Role of Cloud Computing for Implementation of ERP in SMEs

Dr. S. S. Bhatia[1], Vikram Gupta[2]

[1]Assistant Professor, PG Department of Computer Science, GSSDGS Khalsa College, Patiala, India

[2]Research Scholar, Department of Computer Science, Uttrakhand Technical University (UTU), Dehradun, India

Abstract: *The present paper compares technologies used in the architecture of Enterprise Resource Planning (ERP) Systems to evaluate the benefits and advantages of emerging technologies. The emerging technologies, Cloud Computing, Software as a Service (SaaS) and Multi-Tenancy, could significantly alter the current ERP space and become a primary part of ERP Systems of the future. A survey was sent to industry professionals to obtain feedback on their company's ERP Systems and to collect their comments on these new technologies. The survey results and related analysis show that Emerging Cloud ERP Systems outperform Traditional Legacy ERP Systems in all important characteristics - Accessibility, Business Cost, Implementation Time, Mobility, Scalability, Upgradability, and Usability. Cloud Systems were also found to have a shorter implementation time and a larger proportion of Cloud Systems were on the most recent version of software. Furthermore, industry professionals identified Cloud Computing, SaaS and Mobility as the emerging technologies of the coming decade. The present demonstrates that there are significant benefits for companies to use ERP Systems that use the emerging technologies and that the shift to Cloud ERP Systems has begun.*

Keywords: Enterprise Resource Planning, ERP, Cloud Computing, Multi-Tenancy, Software as a Service

1. Introduction

Cloud Computing, the delivery of computing as a service rather than a product provided to computers as a utility over the Internet is a technological shift that is sweeping across the IT landscape. The term Cloud Computing was first used in its current context in 1997 in a university lecture by Ramnath Chellappa. In 1999 Salesforce.com became the first major company to use this new technology in their Customer Relationship Management software, followed by Amazon in 2002, Google in 2006 and Oracle in 2010. Cloud Computing has currently taken off as a revolution to IT infrastructure. Enterprise Resource Planning (ERP) Systems were developed and implemented dating back to the late 1980s and early 1990s. The invention of the ERP System made it possible to integrate business processes throughout an organization. These integrated processes allowed the computing system to then manage and automate tasks for the ERP users. The integration of an ERP System throughout an organization enabled both internal and external customers to more easily share information with one another. Gartner, the world's leading information technology research firm, has estimated that 55% to 75% of all ERP projects fail to meet their objectives. Due to advances in computer technology both in software and hardware, the fundamentals of how to design an ERP System have changed. Modern approaches involving emerging technologies allow for a ground up rethinking of the infrastructure used to develop these systems. The foremost emerging technology Cloud Computing was leading the way in redefining ERP Systems. Two other emerging technologies, Multi-Tenancy and Software as a Service (SaaS), were identified as critical to support Cloud Computing. Multi-Tenancy is a form of software architecture where a single instance of the software runs on a server serving multiple client tenants while SaaS is a software delivery model in which software and its data are hosted online where a client can access their data through the Internet. The literature review identified further study was needed for new Emerging Cloud ERP Systems that can take advantage of all three of these emerging technologies.

2. Literature Survey

2.1 Importance of ERP Systems

Enterprise Resource Planning (ERP) Systems integrate information across an entire enterprise, both internally and externally, to allow for a seamless flow of information. These systems can consist of one full end-to-end integrated system, a few partially integrated systems, or many best-of-breed systems depending on the organizations requirements. These systems can connect an entire organization from manufacturing, human resource management, sales and service, customer relationship management, project management, finance, etc. This connectivity facilitates the flow of information across departments, business processes and business functions. It allows an enterprise to better function as a single entity rather than as many separate departments and work processes. An ERP System running on location with a single tenant was appropriate given the technology and infrastructure of its time but as technology advances so should ERP Systems evolve to take advantage of new technologies. Since the time when software vendors first build the initial Extended ERP System in the early 1990s, a lot has changed. The Internet was commercialized in 1995 when NSFNET was decommissioned and this has had a dramatic impact on how individuals access information. Through the Internet people are now interconnected all over the world. New technologies that leverage the Internet now have dramatic benefits for companies. The emerging technologies explored in this thesis wouldn't be possible without the Internet's advance.

