Outsourcing Business to Cloud Computing Services: Opportunities and Challenges

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Abstract:

Advances in service oriented architecture (SOA) have brought us close to the once imaginary vision of establishing and running a virtual business, a business in which most or all of its business functions are outsourced to online services. Cloud computing offers a realization of SOA in which IT resources are offered as services that are more affordable, flexible and attractive to businesses. In this paper, we briefly study advances in cloud computing, and discuss the benefits of using cloud services for businesses and trade-offs that they have to consider. We then present 1) a layered architecture for the virtual business, and 2) a conceptual architecture for a virtual business operating environment. We discuss the opportunities and research challenges that are ahead of us in realizing the technical components of this conceptual architecture. We conclude by giving the outlook and impact of cloud services on both large and small businesses.

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1. Introduction

The idea of creating and running a business over the Internet is not new. Banks and large manufacturers are among the first in exploiting the electronic network capabilities to conduct business-to-business (B2B) interactions through technologies such as EDI [1]. With the introduction of the Web and the rapid increase of internet users in the early 1990s, companies such as Amazon and eBay were among the early entrants to the business-to-consumer (B2C) model of e-commerce. As the Internet is a fast, easy-to-use and cheap medium which attracts millions of users online at any time, today there are very few businesses that do not have a Web presence, and there are many small and medium businesses (SMBs) such as retail shops that solely offer their services and products online.

Looking at the enabling technologies, B2B and B2C e-commerce have benefited from many innovations in the Internet and Web. Moving from static content delivery to dynamic update of page content and the introduction of XML created the first evolution in the path to more efficient and interoperable running of electronic businesses. A main characteristic of using technologies of the Web 1.0 era is that almost all the backend IT systems are created, operated and maintained by the business owners. Motivated by business agility, operational efficiency, cost reduction and improved competitiveness, during the last decade, businesses have taken advantage of business process outsourcing (BPO) [2]. In BPO, businesses delegate some of the company's non-core business functionality such as IT operations to third-party external entities that specialize in those functions. It is estimated that by 2011 the world-wide market for BPO will reach $677 billion [3].

Up until recently, outsourced services were not necessarily fulfilled online. BPO has become attractive to both large and small businesses with the advent of service oriented computing [15] and specifically Web services and Web 2.0 [5] technologies. This has enabled offering of business process functions as online Web services and actively engaging customers via the Web [4]. It is estimated that BPO represents around 25% of the overall services market [3].

The next evolutionary wave in this space is *cloud computing.* Cloud computing refers to the offering of hardware and software resources as services across (distributed) IT resources [6]. As a relatively new concept, cloud computing and related technologies have rapidly gained momentum in the IT world. In this article, we study how advances in cloud computing impact the processes of creating and running businesses over the Internet. In particular, we investigate the question of whether the technology is ready to allow business owners to create and run a business using services over the Internet. We refer to this as a "virtual business" in which most or all of its functions are outsourced to online services. It should be contrasted to the concept of "*virtual enterprise*" [7] which often refers to creating a temporary alliance or consortium of companies to address certain needs with an emphasis on integration technologies, knowledge sharing, and distribution of responsibilities and capabilities.

In the following, we first give a short survey of advances in cloud computing, and through an example scenario, highlight trade-offs that businesses have to consider in moving to cloud services. Then, we discuss the requirements of an environment for creating and running virtual businesses, and present a conceptual architecture for such an environment. We study to what extent they can be realized. We also present challenges that are ahead of us in offering such an environment and provide an outlook of the impact of cloud services on businesses.

2. Cloud Computing: a Short Survey

Cloud computing has emerged as the natural evolution and integration of advances in several fields including utility computing, distributed computing, grid computing, web services, and service oriented architecture [6]. The value and originality of cloud computing comes from packaging and offering resources in an economical, scalable and flexible manner that is affordable and attractive to IT customers and technology investors. We introduce a framework to study and survey advances in cloud computing. It consists of four dimensions: cloud services, public vs private clouds, cloud service customers, and multi-tenancy as an enabler.

2.1 Cloud Services

As promoted by the vision of "everything as a service" [8] many products are now offered as services under the umbrella of cloud computing. We summarize them in the following.

Infrastructure as a service (IaaS): Hardware resources (such as storage) and computing power (CPU and memory) are offered as services to customers. This enables businesses to rent these resources rather

than spending money to buy dedicated servers and networking equipment. Often companies are billed for their usage following a utility computing model, where usage of resources is metered. As examples in this category, Amazon[1] offers S3 for storage, EC2 for computing power, and SQS for network communication for small businesses and individual consumers. HP FCS[2] (Flexible Computing Services) provides computing and storage infrastructure as services for businesses.

