Cloud Computing and Business Intelligence

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The complexity of data resulting from business process is becoming overwhelming for the systems that don't use shared resources. Many aspects of the business process must be recorded and analysed in a short period of time with no errors at all. In order to obtain these results, so that management and other departments know what their next decision/job will be, there must be a continuous exchange and processing of information.

"Cloud Computing" is the solution to overcome the problem of processing large amounts of data. By using this technology organizations have the benefit of using shared resources from various systems that are able to face large amount of data processing. This benefits does not only resume to a high performance system but also the costs of using such architecture are much lower.

Keywords: *Cloud Computing, Business Intelligence, shared resources, hardware architecture, SaaS, PaaS, IaaS*

Introduction

In the past decade Business Intelligence systems have evolved to a level that software solutions overwhelmed traditional hardware architecture. By traditional I refer to the simple model that organizations used to store their data in-house on a server (or multiple ones) and process it with the existing software. Business Intelligence solutions offer these days a complex overview of the business process. They integrate software that is able to process, store and analyze data from various departments. A Business solution not only integrates specialized software but also consists in a custom built hardware architecture that is able to handle the amount of processes that result from software operations.

In order to adapt hardware architecture to software solutions, the costs of building and maintaining such system can get extremely expensive. In this case, financial factors are decisive in whether the benefits of such investment worth it comparing to the costs of it. Ideal in this case is to implement Business Intelligence software solutions into a shared hardware resources environment. To accomplish this, "Cloud Computing" solutions where developed so that the costs of implementing custom software solutions that helps the business process will be lower. The Cloud Computing environment is based on a simple but effective principle: resource sharing. This principle helps companies and other organizations to share complex system architecture in order to implement the solutions that they need. This practice raises an important ethical matter that refers to whether this sort of solution provides privacy or not. From a theoretical point of view organizations that share the same Cloud environment can't access each other data because the software implemented is designed not only to handle the processes that was designed for, but is built to ensure a certain level of privacy regarding the data that is working with.

Cloud solutions providers offer maintenance for their clients. This service can cover both hardware and software problems that can appear. For the clients, this ensures a continuous workflow that is reflected into the business process.

By using Cloud Computing, organizations experience cost-effective solutions that will not put pressure on their financial planning regarding investments comparing to the

classical model where companies invest in datacenters and the maintenance of those.

In almost every aspect, using a Cloud environment to implement software solutions is a gain to organizations.

2. Cloud Computing

Cloud Computing, simply described, represents a pool of systems that are connected into a network and provide a scalable infrastructure so that software systems and data can take use of it. By using this type of solution the cost of implementing software solutions and storage of data is reduced significantly.

To have a better understanding of what Cloud Computing represents we have to compare it to traditional concepts such as grid computing.

Grid Computing (**Fig. 1.** Grid Computing –> Simple model) represents the use of resources from many computers connected in a network to solve a single problem at the same time. The problem with grid computing is that if one system fails there is a high risk of others to fail. Cloud Computing (**Fig. 2.** Cloud Computing) tries to overcome this issue by using all the systems in the network as a whole so that if one system fails, another will automatically replace it.
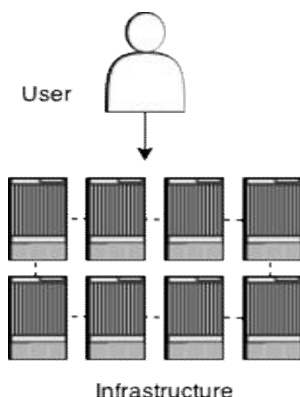

Fig. 1. Grid Computing –> Simple model

Grid computing can be compared to a "super computer" which consists of multiple systems that are connected into a network so the resources can be used in order to handle a single problem. The systems that take part in such infrastructure can be scattered around the globe.