2.2 Emergence of Cloud Computing & SaaS

Cloud Computing is the delivery of computing as a service rather than a product where shared resources, software, and information are provided to computers as a utility over the Internet. The concept of Cloud Computing refers to both the infrastructure and the ability to deliver the application over the Internet. Cloud Computing can be separated into three main areas: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). When discussing the service aspect of Cloud Computing, it is referred to as Software as a Service (SaaS). SaaS is a software delivery model in which software and its data are hosted online where a client can access their data through the Internet. With SaaS, Cloud providers install and operate software in the Cloud and the users access the software through the Internet. The user does not manage the software infrastructure or the platform on which the application is running. This eliminates the need to install and run the software on an on premise computer which simplifies maintenance and support.

2.3 Emergence of Multi-Tenancy

Multi-Tenancy is a form of software architecture where a single instance of the software runs on a server serving multiple client tenants. In Multi-Tenancy software architecture an organization's data is served as a single instance by a hosted application that many customers use. This instance of an organization's data is referred to as a tenant. This allows multiple tenants of different organization's data to be based on the same shared hardware and software infrastructure. Each of these tenants has the ability to be configured to the degree that is allowed by the software infrastructure but not usually provide a high degree of customization. This means that different data, business processes, reports, and securities can be set up for each tenant but the organization cannot customize the application code.

Multi-Tenancy is one of the main emerging application infrastructure technologies that are being leveraged to support Cloud Computing and SaaS. An important aspect of this technology is the fact that a SaaS provider can run one instance of the application of an organizations database and through the Internet allowing an unlimited number of customers to access that data. This means that Multi-Tenancy allows for the ability of the ERP System to scale with the organizations it supports. This technology is also important because it allows service providers to leverage the economies of scale to achieve significant cost savings. Software development and maintenance costs are all shared with this model. Infrastructure and hardware costs are also shared allowing for significant cost savings. The shared costs are a key difference from the single-tenancy model. In a Single-Tenancy model the infrastructure and software has to be maintained by an organizations internal Information Technology (IT) team. The internal IT team is also tasked with keeping the ERP System current with technology changes. This is also an important advantage of Multi-Tenancy architecture because the service provider only has to make one update to keep every tenant on the same version of the software (Guo et al. 2007). Since the service provider can update all tenants at the same time, this means that every organization can be on the latest version at all times.

3. Research Methodology

Literature review was performed to establish a basis for ERP Systems and the emerging technologies. To expand on the current research, available in the literature, an industry survey was conducted that presented questions to industry professionals. The survey used the literature review as a guideline when proposing questions for the industry survey. Industry professionals were asked questions about each of the ERP Systems they had worked with or had experience using. Each respondent was asked 41 questions plus a possibility of extra questions depending on their responses. Questions focused on information about the industry professional's company, characteristics they found important in ERP Systems, their company's current and prior ERP Systems, and their opinion on ERP emerging technologies. To enable industry professionals to easily respond a website was established and professionals were invited to participate in the survey. In order to prevent fraudulent submissions the survey could only be accessed by the link provided to the participant. All submitted data was stored in an online database that was then downloaded into an Excel file once the survey was closed. A hypothesis was created based on current ERP technologies and the literature review on ERP emerging technologies. The hypothesis that ERP users could benefit from ERP Systems that use emerging technologies was formulated based on this information. Based on the developed hypothesis this research aimed to bridge this gap. The analysis method illustrates each type of analysis conducted in this thesis. T-Tests, Analysis of Variance (ANOVA), Proportion and Chi Square tests were primarily used to establish significance from the survey results. T-Tests tests were performed about different ERP characteristics to see if Cloud Systems rated better than Legacy Systems. ANOVA tests were performed on the important characteristics. Proportion tests were used to determine if there was a difference in population proportions for the type of ERP System, the company's size and the company's type of industry. Chi Square tests were applied to see if there was an association in the ERP Systems a company used based on the attributes of the ERP users company. Also, descriptive statistics were performed to obtain basic information on the results.

4. Analysis of Data

4.1 Descriptive Statistics: Rating

Variable Characteristic	Mean	Std Dev	Median
Rating Accessibility	4.132	0.844	4.000
Business Cost	3.947	0.804	4.000
Implementation Time	3.658	0.878	4.000
Mobility	3.289	1.137	3.000
Scalability	4.079	1.100	4.000
Upgradability	3.737	0.978	4.000
Usability	4.289	0.898	5.000

This descriptive statistics for the level of importance ERP users rated each characteristic in the survey. In the Industry

Survey the industry professional was asked "What characteristics are most important in your company's ERP System?" The survey respondent then rated the seven characteristics in the table from Unimportant-1 to Critical-5. The characteristic that had the highest mean rating was *usability* while the characteristic that had the lowest rating was *mobility*. This data shows which characteristics ERP users see as the most value in ERP Systems they use.

