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Migration to Windows Azure – Analysis and Comparison

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Abstract

Cloud computing turned utility computing into a reality. Organizations may currently pay only for what they use, in computing power or storage capacity, as well as in electricity or other utilities. This enables a reduction of the investment in IT and leads to the more efficient use of datacenters, while allowing organizations to focus on the IT services they need to hire. To be able to fully benefit from the advantages of the cloud computing, organizations need to migrate their current applications to the cloud. After a brief introduction to cloud computing and to the Microsoft Windows Azure platform, this paper analyzes the migration of an on-premises web application, used on a secondary vocational school, to the cloud. It then compares the application's performance when deployed to a traditional Windows server versus its deployment to Windows Azure.

Keywords: Cloud Computing; Windows Azure; Application Migration; Performance Comparison.

1. Introduction

Businesses are, nowadays, supported by a more or less inter-related and integrated pile of corporate applications. These applications are typically installed on corporate datacenters, which need to be sized for the

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maximum instantaneous processing weight and to a mid to long time storage dimension. This situation leads to the underutilization of physical servers in most corporate datacenters, which, because of inefficient power consumption and space utilization, are becoming a liability [1]. In fact, it is estimated that in average, 90 percent of Windows-based production servers run below 10 percent average utilization [2], and server overcapacity is costing IT organizations over $140 billion [1, 3].

Cloud computing made utility computing, as it was uttered at MIT in the early 1960s, a long waited reality. Currently it is possible for organizations to pay only for what they use, in computing power or storage capacity, as well as in electricity or other utilities. This makes possible to reduce corporate's investment amount in IT, because organizations need not invest in datacenters sized for the maximum capacity they think they will ever need, leading to the more efficient use of shared datacenters. This also enables organizations to focus on the IT services they need to hire, being confident that the hired IT services will elastically grow or shrink according to the services usage needs.

To be able to fully benefit from the advantages of the cloud computing, organizations need to migrate their current applications to the cloud, by hiring IT services deployed in one of the cloud computing service models, which are addressed in the next section. After a brief introduction to cloud computing and to the Microsoft Windows Azure platform, this paper addresses the migration of an on-premises web application, developed for a secondary vocational school, to the cloud. The process of migrating a "traditional" Windows server Web-based ASP.Net application to Windows Azure is established and the application's performance in both platforms is compared and analyzed. To note that also the application's database is migrated from an on-premises SQL-server installation to SQL Azure.

The rest of this paper is organized as follows: the next section introduces the characteristics and service and deployment models of cloud computing. Section 3 introduces Windows Azure platform. In section 4, the application migration process to Azure is reported, and in section 5, a performance comparison and analysis is made between the on-premises Windows server deployment and the Windows Azure deployment of the referred application. Section 6 concludes the paper.

2. Cloud computing

Cloud computing involves a paradigm shift, both because the location of processing and data storage changes from the organization's computers to servers on the internet [1, 4], and because computational resources used have an elastic processing power and high availability, enabling one to talk about a new computational model [5].

Indeed, cloud computing is defined by the U.S. National Institute of Standards and Technology (NIST) as a "model for enabling ubiquitous, 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" [6]. This cloud model is composed of five essential characteristics, three service models, and four deployment models. The five essential characteristics are [6]:

- On-demand self-service, that is the unilateral provision of computing capabilities (e.g., server time, network storage) as needed, without requiring intervention of the service provider.
- Broad network access. Capabilities are accessed through standard mechanisms and by heterogeneous client platforms (e.g., mobile phones, tablets, laptops, and workstations).
- Resource pooling. Computing resources (e.g., storage, processing, memory, and network bandwidth) are pooled, by the provider, to serve multiple consumers using a multi-tenant model. The customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter).

- Rapid elasticity. Capabilities can be elastically provisioned and released, to scale depending on consumer's demand. The capabilities available typically appear to be unlimited, from the consumer's viewpoint.
- Measured service. Cloud systems automatically control and optimize resource use by leveraging a metering capability at a level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts).

Service Models define the kinds of services provided by the service provider and are summarized in Table 1.

Table 1. Service models in cloud computing [6].