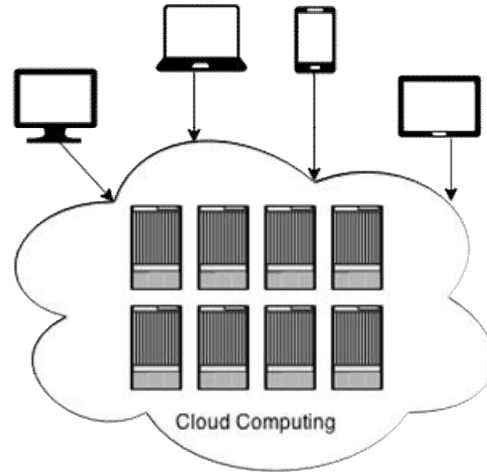Cloud Computing can be described as an evolved grid computing infrastructure.

Fig. 2. Cloud Computing

Cloud resources can be reallocated on demand to fulfill the client needs. For example, some countries don't allow storing of user data outside their border. In order to accomplish that, cloud providers can create an infrastructure that can reside in that country. Also, cloud infrastructure can be extremely flexible and can offer for example multiple time zones to work with. If the cloud solution is located in Canada it can be used by European clients because it can adapt to different time zones.

2.1 Cloud Computing – Characteristics

Cloud solutions can be described as having high scalability, agility, high availability and reliability and multi-sharing.[1]

Regarding the "High scalability" characteristic, this refers to enabling the use of resources for a large pool of users that have different needs. The agility characteristic is the one that describes the response time of the system regarding the tasks that are submitted by users. In this case, the response time is very short considering the complexity of the infrastructure.

A cloud infrastructure is also highly available and reliable. Thus, the

organizations/users that take advantage of the speed and scalability of the system can also enjoy a very high rate of availability for their implemented solution. Also, cloud infrastructure is very reliable because is continuously adapted to the user needs. The multi-sharing characteristic describes the defining part of cloud computing. This is the main purpose of this technology: resource sharing for the users that are using it.

2.2 Cloud Computing – Models
Cloud computing providers offer service according to client needs. Based on this, the implemented cloud solutions are cost-effective and reliable. There are three Cloud Computing models (**Fig. 3.** Cloud Computing -> Models):

- **Infrastructure as a service (IaaS)**

The IaaS providers offer physical or virtual machines that are able to fulfill customer needs to implement software solutions on it. It also provides various resources such as firewalls, load balancers, software solutions and many more. This type of service offers a great advantage to clients that need a solid and flexible infrastructure. It can also provide the security that they need. This model helps users deploy their own software at reduced costs. Another advantage of using IaaS is that users can deploy and

maintain the operating system of the infrastructure. Thus, the provider is not forcing the clients to use a specific OS. Usually the clients pay only for the resources allocated for their implemented solution, without worrying for hardware maintenance.

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

This type of model has installed already an operating system, a programming language, a web server, etc. This is probably the most common type of cloud that is used because it facilitates the implementation and testing of software solutions. This model also provides the needed resources for an application to run. The resources are automatically allocated so that the user does not need to do that manualy.

- **Software as a service (SaaS)**

The SaaS model is described as a pay-per-use service where the providers offer clients a fully configured (hardware and software) solution. To access this, clients must pay a subscription fee. The advantage of using this system is that clients don't have to worry about any maintenance, hardware or software. The SaaS provider is taking care of that for the client.