IaaS providers can allocate more computing power and hardware resources to applications on an as-needed basis, and allow applications to scale in a horizontal fashion (several machines running the same application with load balancers distributing the workload). This enables flexibly scaling up or down the amount of required resources on-demand. This is a valuable feature for companies with occasional large computation needs or sudden peaks in demand such as flash crowds. On the other hand, IaaS providers, e.g., Amazon EC2, offer virtual machines to customers where they can deploy and run their programs. Typically several virtual machines run on the same physical machine to address the problem of under-utilization of physical resources. Statistics show that 80% of computing power and 65% of storage capacity is not efficiently utilized, where a single company privately owns dedicated machines [9].

Database as a service (DaaS): A more specialized type of storage is offering database capability as a service. Examples of service providers are Amazon SimpleDB, Google BigTable[3], Force.com database platform and Microsoft SSDS[4]. DaaS on the cloud often adopts a multi-tenant architecture, where the data of many users is kept in the same physical table. Also, in most cases, the database structure is not relational. For instance, Microsoft SSDS adopts a hierarchical data model, and data items are stored as property-values or binary objects (Blobs). Google BigTable, Apache HBase[5] and Apache Pig[5] also provide abstractions, which allow users to save data in a key-value pair fashion. Each DaaS provider also supplies a query language to retrieve and manipulate data. However, not all support operations such as joins on tables (such as Apache HBase and Amazon SimpleDB).

[1] *www.amazon.com*

[2] *www.hp.com/services/flexiblecomputing*

[3] *labs.google.com/papers/bigtable.html*

[4] *www.microsoft.com/azure/data.mspx*

[5] *hadoop.apache.org*

Software as a service (SaaS): In this model, software applications are offered as services on the Internet rather than as software packages to be purchased by individual customers. One of the pioneering providers in this category is Salesforce.com offering its CRM application as a service. Other examples include Google web-based office applications (word processors, spreadsheets, etc.), Microsoft online CRM and SharePoint, or Adobe Photoshop and Adobe Premiere on the Web. Commercial applications in this category may need a monthly subscription per user (salesforce.com) or can be billed per use, both of which are considerably cheaper than owning and maintaining the software as an in-house solution. In this approach, there is no official software release cycle, and the customer is free from applying patches or updates as this is handled by the service provider. Customer data is kept in the cloud, potentially based on DaaS.

Platform as a service (PaaS): This refers to providing facilities to support the entire application development lifecycle including design, implementation, debugging, testing, deployment, operation and support of rich Web applications and services on the Internet. Most often Internet browsers are used as the development environment. Examples of platforms in this category are Microsoft Azure Services platform[6], Google App Engine[7], Salesforce.com Internet Application Development platform[8] and Bungee Connect platform[9]. PaaS enables SaaS users to develop add-ons, and also develop standalone Web-based applications, reuse other services and develop collaboratively in a team. However, vendor lock-in, limited platform interoperability and limitations of programming platforms in supporting some language features or capabilities are major concerns of using current platforms.

There are other types of capabilities that are offered as services in the cloud. Offering management, monitoring and integration as services are examples. In monitoring as a service, a third-party provider (e.g., Red Hat Command Center) observes SaaS applications or the IT network of an enterprise on behalf of a customer with respect to SLAs and reports performance metrics to the customer. Management as a service generally includes monitoring but adds responding to events rather than just reporting them. Providers of integration as a service such as Bungee Connect[9] and Boomi[10] aim at providing facilities

[6] *www.microsoft.com/azure/data.mspx*

[7] *code.google.com/appengine*

[8] *www.salesforce.com/paas*

[9] *www.bungeeconnect.com*

[10] *www.boomi.com*

(PaaS) to allow users to develop adapters and mappings that enable the interoperation of heterogeneous services or data.

Another important type of service that is offered on the cloud is people as services. Offering of services by people, e.g., their programming skills per hour on the net, is possibly as old as the Web itself. However, what is new in the cloud is there are people specializing in SaaS or PaaS platforms and offering consultation for businesses that need to use or customize SaaS solutions or integrate solutions from multiple SaaS providers. For example, Salesforce.com AppExchange opens up an opportunity for such people to offer their services.