Service Model	Description	Resources managed by the consumer
Software as a Service (SaaS)	The consumer uses the provider's applications running on a cloud infrastructure.	Possibly, user-specific application configuration settings.
Platform as a Service (PaaS)	The consumer deploys to the cloud infrastructure applications created or acquired by him/her, libraries, services, and tools supported by the provider.	User has control over the deployed applications and, possibly, some configuration settings for the application-hosting environment.
Infrastructure as a Service (IaaS)	The consumer is able to deploy and run arbitrary software, which can include operating systems and applications, to the storage, networks, and other computing resources provided by the provider.	User has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

In every service model, the consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, with the possible exception of user specific configuration settings for the provided applications, in the case of SaaS, or the provided application-hosting environment, in the case of PaaS. In the IaaS model, the consumer also does not manage or control the underlying cloud infrastructure but has control over the operating systems, storage, and deployed applications.

In what concerns to the possession and management of the cloud infrastructure, four deployment models can be considered [6, 7]:

- Private cloud. The cloud infrastructure is thought of for exclusive use by a single organization. The infrastructure may exist on or off premises, and its ownership, management and operation responsibility may be of the organization, a third party, or some combination of them.
- Public cloud. The cloud infrastructure is aimed at the general public, and exists on the premises of the cloud provider. It is owned, managed, and operated by a cloud service provider organization.
- Hybrid cloud. The cloud infrastructure is a combination of two or more distinct cloud infrastructures (private or public) that are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).
- Community cloud. The cloud infrastructure is aimed at a specific community of consumers from organizations or groups with shared concerns. Its ownership, management and operation may be the responsibility of one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.

3. Windows Azure Platform

Windows Azure is provided by Microsoft as a Platform as a Service. This platform works as an operating system and provides developer-accessible services for creating applications and storing data [8, 9], and instead of being installed on one server, it spans several hundreds of servers. Its main elements are Windows Azure, SQL Azure, and Windows Azure AppFabric.

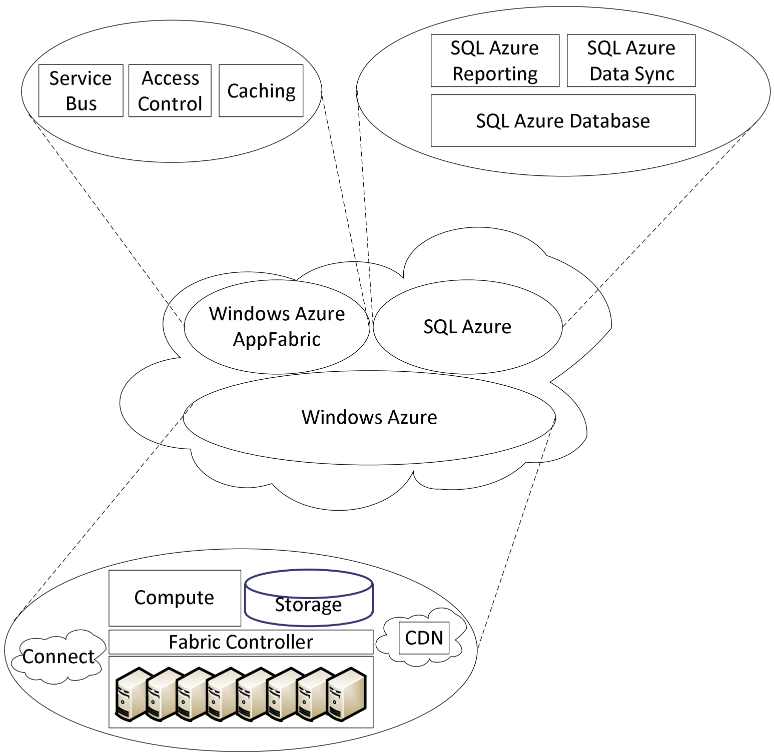

Fig. 1. The Microsoft Windows Azure platform (adapted from Mell and Grance, 2011).

3.1. Windows Azure

The Windows Azure element, of the Azure platform, comprises five main components [8, 9], as depicted in Fig. 1.