For a better understanding, SaaS can provide access for a company to a BI solution. For this, the company will pay a monthly or yearly subscription that will depend on the customization of the BI solution and/or the resources allocated for that company.
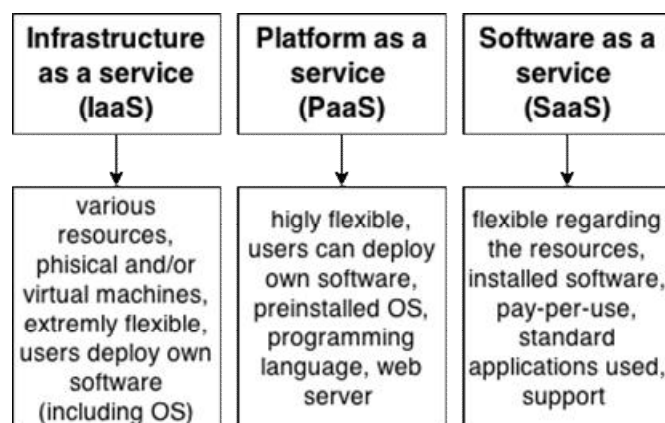
Infrastructure as a service (IaaS)	Platform as a service (PaaS)	Software as a service (SaaS)
various resources, phisical and/or virtual machines, extremly flexible, users deploy own software (including OS)	higly flexible, users can deploy own software, preinstalled OS, programming language, web server	flexible regarding the resources, installed software, pay-per-use, standard applications used, support

Fig. 3. Cloud Computing -> Models

There are three main types of Cloud deployment (**Table 1.** Cloud Computing -> Deployment):

- **Public Cloud** – which generally means that is open for public use. Users can store data on it without having the privacy that a secure network provides. This type of Cloud can also be offered as free to use. The main concern is privacy because providers don't guarantee it.

- **Private Cloud** – this is an infrastructure that is used by one user/company. This can reside whether internally the company building (data center) or externally (provider). This is a highly secured Cloud and is preferred by most companies because, when is resided externally, maintenance can be offered by the provider. Another advantage is the resources allocated to a single client. By doing this, the infrastructure is custom built to offer great performance and stability.

- **Hybrid Cloud** – this is a combination of private and public Cloud. By doing this, users can specify which data resides on public Cloud and which on private. The advantage of using Hybrid Cloud is that the expenses can be reduced. The data is aggregated from both sources in order to provide the results that users needed.

Table 1. Cloud Computing -> Deployment

	Public Cloud	*Private Cloud*	*Hybrid Cloud*
Cost	free	depends on resources allocated	lower than Private Cloud
Security	low	high	moderate
Flexibility	high	very high	very high
Resources	high	high – based on needs	high – based on needs

There is also a fourth deployment type of Cloud which is called **Community Cloud**. This is refers to a Cloud infrastructure that is used by a group of organizations that share data on it. Such type of infrastructure is used by government institutions, universities from a region or even country, suppliers, etc.

The security provided on this type of Cloud is similar to that on a Private Cloud because in reality is a Private Cloud that is shared by numerous entities that share the same purpose.

2.3 Cloud Computing – Obstacles and Opportunities

The obstacles of Cloud Computing can be cataloged in terms of adoption, growth, policy and business.[2]

One of the first obstacles that need to be overcome in Cloud Computing is data privacy. To many, keeping data on a shared infrastructure raises a privacy issue. Even thought that data can only be accessed with specific software under specific security circumstances (password protected, encryption, etc.), this is not enough.

The cloud user takes responsibility for the software security that he implemented in the Cloud environment. This is a problem because in a closed and controlled infrastructure (such as intranet), the user can only access the system from within the network. A solution like this can provide

enough security because it can't be accessed from outside the trusted network. Cloud is not able to do that, even though the service provider is ensuring the security of the infrastructure by adding firewalls and other hardware or software solutions that prevents outsiders from stealing data. In most cases this is efficient but there are situations in which Cloud users are victims of phishing sites and/or emails. For example if a company uses a customized BI implemented in Cloud to which its employees login solely with username and password than if anyone that have those credentials can login into the system. Unfortunately users are not always careful and whether they use easy or common passwords or they complete phishing forms.

In this case, Cloud provider can't be held responsible. If the security of the Cloud infrastructure is affected, data from many clients may be exposed to risk.