2.2 Public vs private clouds

It can be argued that the cloud is the result of natural transformation of the IT infrastructure of enterprises over the last decade. The traditional IT architecture was based on having dedicated resources for each business unit in an enterprise. This model leads to under-utilization and waste of IT resources due to resource fragmentation and unequal distribution of workload. To overcome this, enterprises have implemented adaptive infrastructure techniques [10]. These include employing virtualization to address the under-utilization problem complemented with automation techniques to reduce the significant labor costs of IT operations. This type of cloud is called a “private” cloud as it is privately owned by enterprises. Examples of this category are clouds maintained by manufacturers such as Boeing or GM.

On the other hand, there are other cloud offerings (e.g., those provided by Amazon, Google, Microsoft and Salesforce.com) for public use. Some of these clouds e.g., those offered by Amazon and Google, are indeed extensions of their private clouds that are offered to the public. There are also cloud providers such as Salesforce.com that have created and offered cloud services solely for public use. It is interesting to notice that enterprises and large businesses are mainly the owners and users of private clouds, while public clouds are used by smaller businesses and millions of individual consumers.

In addition to cloud vendors, who own and operate cloud services, there are other providers called out-clouders (re-sellers). Out-clouders are gaining popularity and trying to acquire and re-sell unused computing resources of enterprises with private clouds [11]. Out-clouding is also a source of income for enterprises who rent out part of their IT resources which they are not utilizing efficiently.

2.3 Cloud service consumers

In addition to the coarse-grained categorization of cloud users as enterprises, SMBs and individual consumers, it is useful to identify and study various types of customers of cloud services. Understanding the target customers of cloud services and their requirements allows determining what type of services can be used by which customers. In general, cloud customers are of the following types: IT administrators, software developers, managers and business owners, and finally individual (business) users. Table 1 shows the distribution of various cloud customers for various cloud services.

Table 1.Cloud customers vs Cloud Services

Customer type	IaaS	DaaS	SaaS	PaaS	Others
IT administrators	Use to deploy images of existing software	Configure to store data	Only for administration use	N/A	Monitoring as a Service (to setup and monitor SLAs)
software developers	May use to deploy software	Store data	Mainly to browse and find existing services to reuse and add-ons	Main users of PaaS	Integration as a Service
managers and business owners	N/A	N/A	Occasional users to manage their business	N/A	Monitoring as a service (dashboards), May employ people as services
Business users	N/A	N/A	Main users of SaaS, may perform simple configuration tasks and use add-ons	N/A	

2.4 Multi-tenancy as an enabler

Multi-tenancy refers to sharing resources among users and/or applications. It is preferred over single-tenancy in cloud services due to higher utilization leading to cost reduction. Enterprises often have thousands of users but typically operate a variety of software environments and applications. Thus in private clouds multi-tenancy is often about having multiple applications and environments deployed on shared resources. In contrast, in public clouds there are millions of users and service providers try to minimize the number of software applications and environments. Therefore, multi-tenancy is about sharing resources among millions of users (e.g., keeping various users' data in the same table and secured). If public cloud providers offer PaaS, then a variety of application environments are also supported. In this case, multi-tenancy techniques need to enable sharing resources among volumes of applications and users.

3. CloudRetail as a Virtual Business

Exemplary scenario. As an example scenario, let us consider a small fictional company called CloudRetail, from the category of SMBs with a few hundred employees across the country. CloudRetail designs and sells fashionable and eco-friendly clothing and accessories. They use contract manufacturers but sell directly to their customers via their catalog and Website. Their core competency is eco-friendly product design quickly capitalizing on trends in the marketplace. CloudRetail runs software in-house for some functions, such as human resources, customer relationship management (CRM), and their customer-facing web site. They have an IT department which maintains the IT infrastructure inside the company. This IT infrastructure has grown more complex and expensive to maintain as it has grown with the company. It now includes dozens of servers, specialized storage and network equipment, and an ever-growing list of software, much of it to ensure smooth and secure operation of the company and the website.

CloudRetail invested heavily last year in website hardware and network bandwidth to be prepared for the rush of orders during the holiday shopping season. The vision of CloudRetail is to reduce operational costs and enhance focus on their core competencies by benefiting from the advances in technology, and if possible, to transfer all non-core business operations, including support functions, to external companies.

Evolving CloudRetail into a virtual business using cloud services. CloudRetail can take advantage of many existing cloud services including CRM, HR, IT infrastructure and the hosting and operation of their

website. Using cloud services provides the following benefits: (1) avoiding huge initial investments in hardware resources and software, (2) reducing ongoing operational, upgrade and maintenance costs, (3) scaling up and down hardware, network capacity and cost based on demand, (4) higher availability compared to in-house solutions for small businesses and individual-consumer maintained resources, and (5) access to a variety of software applications and features offered as SaaS that otherwise CloudRetail would have to purchase separately.

