# Cloud Computing: "Another Buzzword" or "Leveraging Technology?"

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**Abstract**
Cloud computing is the latest buzzword in the computer world, but many maintenance professionals do not understand what it is or how it can help their operation. "The Cloud" promises unprecedented levels of efficiency, uptime, and transparency for maintenance professionals. Is cloud computing the way of the future, or is it something that is already available today? How can a maintenance operation use cloud computing to improve plant performance? Can maintenance professionals leverage this technology and revolutionize the predictive maintenance industry?

**What is Cloud Computing?**
Cloud computing is a hot topic these days. Every IT, software, hardware, and Web company is using this buzzword in its marketing. The term is so widely used, and rarely explained, that it leaves many non-computer professionals scratching their heads. The confusion is due in part because the term "cloud computing" can mean many different things. Every company has its own spin on what cloud computing is and how it can benefit customers. Because the term is used in so many different contexts, it is difficult to define.

At least one organization has put a definition to the term cloud computing. According to the National Institute of Standards and Technology (NIST):

> "Cloud Computing is a model for enabling 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."[1]

What does this mean? In laymen's terms, cloud computing is a way to make computer resources available over the Internet to anyone with a network connection. These resources can come in many forms. The resource could be a server, a network, or software as long as the intended user can quickly and easily gain access over the Internet. Typically, these resources are provided by a vendor on a subscription or rental basis without any capital expenditures necessary on the part of the client. NIST further specifies three service models for cloud computing:[2]

- Infrastructure as a Service (**IaaS**)
- Platform as a Service (**PaaS**)
- Software as a Service (**SaaS**)

The first two models are only used by computer professionals and are beyond the scope of this paper. For the purposes of this paper, wherever the term cloud computing is used, the SaaS model is assumed.

**What is Software as a Service (SaaS)?**
With the Software as a Service (SaaS) model, the client pays a subscription to use software. All other tasks associated with maintaining the software are handled by the provider. These tasks include software updates, data backups, server maintenance, etc. The SaaS model is the most commonly encountered by non-computer professionals and offers the most benefits and cost savings.

The term "cloud" comes from the idea that the user does not see or touch the physical equipment that powers a cloud-computing system. So, what is a cloud-computing system made of? Today, large server farms power many web-based software systems. A server farm is multiple connected servers that function as a large "super computer." The server farm can instantly scale by powering up or down servers as needed without interruption to service. Multiple software systems can run on a single farm. As more computing power is needed more servers are added to the farm without downtime. During low-use periods like nights or weekends, many of the servers in the farm can be powered off to conserve energy. This also allows maintenance activities to take place without impact to the user. As demand increases, more servers are brought online to meet the users' needs.

Cloud computing is one of the few computer innovations to start at the consumer level and then migrate to enterprises.[2]

> "Most IT innovations start in the enterprise and go to customer. This one is going to enterprise from consumer." —Geoffrey Moore, TCG Advisors.[2]

Some of the oldest, most well-known, cloud-computing systems are consumer products. Google Gmail, Facebook, Windows Live Hotmail, and YouTube are all examples of cloud computing, more specifically SaaS, in the consumer market. Hotmail, one of the first Web-based email systems, officially launched July 4, 1996, symbolizing freedom from client-ISP based email and the ability to access a user's inbox from anywhere in the world.[6] By February of 2009, Hotmail reported over 30 million users worldwide.[6]

Today, both private and public institutions are making a similar switch. The City of Los Angeles now uses Google Apps, an integrated email and document system by Google, for its 30,000 employees.[4] Los Angeles joins the ranks of many other notable institutions using Google Apps for their email, including the University of Notre Dame, Motorola Mobile Devices Division, and Arizona State University. A host of cloud-based business systems are available on the market. There are cloud-based alternatives to most any traditional client-server software systems. Salesforce.com, a Customer Relationship Management (CRM) system using the SaaS model, has become one of the most popular CRM systems available today. According to Gartner, a leading IT research firm, 30% of new customer service and support application investments will be through the SaaS model.[3] It is likely that other business systems will follow the same evolution.