Another security issue is protecting the user from the provider. This means that the provider can access all the data that is stored on the infrastructure and do what he wants with it, although is illegal. To protect clients from that they can use software that allows them to encrypt sensitive data. By doing this, even if the provider has access to data he can't use it since he is unable to read it. By encrypting data the user might experience some issues in the response-time of the implemented software because on one side the information is encrypted and transmitted to cloud infrastructure (**Fig. 4.** Cloud Computing -> Data encryption). This process must be reversed in order for the information to be read by the user.

Another obstacle in the use of Cloud computing is software licensing. Software providers usually sell their software with a license/machine. Since in Cloud there is a pool of machines that are working at the same time this type of license can't be applied. Cloud providers are using, in general, open source software. Software developers are

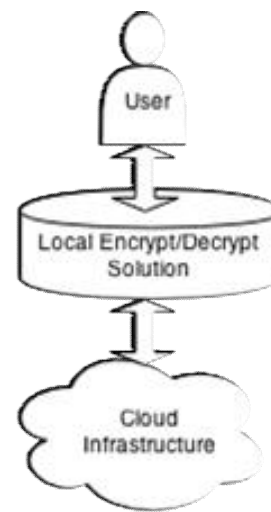starting to change their license agreement so that the software they create can be used in a Cloud environment.

Fig. 4. Cloud Computing -> Data encryption

2.4 Cloud Computing – Conclusions

Using a cloud infrastructure can have a lot of benefits in terms of costs. From small sized business to a large corporation, cloud computing can be the best solution for implementing commercial or open source software. Another upside of using cloud services is that this type of infrastructure is highly scalable which means that will always fulfill your software need for resources. Also, by using an external cloud system (from a provider) will keep organizations from spending money on maintenance and also on data redundancy (backup). The backup solution is very useful in case of system failure. This will allow the user to recover his data with no workflow interruption.

Cloud computing provides great flexibility regarding software implementation. Whether the user need an infrastructure that provides only hardware capabilities, with no software installed on it or he needs BI software ready to use in cloud, a cloud provider can offer that.

Unfortunately, when information resides on a hard drive that the user does not posses, security issues might appear. Most of these concerns gravitates around one question: *Are your data private?* The answer to this

question is not only a *yes* or *no*, instead is another question: *How important are those data to you?* By answering this question plenty of software and hardware solutions can be used so that sensitive information won't go into wrong hands. The problem with high security is that it involves high costs. Also, implementing security solutions might generate additional cost for local hardware implementation. It can also affect the response time of data transactions, independent from the cloud infrastructure.

Software licensing is another issue that software companies must handle. They have to allow their clients to use the software in a cloud environment. Changing the license agreement by making it independent from the number of machines that is used on might be a solution. Also, they can sale their products for two types of environments: one that is dependent on the number of machines that is being used on and another that can be called "Cloud licensing" and will need a proper verification by the vendor.

The need for using cloud computing is growing and will soon become imperative. Giving the fact that information and processes grow exponentially each year, sharing resources is the answer that can solve many problems.

3. Cloud BI or integrating Business Intelligence solutions into Cloud

3.1 What is Business Intelligence?
The term business intelligence or simply BI represents a set of software tools and hardware infrastructure that has the purpose to offer support in the strategic planning of a corporation. BI systems provides for the company solutions to gather, store and analyze data in order to help in decision-making.
Most companies gather large amount of data from different departments using numerous software solutions. Is hard to put all that data together and use it in the decision-making process if is not filtered previously. Here is where BI solutions help. These solutions can offer a quick and readable overview of data from different departments. The data can be easily analyzed and can be used in the decision-making process.

BI software is designed to extract important data from raw data in order to reveal insights that can help a manager (and not only) take faster and accurate decisions. Business intelligence software uses features like data mining, statistics and predictive analytics that can reveal certain patterns.

For a complete usage of BI capabilities, BI must be flexible and must provide various facilities for employees, teams and total organization levels.[3] This means that the software provided must be able to grant access for all the employees to structured data that concerns their line of work.

