V.BPM IN THE CLOUD

Cloud Business Process Management is the use of BPM tools which are delivered as software services (SaaS) over a

network. Cloud BPM offers controlled IT Budgeting and also enables geographical mobility. The application should be organized according to the BPEL specification and executed by a BPEL execution engine. BPEL stands for Business Process Execution Language. It is an XML-based language which is used to define how a business process and its web services will be executed. It allows web services in a SOA (Service Oriented Architecture) to interconnect and share data. Let us consider the service models for BPM in the Cloud:

IaaS: When an application is moved to IaaS Service model, the customer or the cloud user is responsible for managing and control of the applications, middleware and the OS running on the virtual machine. The provider of the cloud is responsible for the hardware. Thus, installing BPM software in a IaaS cloud solution is similar to installing a BPM software on premise, because almost everything except the hardware is managed by the cloud user. Also, here, the cloud user or the customer needs to take security measures such as blocking ports, keeping the system and software updated and enforcing access control policies to protect the system from intruders.

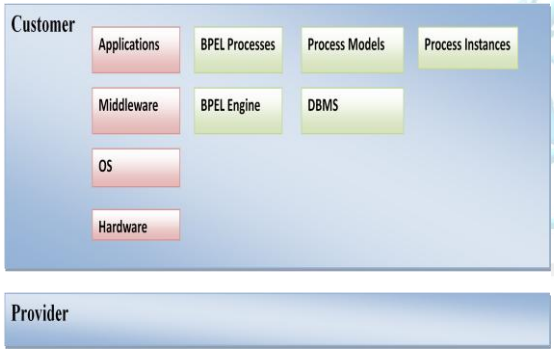

Figure 6: Responsibilities of Customer and Provider in IaaS model

PaaS: When the application is moved to PaaS service model, the responsibilities for both the cloud provider and the cloud user changes. The BPEL engine in this case is provided by the provider since it is assumed to be a part of the platform where it is shared and thus can be used by multiple users as well. The cloud users need to upload their processes in order to run them in the cloud. Data storage and management is done by the provider and thus there are various security issues which need to be dealt with. For a secure BPEL engine on PaaS service model, the following three requirements needs to be included.

- Process Models cannot be altered by Intruders
- Process Models should not be readable to intruders in case they gain possession of a process model description file.
- Process Models cannot be deployed on any other engine by intruders.

To achieve these requirements, the process models should be encrypted to ensure that they are not readable to intruders and signed to ensure that a file is valid for only one execution engine and would produce a failure if attempted to port to another execution engine. It is also crucial to encrypt the data in the database storages to make it unreadable to intruders. But this can often lead to a restriction of query expressiveness with respect to relational operators.

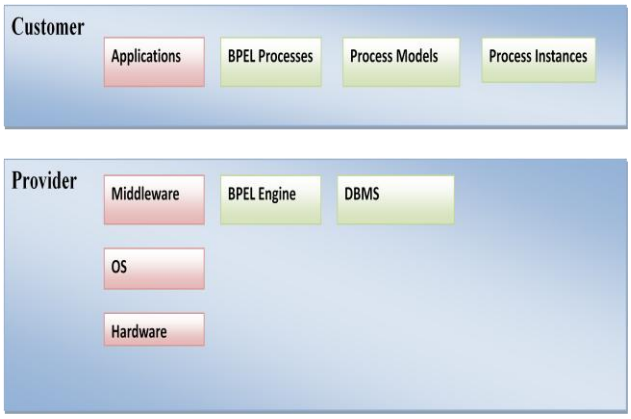

Figure 7: Responsibilities of Customer and Provider in PaaS model

SaaS: When the application is moved to SaaS service model, the cloud provider is responsible for the whole application. It means that the cloud provider provides the application-specific services to the cloud user while the cloud user need not worry about the management of the application. Multiple cloud users can be offered the application through single-tenant or multi-tenant architecture. In single-tenant architecture, each process model is installed with a new BPEL engine. The security of data and databases and protection against intruders is as crucial here as it is in other two categories and appropriate security measures needs to be taken. In multi-tenant architecture, multiple users and process models are served by a single BPEL engine. For security reasons, the data used by one cloud user should not be accessible to another and thus different databases can be created for each cloud user, or a column with a unique identifier number can be added to the database to ensure secure access.

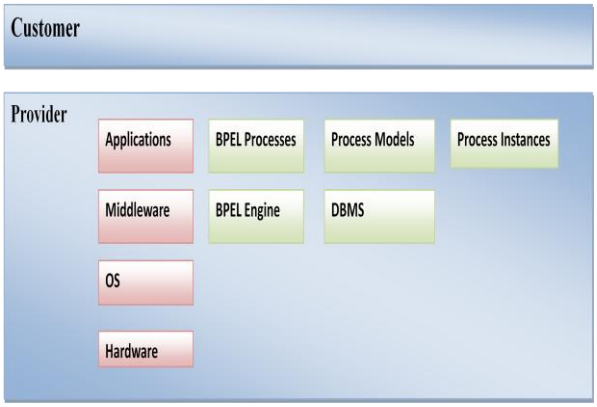

Figure 6: Responsibilities of Customer and Provider in SaaS model

VI.BPM ARCHITECTURE

To investigate the distribution possibilities of BPM in the cloud, we introduce a PAD (Process- enactment, Activity execution, Data storage) model which describes the distribution of three independent features in the BPM Architectures. The cloud users can place sensitive data and computation-intensive activities at the user end side and all the non-sensitive data and activities in the cloud by being able to make the distinction between the process, activities and data.