**Advantages of Cloud Computing**
The most noticeable and immediate benefit of cloud computing is the elimination of capital costs. Without on-site servers and expanded IT infrastructure, the up-front capital investment is often zero dollars. This is a huge advantage when making a business case for a cloud-based system.

In addition, the ongoing operating costs are also reduced greatly. There are a wide range of savings estimates, some of which are much more optimistic than others, spanning from 39% to 90% operating savings.[4] There are many well-documented cases demonstrating a combined implementation and operating cost savings in the 20% to 40% range.[7] An analysis by the City of Los Angeles in its move to Google Apps found five-year costs were reduced by 23.6%, saving over $5.4 million.[4]

These operating cost reductions are a direct result of increased efficiencies. In many companies, servers run at 15% to 20% of their capacity.[5] A cloud-provider can easily consolidate the usage of a system from many companies to a set of servers that is sized to match the workload. A cloud provider can also control the load on their servers even as demand fluctuates. By sharing fewer computing resources among a larger group of users, operational efficiency is increased. In addition, the manpower to maintain the systems is utilized more efficiently. With traditional client-server systems, maintenance and support activities may require 5% to 10% of one IT person's time. A cloud provider can utilize almost 100% of their IT person's time, which creates an increase in manpower utilization and efficiency. Granted, with a traditional system, the IT person would have other tasks to perform when they are not supporting the system. With cloud computing, multi-tasking is reduced and the IT department is free to focus on more important activities.

In addition to the obvious and direct cost savings, there are other indirect savings and benefits associated with cloud computing. For example, most cloud computing vendors perform maintenance upgrades routinely with zero downtime. This means that users receive the benefits of new features and enhancements without interruption to operations. In addition, cloud providers have many fail-safes in place for power, network, and servers. Because of this, many providers guarantee a level of uptime that is difficult to achieve with a single, client-owned server. All of this adds up to more productivity for the users.

Another benefit of cloud computing is ubiquity. A cloud system is available from anywhere that has an Internet connection. Some systems are even available via mobile phone or iPod. Because the same, high-security standards are imposed no matter where the users are connecting from, there is little risk of exposing the system and data to attack or theft.

Other risks are also minimized by using the cloud. Costs and performance are predictable because pricing and Service Level Agreements (SLA's) are written into the contract. There will not be any unforeseen costs associated with hardware failure or data recovery services. The vendor bears the burden of these costs and is better protected against these hazards in general. Even if a hard drive fails, the system will failover to a redundant data drive. The cloud provider would then hot-swap a new hard-drive without impact to the customer. All of this is driven by the vendor's need to meet their contractual obligations.

**How Cloud Computing Applies to the Predictive Maintenance Industry**

Drawing on the NIST definition, a fourth model can be defined specifically for the Predictive Maintenance (PdM) industry: Expertise as a Service (EaaS).

In this model, expert diagnostic knowledge is delivered via the cloud. For the PdM industry, those reaping the most cloud-computing benefits are combining EaaS with SaaS.

To do this, vendors are providing the hardware and software needed for their solution via the Internet (SaaS) and then leveraging their own setup to also deliver diagnostic expertise (EaaS) on a much larger scale than ever possible. This combination is enabling vendors to maximize the benefit and efficiency of their cloud-based PdM program by delivering highly-skilled diagnostic knowledge to a wide audience without any physical travel by analysts. This combination of models lets maintenance staff and analysts access the PdM software over the Web and then perform whatever tasks are relevant to them. While the analyst accesses the software to review data to detect faults, the plant manager accesses it to see the analyst's recommendations and assess the health of his entire fleet based on the latest data.