However, the potential risks of using cloud services include: (1) loss of direct control of resources and software, e.g., website infrastructure and operations staff for CloudRetail, (2) increased liability risk due to security breaches and data leaks as a result of using shared external resources, (3) decreased reliability since the service providers may go out of business, causing business continuity and data recovery issues, and (4) SaaS solutions are mainly built as one-size-fits-all customers, although there are sometimes add-ons to complement the functionality. CloudRetail is limited to the functionality offered by the SaaS proivders and it is hard to customize solutions based on its needs.

Besides considering the above trade-offs, the difficult questions to answer for CloudRetail are (1) which functions to move to the cloud in what order, (2) how to ensure a smooth migration process given legacy applications in their environment, and (3) how to find and select service offerings that meet their requirements and establish seamless interoperation between services. For instance, assume they would like to move their website operation, CRM, accounting, and HR systems to cloud services. Customer behavior information from the Web site has to be sent to CRM systems and the accounting function needs information from the Web site on sales and taxes. There is a need also for data integration solutions to migrate data from CloudRetail's legacy applications to cloud services.

Currently there is no environment to help CloudRetail in addressing the second and third concerns above, i.e., locating services, facilitating the process of using them and managing the whole lifecycle of engagement with cloud services. We discuss issues related to offering of such an environment in the next section.

4. Virtual Business Operating Environment

A large and increasing number of services are available most of which target small businesses and individual consumers (the long tail of service customers). The wide variety and low cost of cloud services provides an unprecedented opportunity and financial motivation for businesses to move their IT infrastructure to services in the cloud. There is a pressing need for an environment that allows SMBs and

individual consumers to create and run a virtual business using cloud services. We call this a virtual business operating environment. A natural question becomes whether and how it is possible to provide it as a service in the cloud?

4.1 Requirements of a virtual business operating environment

A virtual business operating environment provides facilities that allow business owners to build their business in a holistic way: define their business, express their requirements, find and engage cloud services that match their needs, compose services if needed, and monitor their business operations over outsourced services. In particular, it should provide the following sub-environments:

Business definition environment: This should allow the business owners to define the business, its structure (e.g., organization chart), goals and strategies in some form that can be tracked down to the service execution level and managed.

IT services marketplace: This refers to an environment where the requirements of users in terms of IT services can be captured, existing services could be advertised, and facilities to browse and find available services are provided. The services marketplace may support various business models of offering services, e.g., bidding for user tasks, pay-per-use or subscription-based payments.

Business services design, integration and composition environment: This refers to an environment where selected services from the marketplace can be configured, composed, new services developed if needed and deployed to IaaS platforms. Interoperation among services for both functional and non-functional aspects can be checked and integration solutions developed.

Business services management environment: Once the business services are designed, the management environment provides facilities to initiate the interaction with services, monitor and manage the interactions and provide reports to the business owners using business dashboards.

In the following, we present a conceptual architecture for a virtual business operating environment, and discuss how it can be realized.

4.2 Virtual business operating environment: Conceptual architecture

Business architectures have been extensively studied during the last thirty years. Frameworks such as Zachman[11] [12] and industry standards such as TOGAF[12] [13] describe enterprise architecture. In particular, the Zachman framework identifies a number of orthogonal (horizontal and vertical) aspects. The horizontal layers include contextual (goals and strategies of business), conceptual (high-level design), logical (system-level design) and physical (technology model) definitions for an enterprise. The vertical dimensions identify aspects that characterize each horizontal dimension. Other recent work also shows how a service oriented design and implementation of systems in an enterprise can fit in the Zachman framework [14]. However, these frameworks consider cases where the IT infrastructure and services are developed and deployed as in-house solutions. We present the business architecture in an outsourced service environment as depicted in Figure 1 and described in the following.