Two-Sample T-Test and CI: Cloud, Legacy

	N	Mean	Std Dev.	SE Mean
Cloud	15	4.267	0.799	0.21
Legacy	58	3.21	1.09	0.14

Difference = mu (Cloud) - mu (Legacy)
Estimate for difference: 1.060
95% lower bound for difference: 0.633

T-Test analysis when comparing user ratings for the characteristic *accessibility* to the type of system. The Question was asked the ERP user to rate how well their system performs for the characteristic *accessibility*. The response to this question is then compared to whether the ERP System the user was rating is an Emerging Cloud System or a Traditional Legacy System. A p-value of 0.000 indicates that there is a very low risk of making Type I error (incorrectly rejecting the correct null hypothesis). With this low p-value we can conclude that the mean levels of satisfaction for a Cloud System and a Legacy System are statistically different. With a mean of 4.267 for Cloud Systems and a mean of 3.21 for the Legacy Systems, users of the Cloud Systems were more satisfied with the *accessibility* of their company's ERP System.

T-Test of difference = 0 (vs >): T-Value = 4.22
P-Value = 0.000 DF = 29

ANOVA Analysis

ANOVA tests performed in the analysis
S = 0.9557 R-Sq = 10.02% R-Sq(adj) = 7.94%

Source	df	ss	ms	f	p
Characteristics	6	26.353	4.392	4.81	0.000
Error	259	236.553	0.913	-	-
Total	265	262.906			

S = 0.9557 R-Sq = 10.02% R-Sq(adj) = 7.94%

Level	N	Mean	Std.dev.
Accessibility	38	4.1316	0.8438
Business Cost	38	3.9474	0.8036
Implementation cost	38	3.6579	0.8785
Mobility	38	3.2895	1.1368
Scalability	38	4.0789	1.0999
Upgradability	38	3.7368	0.9777
Usability	38	4.2895	0.8977

Grouping Information Using Tukey Method

Characteristics	N	Mean	Grouping
Usability	38	4.2895	A
Accessibility	38	4.1316	A
Scalability	38	4.0789	A
Business Cost	38	3.9474	A
Upgradability	38	3.7368	A
Implementation Time	38	3.6579	A
Mobility	38	3.2895	B

Means that do not share a letter are significantly different.

The results of ANOVA comparing user ratings for the importance of each of the seven characteristics: *Accessibility*, *Business Cost*, *Implementation Time*, *Mobility*, *Scalability*, *Upgradability*, and *Usability*.

A p-value of 0.000 indicates that there is a low risk of making Type I error (incorrectly rejecting the correct null hypothesis).

With this p-value we can conclude that the mean level of importance of the various characteristics is statistically different. A Tukey Test has shown that the rating of the characteristic *mobility* is statistically different than all other characteristics. With a mean of 3.2895, *mobility* was rated as the least important characteristic. All other characteristics share a letter in the Tukey Test which means these six characteristics are not statically different from one another even though variations occur in their ratings.

5. Findings

The objective of this investigation was to determine if ERP users could benefit from systems that use emerging technologies relative to Legacy Systems. A number of important findings were revealed from the survey results and related statistical analysis. These findings are as follows:

- Industry professionals were asked to rate how well their company's ERP System performed for each of the seven characteristics: *Accessibility*, *Business Cost*, *Implementation Time*, *Mobility*, *Scalability*, *Upgradability*, and *Usability*. These responses were then compared to whether their company's system was an Emerging Cloud System or a Traditional Legacy System. All seven T Test showed that there was a statistically significant difference between the rating of Cloud Systems and Legacy Systems. In all seven statistical tests users has a higher level of satisfaction with Cloud Systems compared to Legacy Systems.
- ERP users were asked if their company's ERP System was on the most recent version of software. These responses were then compared, with a test of differences between two proportions to whether their company's system was an Emerging Cloud System or a Traditional Legacy System. The analysis indicates there is strong evidence that the two proportions are statistically different. The test found that a statistically larger amount of Emerging Cloud ERP Systems are on the most recent version of software. This finding validates material that was discovered in the literature review regarding the advantages of a Multi-Tenancy Cloud ERP System.