3.1.1. Compute

Windows Azure Compute provides developers with a platform for running, storing, and managing applications. These applications may be developed through the use of one or more types of components (named roles). There are three types of roles [9, 10]:

- Web Roles. Their main goal is to present website contents, and for that web roles fully support IIS, enabling to run several sites in one web role. Tasks that are needier of computational resources should run in a worker role.
- Worker Roles. Are aimed at executing tasks that need higher computational resources. Communication with other roles may be accomplished through the use of MessageQueues.
- VM Roles. In contrast to the previous two roles, VM Roles are not at PaaS level. A VM role provides services at the IaaS level, functioning as a virtual machine that allows to put in the cloud an image of an on-premise solution. This facilitates the process of adopting the cloud by organizations, as it allows migrating to the cloud the same applications that were previously on premise.

Applications may be developed with the .Net framework, by using C#, VB.Net, or other supported languages, or they can be developed without the .Net framework in languages such as C++, Java or PHP.

3.1.2. Storage

The storage service enables storing resources in the cloud in a secure and scalable way. Those resources may be named files, such as documents, images or video, together with relevant metadata information, or may be structured or semi-structured information. There are three forms of storage provided as data services available through an HTTP API [9, 11]:

- Binary Large Objects (BLOB). It's the simplest way of storing named files in Azure, being prepared for storing high volumes of data (each file can be up to 1TB).
- Tables. Ideal for storing high volumes of structured data, being able to use a query language for querying them. This is not, however, related to the relational model, as the table storage service provides no SQL support, nor foreign key constraints or other relational capabilities. Data is stored in the form of entities with properties, corresponding to massively scalable tables that are replicated for preventing data loss, and may be partitioned across several machines to improve query performance.
- MessageQueues. Used for asynchronously changing messages between two roles.

3.1.3. Fabric Controller

As mentioned before, Windows Azure runs on a countless number of machines (nodes). The main task of the Fabric Controller is to provide a single view of the whole, over which Compute and Storage services are based. The Fabric Controller monitors the state of the hardware and the state of each application so that, in case of a node failure, every affected application may be restarted on the same node or a different one [11].

3.1.4. Content Delivery Network

Content Delivery Network (CDN) is commissioned to seamlessly keep cached copies of frequently accessed data replicated in servers around the world, in order to being able to rapidly provide that data to users.

3.1.5. Connect (Virtual Network)

It allows to access cloud applications as if they were inside the secure intra-network of the client organization. It enables to create a direct connection between the cloud-based platform and the organization's datacenter, or to integrate the cloud-based services with the directory services in the organization.

3.2. SQL Azure

The SQL Azure element of the Azure platform provides scalable and reliable storage services for relational databases. SQL Azure is based on SQL Server 2008 R2, lacking it some functionality, though, not supporting, for instance, database mirroring, user-defined types, distributed transactions, and naturally Windows authentication mode [9, 11].

In structural terms, SQL Azure comprises the following main components [9] (recall Fig. 1):

- SQL Azure database – It is a cloud-based database management system, and represents Microsoft's proposal for relational databases in the cloud. It is based on SQL Server but has the advantage of not requiring, from its users, the burden of installing and maintaining its infrastructure. It supports storing data both from on-premises applications and cloud-based applications.
- SQL Azure Reporting – Adds reporting and business intelligence features to SQL Azure. It is a cloud version of SQL Server Reporting Services.
- SQL Azure Data Sync – Based on the Sync framework, its main function is to make database synchronizations between SQL Azure and on-premises databases.

3.3. Windows Azure AppFabric

Windows Azure AppFabric works as a cloud-based middleware layer, in the sense that it may be used to integrate existing applications, being very helpful in situations of hybrid clouds. The main components of the Windows Azure AppFabric are [9, 11]:

- Service Bus – Simplifies the process of putting services on the Internet for other applications (cloud-based or not) to use. Each service, meaning any generic server-side application, is exposed through a URI, which clients can use to locate and access the service.
- Access Control – The diversity of authentication mechanisms that can currently be used, like Active Directory, Google accounts, or Windows Live ID, among others, can pose complex challenges to the applications that intend to support them. Access Control aims to simplify this process by providing support to all of them, establishing itself as the place for defining access rules.
- Caching – One way to speed up applications that repeatedly access the same information is to cache that information. Additionally, AppFabric caching provides a convenient way to share session state variables between different Azure computing instances, as we will see in the next section.