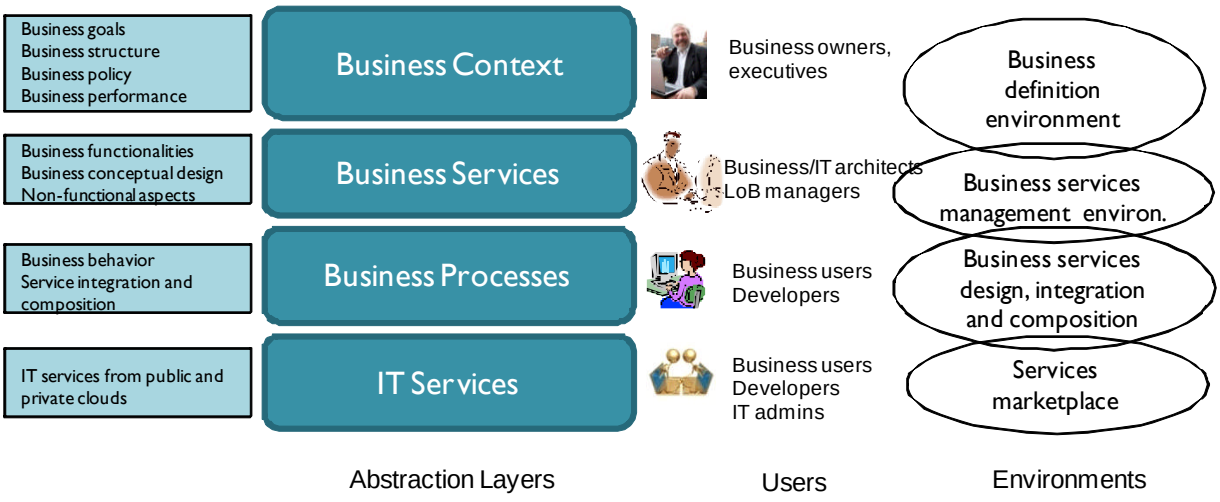

Figure 1. Business architecture in an outsourced services environment

We define the architecture of business in an outsourced services environment in four layers: *business context, business services, business processes and IT services*. Business context layer provides for the definition of business goals, strategies, structure, policies and performance metrics and indicators. The main users of facilities at this level are business owners and executives who are rarely IT experts. The major functions (supporting or core) of a business such as human resources, payroll, accounting, etc. are

[11] *www.zachmaninternational.com*

[12] *www.togaf.org*

defined as coarse-grained services, referred to as “business services” in the business services layers. Users such as business/IT architects may define or select the required business services from out-of-box business services blueprints. The IT services layer represents the services that are offered in the cloud. Finally, the business processes layer is the representation of selection, design, integration and composition of IT services in the form of workflows that fulfill the requirements of outlined business services. Figure 1 also shows the correspondence of sub-environments of a virtual business operating environment with the virtual business architecture, and the users of various layers/sub-environments.

4.3 Realizing the virtual business operating environment: Opportunities and challenges

Let us review how the current advances in SOA, cloud computing and existing standards and methodologies help in realizing a virtual business operating environment, and identify the limitations and challenges. Note that besides the new and unique challenges posed by offering and using services in the cloud, some of which we review in the following, many challenges of realizing a virtual business operating environment are related to locating, composing, integrating and managing services. Most of these are the same as those identified for general services in SOA [15]. In the following, we highlight why fresh solutions for tackling these problems are needed in the cloud services environment.

Business context layer: The Object Management Group (OMG, www.omg.org) has proposed a set of complementary business modeling specifications. In particular, the model of business outlined in the business motivation modeling (BMM) specification (v1.0)[13] can be considered as a baseline for the business context layer. It models a business having elements including “end” (vision, goals, and objectives of the business), “means” to realize the end (mission, strategy, tactics, and directives including business policies and business rules) and assessment elements to define and evaluate the performance of the business. It should be noted that for an SMB not all these components may be necessary, however, these provide guidelines that can be customized to define a business in a virtual business scenario.

Business services layer: Business services can be divided into three categories: common (found in most businesses such as HR or CRM), industry-specific (found in vertical industries of the same type of business) and company-specific (unique to the given business). The environment has to provide blueprints of business services in the above categories, and also allow businesses to define company-

[13] *www.omg.org/spec/BMM/1.0*

specific business services. These descriptions can be used to find services from the marketplace that may fulfill the requirements. There is some initial work on the definition of business services [16], however, a more thorough study is needed to capture various business-level properties and policies into this definition.

IT services layer: While there is a large body of work in SOA on IT service description, search and management based on both functional and non-functional aspects [15], the following challenges remain:

Service description and search: A first challenge is that not all services that are available on the Internet are described using Web services interfaces (e.g. WSDL) nor are they actually offered online. Some of these services only have textual descriptions with some form-based data entry for service request. Existing service search techniques are mainly focused on the interfaces (functional aspects) of services and only support Web services, e.g., UDDI[14] and Woogle [17], or are merely catalogues with keyword search, e.g., seekda.com. Innovative approaches in service search technology are required to combine techniques to consider Web services, REST services as well as services with non-structured and non-standard descriptions. These approaches also need to be highly scalable to index millions of services that will be available in the cloud and allow service seekers to pose potentially diverse constraints on service functionality as well as cost, performance, ratings, usage controls, regulatory requirements, and policies for data retention, transfer and protection.