BI solution is helpful for remaining competitive. Having the necessary information will help a company to assess its weaknesses and strengths. Also is helpful to make correct predictions so that management will take decisions that will help the business to reach its goal (**Fig. 5.** Business Intelligence -> Business goal)
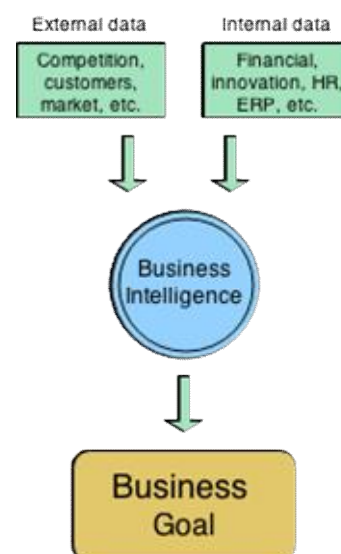

Fig. 5. Business Intelligence -> Business goal

Business Intelligence software is able to provide detailed reports to the management based on the information collected from various sources, internal or external.

Implementing a successful BI solution is also related to information relevancy that is processed. Working with raw data is time consuming and extremely hard. To avoid analyzing useless data the perfect solution is to use custom software for each department that is involved in the business process. After this objective is achieved, the BI solution implemented will provide accurate results.

In deploying a BIS there are many risks involved: system design, data quality and technology obsolescence.[4] The system design of BI plays an important role in order to obtain all the information necessary for the decision-making process. If there is one area that is not covered by the BI processing and analytics tools this might result in an erroneous report that can jeopardize the reach of the business objective.

Also, data quality is of high value. As stated before, the quality of information determines the quality of the results. This is also important for predictive reports.

Technology obsolescence is an obstacle in the path of reaching the information and processing it. While a company grows the amount and complexity of data that needs to be processed becomes so big that the hardware architecture which was designed five years ago is now obsolete. In this case the hardware system is not the only one affected by the growth of a company. The BI system will start having flaws.

3.2 Integrating Business Intelligence software into Cloud

Integrating a BI into a cloud environment will overcome the technology obsolescence problem. By doing this scalability will be achieved. In this case, no matter how much the data complexity and amount from a company will evolve a BI integrated into a cloud infrastructure can handle it.

Integrating BI into Cloud is an advantage to a company not only for its scalability but also for elasticity and ease of use. By elasticity I refer to the ability of a BI to continuously absorb information from newly added software. For example, a company decides at a point that it needs an online helpdesk for its customers. This can be implemented in cloud and integrated into BI processes in a very short time, with no need for purchasing additional hardware, such as servers, so that helpdesk software will run on. The ease of use of a Cloud BI is determined also by the ease of access of BI software on various devices. Implementing a web solution for helping the decision-making process has the advantage of being able to access it whether the user resides in the company or anywhere else. This will keep users that are on the move permanently informed. This provides also accessibility. The BI can be accessed on any web browser. Shimaa Ouf and Mona Nasr suggest that BI solutions can be moved to cloud using PaaS. [5] By using platform-as-a-service model a BI solution can be implemented in a short period of time. The solution can take advantage of the PaaS preinstalled software such as relational database software. Users will not engage into a continuous software managing and patching activity. The database platform that is present on cloud is scalable so it will meet the needs of resources available to handle an organization information volume.

Also, another advantage that Cloud provides to BI integration is reduced costs. Sharing resources will result in a lower cost per machine. Also, hardware maintenance will be handled by the cloud provider as well as the implementation of hardware firewalls and load balancers to handle the traffic towards the data center.

Availability of BI solutions is another gain for companies that chose to integrate it into Cloud. By availability I refer to the so called "up-time" of a service. Cloud infrastructure is capable of working regardless of a system

failure. Also, cloud providers ensure their internet connectivity by one or more alternate connection so if one fails, another will take over the traffic.