4. Application migration to Azure

This section addresses the migration to the Azure platform, of a .Net Web application, deployed on premises, that we can see as representing the set of applications currently installed in organizations. In order to fully benefit from the advantages of PaaS services on the cloud, these applications need to be migrated to cloud datacenters.

The application being migrated, developed with Visual Studio .Net 2010, and making use of SQL Server 2008, aims to manage complaints and instances of noncompliance that arise in a secondary vocational school, which is certified ISO 9001 [12]. According to this certification, all issues and nonconformities must be registered and treated accordingly, and it must be possible for the person who triggered the complaint or nonconformity issue to be able to trace its treatment process. The application makes use of ASP.Net membership functionality to address users' authentication and authorization.

Generically speaking, and considering that there is a great compatibility between the source and target platforms, the application migration to the Azure platform involved the following steps [12, 13]:

- Migrate the application database from SQL server to SQL Azure, for which SQLAzureMW v3.7.7 was used. This migration wizard allows to analyze the source database in order early detect incompatibilities with SQLAzure, and then generates a migration script.

- Modify the on-premises application's database connection string, so that it works on the new cloud database.
- Convert the source Visual Studio Web Application project into a Windows Azure Web Role project, and test the new project in order to assure that it runs in the local development fabric.
- Create the application deployment package for Windows Azure, in Visual Studio, and load it to a newly created hosted service in the Windows Azure subscribed platform.
- Test the application deployed to Windows Azure.

This migration process was carried out without major problems. To note that, as Microsoft only accepts SLAs with at least two instances (http://www.windowsazure.com/en-us/support/sla), the web role for the application in Azure, must have at least two instances. An instance is a way of horizontally scale the application, meaning to empowering it to being able to cope with many simultaneous accesses. The existence of more than one instance, however, raises a problem related to the use of the session state by the application. Since Windows Azure will balance load between the available instances, and these aren't able to share the session state, the application ceases to work. The work around was to use the Azure AppFabric caching service as described in [9, 12].

5. Analysis and Comparison of results

After having migrated the application to the cloud, we need to compare the performance results in order to assess the advantages in terms of performance between deployment in the cloud and deployment on-premises. For that, we deployed the application both to an on premises server and to Windows Azure. To have an additional comparison term, we have also deployed the application to Somee's "traditional" web hosting solution (www.somee.com). The only difference, naturally has to do with the deployment package (instead of deploying an Azure Web role project, to the on-premises server and to Somee a Web site project has been deployed).

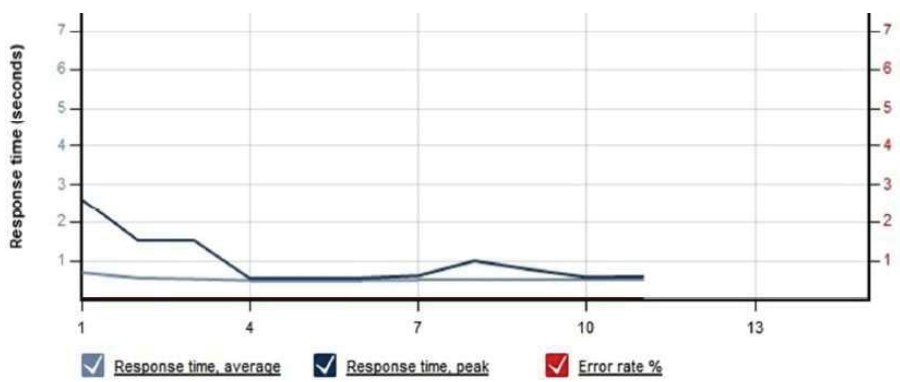

Fig. 2. Performance test results for application deployed in Windows Azure platform (Costa, 2011).

Having the three deployments in place, the conditions to compare performance results are created. For comparing their performance, the LoadStorm's solution (www.loadstorm.com) for load tests has been used. LoadStorm allows the creation of test scenarios, simulating a sequence of user tasks on a web application, and then run those test scenarios on the application. A few seconds after the test starts, with one simulated user, LoadStorm starts to create concurrent users and each user executes the test scenario.