- An ANOVA analysis has shown a statistical difference between the levels of importance for the characteristic *scalability* based on a company's size. A follow-up Tukey Test has shown that the mean rating for a large and small company are statistically different, while a medium sized company is not statistically different from a large or small company. Large companies rated *scalability* statistically more important than small companies.

6. Conclusion

ERP users also rated Emerging Cloud ERP Systems with higher satisfaction than Traditional Legacy ERP Systems in all seven important characteristics - *Accessibility*, *Business Cost*, *Implementation Time*, *Mobility*, *Scalability*, *Upgradability*, and *Usability*. The survey results obtained for this study, and the related analysis, indicate that users of Emerging Cloud ERP Systems are significantly more satisfied with the performance of their company's system in all of these important characteristics.

References

[1] Armbrust, Michael, Armando Fox, Rean Griffith, Anthony D. Joseph, Randy Katz, Andy Konwinski,Gunho Lee, David Patterson, Ariel Rabkin, Ion Stoica, and Matei Zaharia. *Above the Clouds: A Berkeley View of Cloud Computing*. 10 Feb. 2009. UC Berkeley Reliable Adaptive Distributed Systems Laboratory.
[2] Bezemer, Cor-Paul, Andy Zaidman, Bart Platzbeecker, Toine Hurkmans, and Aad 't Hart. "Enabling Multi-Tenancy: An Industrial Experience Report." *2010 IEEE International Conference on Software Maintenance* (2010).
[3] Guo, Chang Jie, Wei Sun, Ying Huang, Zhi Hu Wang, and Bo Gao. "A Framework for Native Multi- Tenancy Application Development and Management." *The 4th IEEE International Conference on Enterprise Computing* (2007). Print.
[4] Forrester Research, Inc., Cambridge, MA.Hossain, Liaquat, and Jon D. Patrick. "The Evolution of ERP Systems: A Historical Perspective." *Enterprise Resource Planning: Global Opportunities & Challenges*. By Mohammad A. Rashid. E. Chocolate Avenue: Idea Group, 2002. pp1-16.
[5] Herbert, Liz, and Jon Erickson. *The ROI Of Software-As-A-Service*. 13 July 2009.
[6] Kim, Won, Soo Dong Kim, Eunseok Lee, and Sungyoung Lee. "Adoption Issues for Cloud Computing." *Proceedings of the 7th International Conference on Advances in Mobile Computing and Multimedia* (2009): pp2-5.
[7] Lenart, Anna. "ERP in the C loud – Benefits and Challenges." Ed. Stanisław Wrycza. *Research in Systems Analysis and Design: Models and Methods*. Berlin, Heidelberg: Springer-Verlag GmbH Berlin Heidelberg, 2011.pp39-50

Author Profile

Dr. Sarvjit Singh Bhatia is working as Assistant Professor in Department of Computer Science, GSSDGS Khalsa College, Patiala, Punjab, India. His Academic Area is ERP. He has done M.Tech.(IT), Ph.D. and has Professional Experience of 16 years of Teaching the Under Graduate and Post Graduate Classes. His area of Research interest includes Interface of ERP with Cloud Computing. His Research Papers are as follows

- Empirical Study on the Implementation of ERP in SMEs(International Publication).
- Framework for the implementation of ERP in SMEs(National Publication).

Books Published:
- Data Communication and Computer Network
- DBMS with MS-Access
- Programming in C
- Data Structure Using C / C++
- Computer System Architecture

Vikram Gupta is working as Assistant Professor in Department of Computer Science, GSSDGS Khalsa College, Patiala and doing Research at Uttrakhand Technical University (UTU), Dehradun, India. He has done Bachelor of Engineering *(Computer Technology) and* Master of Technology (IT). He has Professional Experience of 16 Years of teaching the Under Graduate and Post Graduate classes. The area of Research interest includes: Interfacing ERP with Cloud Computing.

Books Published:
1) Programming Fundamentals Using C
2) Simplified Approach to Information Technology
3) Programming in C and Data Structure
4) Relational Database Management System with Oracle.
5) Computer Application for Business
6) Computer Programming & Problem Solving Through C (Kalyani Publishers)