Pros and cons regarding the integration of a BI solution into Cloud

Pros:
- Scalability and elasticity;
- Reduced costs;
- Ease of use and access;
- Cloud relational database;
- Availability;
- Hardware maintenance.

Cons:
- Privacy;
- Government regulations (where applied).

As stated before in the Cloud Computing section of this article, privacy remains an issue. BI solutions are not an exception. The security provided by BI solutions is only at an UI (user interface) level. The data stored on Cloud database is exposed to the provider.

Government regulations are, in some cases, a barrier in the migration of BI solutions of companies to a Cloud infrastructure outside the border. This represents a downside in terms of cloud computing expenses. The Cloud providers that are located in the same country with an organization might have higher costs than foreign providers.

Eumir P. Reyes describes a basic BI architecture based on cloud infrastructure in his paper "A Systems Thinking Approach to Business Intelligence Solutions Based on Cloud Computing". (**Fig. 6.** Cloud BI or integrating Business Intelligence solutions into Cloud -> Basic Architecture).
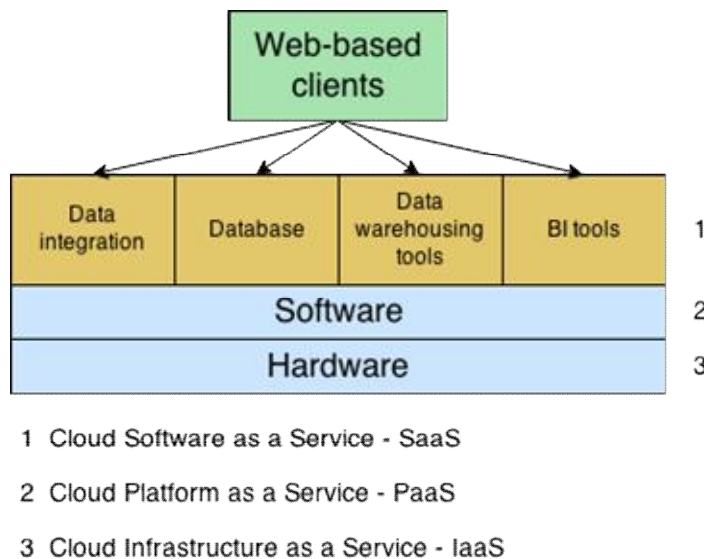

Fig. 6. Cloud BI or integrating Business Intelligence solutions into Cloud -> Basic Architecture [6]

Reyes takes the architecture of a BI in Cloud further than Shimaa Ouf and Mona Nasr did. Reyes considers that a BI solution is located in a SaaS model.

Cloud computing providers offer fully integrated BI solutions that are capable of fulfilling most of the companies' needs regarding BI software. By doing this, a company has the advantage of externalizing this type of service. In this case there is no need for software maintenance at all or any other backup concerns. Any software update will be handled by the Cloud provider.

There is another advantage in using web based BI software. Web development is gaining more and more control and traditional software programs are replaced by web based software. A huge advantage in web developing is the use of frameworks. This accelerates the software building process and eases the future developing of modules for the software created. Also, web based software allows users to access data from almost any device through a web browser or a specially designed application. Developing BI solutions with web technology can also reduce the costs of resulted software. In some cases there can be no costs at all.

4. Conclusions

Cloud computing represented, for a few years now, the leading technology in terms of scalability and flexibility. Using shared resources offers a great advantage for an expanding company. This is also reflected in investments. By not investing a lot into hardware architecture and the maintenance of it will allow organizations to expand much faster by investing into innovation, marketing, etc.

Integrating Business Intelligence software into a Cloud environment is necessary if the organization wishes to gain an advantage. This solution will provide a company the necessary tools to get in front of its competitors.

The ease of use and access that a Cloud BI offers will allow the employees to have mobility without harming the decision-making process.

Still, the primary concern of using a Business Intelligence solution in a cloud environment is related to privacy. This issue will persist until a viable solution will be found. This solution might be encryption software that can reside in Cloud.

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