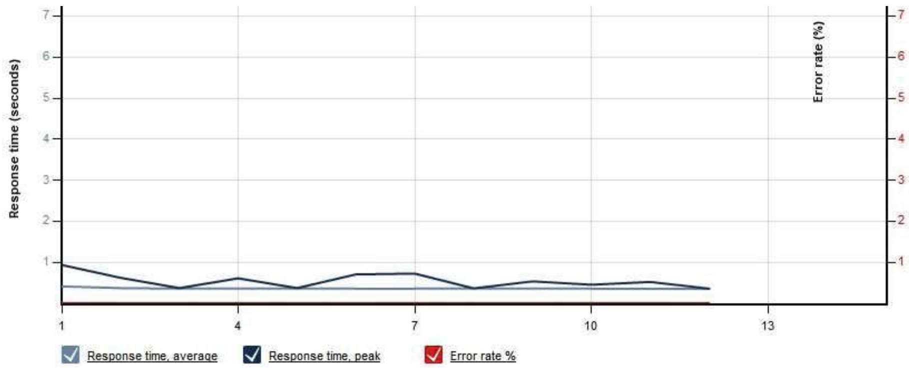

Fig. 3. Performance test results for application deployed on-premises.

Fig. 4. Performance test results for application deployed in Somee [12].

The performance tests' results are depicted in the graphics in figures 2 to 4. Each graphic shows, in the x axis, the number of simultaneous virtual users sending requests to a server, and in the y axis, the response time average, for all simultaneous users, and the response time peak, for the user that waited longer.

The performance comparison involved, then, the creation of sets of equal test scenarios invoking several pages of each one of the deployments. Given the access profile for the application deployed, no more than 25 simultaneous accesses to the application are expected, and that was reflected in the test scenarios. These test scenarios were run on the three systems being compared, and figures 2 to 4 show the results obtained when running one of those test scenarios on the Windows Azure, the on-premises', and the Somee's application, respectively.

The test results of the Azure's and on-premises' solutions show that the response time peaks were low, and similar, between less than 1 second and 2,5 seconds, and didn't suffer with the increase in the number of users. While the results of the Somee's application show a response time peak of around 6 seconds with five simultaneous users. The main reason is that the Somee's web hosting solution, as the on-premises one, doesn't scale horizontally, while the Azure's solution is able to take profit from the two installed instances assured by the SLA.

6. Analysis and Comparison of results

More than a technological solution, cloud computing must be seen as a business innovation catalyst, an opportunity for business process reengineering, leveraging organizations' focus on their core business. Also, the transformation paradigm from investing in IT infrastructures and maintenance to paying for IT services, enables the access of SMEs (small and medium-sized enterprises) to a range of IT services that were previously only accessible to bigger companies.

Through a small case study, we have shown that application performance doesn't deteriorate when migrating applications to the cloud. This is mainly because cloud based applications benefit from elastic resources that grow and shrink according to the user needs. So, at least the same performance for applications and other IT services, or even a performance increase in cases where more simultaneous users exist, is expected when migrating to the cloud. Other major benefits for adopting the cloud for deploying new and existing systems are savings on the purchase of equipment and software, and reducing maintenance and administration costs of IT, the reduction of energy consumption, because the computing center and information storage are not on-premises, better protection against disasters, because cloud services providers typically implement fault tolerance mechanisms, such as data replication, redundant connections or multiple data centers, and access to the information and applications from anywhere and through various devices.

There are, however, some issues that companies must consider before acquiring cloud services. These are usually related to security and mainly privacy issues, because although wanting to benefit from the advantages of the cloud, users want to keep control of their data [14]. Building data-protection as a cloud service may be a way of protecting user data [15]. Other aspects that must be considered before acquiring cloud services have to do with legal and regulatory concerns, like the physical location of customers' data, and the lack of standards compliance by cloud services providers [11].

Migration to the cloud will be, however, primarily accomplished for non-critical business applications, enabling to assure organizations that their core business will not suffer from migration errors, security faults or lack of data privacy. This time frame will allow organizations to gain experience with cloud services usage and will enable research advancements to address remaining issues.

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