SLA, data privacy and security concerns: A consequence of using services in the cloud is that the location where customer data is kept is out of the customer's control. Currently, there is no support for mandating specific data protection policies to service providers, e.g., where, how long and how data is kept. Another more serious issue is that there is no way to specify the policies on how sensitive data is shared among cloud service providers. Information is routinely leaked from sub-contractors with poor data management practices [18]. Indeed, there is a need for approaches to tag directly the data with security and privacy policies that would travel with sensitive data from one provider to another so that the proper technical controls can be employed by the various cloud providers to protect the data. As another issue monitoring service quality experienced by the customers of businesses that outsource functions to cloud services requires new techniques that ensure service providers follow the agreed upon service level agreements.

[14] *www.uddi.org/pubs/uddi_v3.htm*

Business processes and integration layer: Although there are significant advances in service and data integration [19,20] and service composition [21,22] in SOA, problems such as how to automatically discover various Web services (including services with text-based interfaces, people services, etc.) that collectively fulfill a business service, how to automatically compose services, and integrate data and services are among the hard challenges yet to be addressed [15]. Given that most SaaS users are business users (not expert IT people), there is a need for lightweight solutions for composition and integration, e.g., based on advances in mashups [2223], to address these problems rather than only relying on heavyweight solutions of conventional SOA that are targeted for enterprise settings and require expert users' intervention.

As an additional factor, there are millions of users in the cloud but fewer business cases in which services need to be integrated or composed. We anticipate that the integration and composition of services become recurring problems and their solutions are packaged as services that can be deployed in the cloud environment. Therefore, a prevailing approach is to exploit the power of crowd (service users), by exploiting advances in Web 2.0 [5], to allow reusing solutions that are ready-to-use with minor configuration or customization for new settings, or approaches based on capturing solutions as part of integration and composition patterns. Emerging cloud services for integration such as Boomi and Bungee Connect have taken the first step by providing pre-defined connectors between various SaaS and existing applications and also basic data mapping tools, however, they are inadequate for un-supported applications or complex or unstructured data models. To enable scaling such approaches to the diversity of applications on the Internet, a service and data integration development platform and marketplace has to be built that allows users (individuals, SMBs as well as enterprises) to easily develop, share, locate, customize and consume integration and composition solutions.

5. Discussion and outlook

Small businesses such as CloudRetail have already seen the benefits of using services in the cloud for most non-core functionality. Customers benefit from the economies of scale and the highly optimized IT operations of cloud service providers. The opportunity to avoid capital costs and incur predictable expenses which scale up and down with the current needs of the business is very attractive. Customers with occasional or bursty usage see tremendous benefits, as they only pay for resources when they are using them. Customers with stable usage patterns also benefit due to the lower cost of purchasing services than building them in-house. Unless IT is a core competency of the business, most customers

will not be able to attain the same capabilities cheaper by doing it themselves. As one example, Google's corporate email solution is, on average, ten times less expensive than in-house email solutions.

We envision that the low cost of using cloud computing is a key driver of its wide acceptance by individual consumers, SMBs as well as large enterprises. However, large enterprises will employ a hybrid cloud model in which both private and public clouds are present. Many enterprises will run mission-critical applications and store business-sensitive data in the private clouds, while outsourcing their supporting services to the public cloud.

The role that IT staff is playing in the enterprises and businesses is also undergoing a significant transformation due to the push for further BPO based on cloud services. As most IT staff move from business IT departments to service providers, the role of remaining staff converts into support and consultation for service selection, engagement and management.

In terms of usage of services in the cloud, small SMBs and individual consumers will be the main users of IaaS, DaaS, SaaS and PaaS. Enterprises may demand customization of services as the APIs provided by service providers may not offer the flexibility and features they require. In addition, they may demand instances of services to be deployed in their private clouds for the sake of keeping data onsite and retaining control. This can be seen as a transformation of how enterprises use commercial software as services in the cloud.

The virtual business operating environment for creating and conducting virtual businesses using cloud-based services is a missing piece and the current article lays the foundation of architecture for an environment that addresses this pressing need for businesses that intend to use cloud services.

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