The BPM architectures according to the PAD model can be distinguished into four principal types.

- Traditional Standalone BPM
- User-end BPM with cloud side distribution
- Cloud based BPM with user-end distribution
- Existing Cloud-based BPM

Pattern 1 is the traditional architecture where everything is distributed at the user-end while Pattern 4 is used by existing cloud-based BPM where everything is distributed on the cloud. When those users who already have a fully-functioning BPM at their end wish to distribute some additional compute-intensive activities, pattern 2 can be used. Pattern 3 can be used when users do not have a fully functioning BPM on their end.

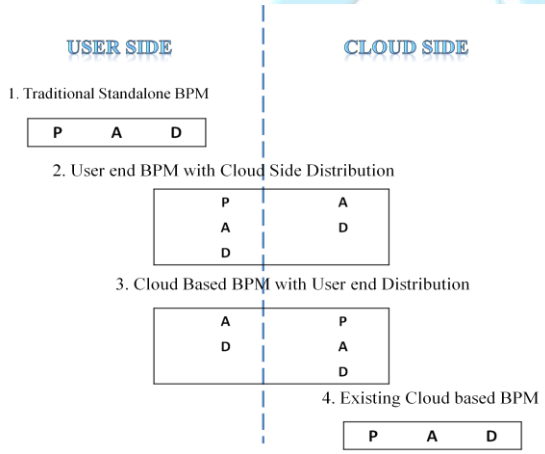

Figure 9: BPM Architectures according to PAD Model

The control-flow business process manages and regulates the activities and sequence of activities performed while the data-flow business process determines how data is transferred from one activity to another. Sensitive data is stored at the user's end and non-sensitive data is stored at the cloud end. The cloud end only deals with data-flow business processes and uses reference Ids instead of actual data. The actual data is transferred to the activity when needed under user surveillance through an encrypted tunnel.

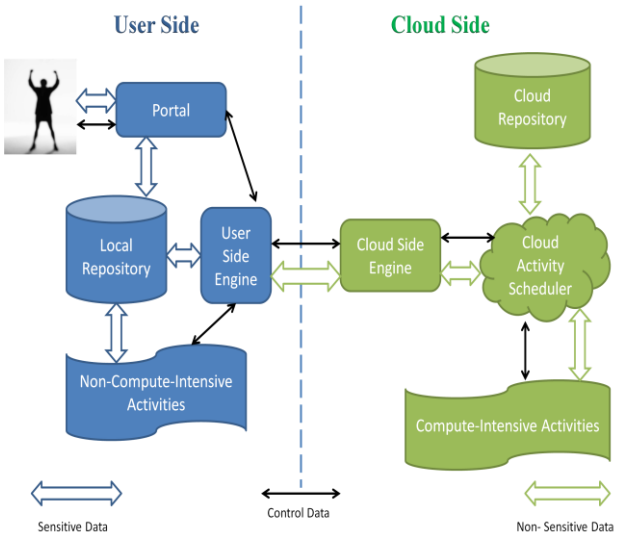

Figure 10: BPM Architecture Function

VI.GENERAL BENEFITS AND CHALLENGES OF CLOUD BPM

Benefits

Pay-per-use: Instead of investing a big amount of money into BPM software, hardware and maintenance, the cloud users can use the Cloud based BPM-Software in a pay-per-use manner.

Elasticity: Due to the usage of cloud services and pay-per-use usage of BPM software, the organizations can flexibly scale up and scale down as and when needed without having to make any major changes.

Challenges

Security: Security is the biggest challenge when it comes to the usage of cloud and its services. The cloud users might lose control over sensitive data by placing a BPMS in the cloud. It is also very important that the organizations can efficiently decide which of the sensitive data should be kept on the user-side and which non-sensitive data should be placed in the cloud. Thus organization of data is a very important factor when using a cloud-based BPM

Processing Activities: While the usage of cloud greatly increases the efficiency of processing most of the business activities, sometimes it may happen that some of the compute-intensive activities which require a huge transfer of data might turn out to be more expensive as the transfer may take longer.

Lack of Resources/ Expertise: Increasingly, the challenge of lack of resources and expertise available in and for the cloud seems to overcome the issue of security as well. As cloud technology is advancing, organizations are placing more workloads in the cloud and thus finding it difficult to keep up with the tools. Additional IT training is needed to curb this issue.

Performance: By moving businesses to cloud, the businesses are becoming dependent on the cloud providers. So the performance of businesses is closely associated with

the performance of the cloud provider for cloud based systems. Thus it is very important that the provider has the right processes in place.

VII.CONCLUSION

As technology evolves, the inherent flexibility of cloud based BPM system appears to be more intriguing to optimize the performance of businesses. Cloud based BPM allows the user to enjoy a full-fledged BPM without worrying about their IT expenditure. However the users need to be cautious when using sensitive information with cloud services and should investigate further as how they can be utilized securely. In this paper, we discussed the most important parts of a cloud based BPM system starting with what is Business Process Management and the different phases and core elements of the same. Further, we discussed about cloud computing and the important service and deployment models. Lastly, we talked about how BPM can be deployed in cloud and its benefits and challenges. As cloud computing is reaching new heights, different research directories can be deployed for future research such as optimizing using relevant tools like BPEL, deployment of workflow engine in cloud, how to protect user's data privacy in the cloud and so on. Cloud BPM can bring many benefits to businesses as well as organizations and is an effective blend of business and technology to drive the future needs.

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