The success of any PdM program rests on the ability of an analyst to make the correct interpretation of volumes of vibration data. In general, it takes about two years for a new analyst to hone his or her skills to be reasonably proficient at diagnosing machine faults. It is common for in-house analyst positions to have

high turnover as proficient analyst are promoted or seek better job opportunities. As a replacement is trained, there is a two-year cycle in which the diagnostic accuracy of the predictive maintenance program suffers. In addition, it is well documented that today's highly skilled analysts are retiring at a steady rate and there are few replacements coming up the ranks from the next generation.

Cloud-based PdM programs enable plants to access highly skilled analysts provided by the vendor. It brings the data to the analyst rather than the analyst to the machine. Plants need only train their maintenance staff to collect vibration data and upload it to the vendor's secure cloud-based system. While there is a slight learning curve, anyone familiar with the machines can be taught to collect and upload data with just a few days ~~or weeks~~ of~~r~~ training. The analyst can then view this data via the Internet, thus eliminating the need for costly travel. It also enables one analyst to serve multiple customers since all customer data can be reviewed securely from a centralized Web-based system. Further, the analyst can review and diagnose from anywhere in the world, as long as there is an Internet connection.

Another huge benefit to the EaaS model relates to delivering the right skills for the problem at hand. An in-house analyst's skills are limited to the types of equipment and problems with which he or she has had experience. By delivering expertise via the cloud, a vendor with a stable of analysts can deliver the person with the expertise that matches the customer's need.

**Revolutionizing PdM**

The predictive maintenance industry stands to gain more from the cloud revolution than most any other industry. To date, PdM systems have been primarily isolated to individual laptop and desktop computers. PdM was completely left behind in the client-server boom of the 90s. By moving to the cloud, PdM systems will reap all of the cloud advantages previously outlined in addition to all of the client-server advantages that these systems have yet to achieve. The move to the cloud will also be easier than for other industries since PdM has not made a large investment in traditional client-server systems.

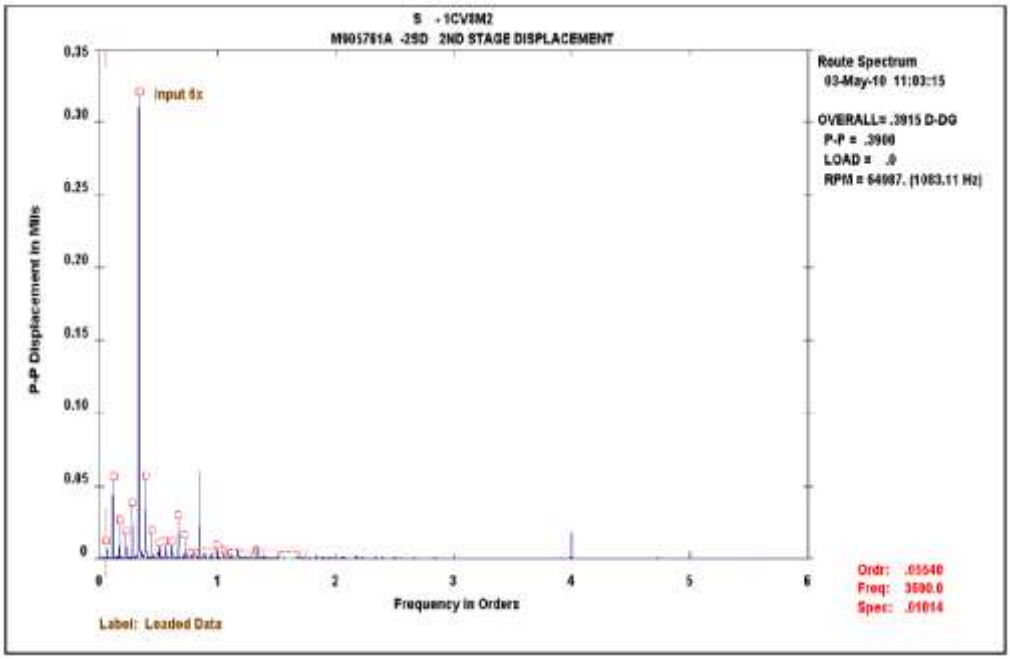
Besides the general benefits outlined earlier, moving PdM to the cloud will revolutionize the industry in several critical areas:

- **Centralization.** Data is leveraged more efficiently. If a person needs to determine which plant in a fleet is at the highest risk for downtime, it can be done quickly because the data is on a single system. The person does not need to talk to several other people or access many different systems to know the health of the fleet.
- **Collaboration.** Multiple people can share the same information. Several experts can be called upon to examine a potential problem. By working together and drawing upon a larger set of experience, these experts can determine the best possible course of action for their customers.
- **Communication.** Because email alerts, text messages, and even automated phone calls are possible, the profile of PdM within an organization is raised.
- **Transparency.** More people in your organization are exposed to the PdM process and can clearly see the benefits. This raises the value of the program, making PdM a "need" instead of a "want."
- **Integration.** With so many people needing information from the PdM program, automated data exchange between business systems becomes a reality.
- **Participation.** The door will be opened for others to gather data, contribute knowledge, report observations, and feedback findings to the system. Instead of a one-way process, PdM becomes an interactive, ongoing process with many other departments feeding data back to the system.

All of this may sound like predictions of a distant future. Many might question whether all of this is even possible. If so, then the future is here. Cloud-based PdM systems have been quietly growing for more than seven years. Today, more than 50 companies (many Fortune 500) already rely on cloud-based PdM services. In fact, there are already many success stories from migrating PdM to the cloud.

**Case History 1: Equipment in Danger saved by "The Cloud"**
A vibration analyst was asked to perform a vibration analysis on a centrifugal compressor. The compressor was alarming on the Stage 2 vibration sensor that is part of the control system. With a traditional vibration service program, the vibration analyst would travel to the site, gather the vibration data, analyze the data and then issue a report. In this case, it would have taken the analyst a minimum of eight hours to physically get to the plant.

Luckily, this was not a traditional vibration monitoring program. Because this customer's program was implemented using a cloud computing system, the customer was already equipped to gather data on the noisy machine himself and upload it to a secure data center. This was done while the customer was already at the site performing other maintenance activities. The data was then available via the Internet to any authorized user from a centralized, secure cloud-based system. The vibration analyst examined the data and called in a colleague for a closer look. The colleague was two time zones away, but could easily access the same data and diagnostic tools without any travel needed.




Working together, the two highly skilled analysts determined that the problem was not with the Stage 2 impeller, but with its associated oil pump. Because the vibration monitoring service was implemented "in the cloud," the analysts were able to quickly collaborate to make an accurate diagnosis within a short time after the original request. A travel weary, lone analyst could have easily recommended a repair on the wrong part of the machine, a day after the problem first occurred. The delay in analysis and/or a wrong diagnosis would have been very costly.

**Case History 2: Vacationing Analyst has No Impact on Operations**
A customer at a large power plant was gathering vibration data as part of its routine vibration monitoring program. The plant used data collection hardware that automatically analyzes the machine and alerts the technician to a potential problem with a preliminary diagnosis immediately after data acquisition for each machine. The technician received a severe alert for a very critical pump. Normally, the technician contacts the assigned vibration analyst to request a quick review of the data in case there is a need for immediate action. Usually this was not a problem, except this was a weekend and the primary analyst was away on vacation. Luckily, another vibration analyst could be reached. Because this program was implemented using cloud computing technologies, the data was available to any analyst with Internet access (and credentials on the system). The backup analyst was at a backyard barbecue, but was able to borrow a laptop. With cloud computing, not only is data centralized, but so is the software.

Using only a Web browser, the analyst was able to review the data and determine that the machine did not have a problem. To the relief of the technician, this was a false alarm. The baseline data for this machine was still being established. The alarm thresholds were adjusted accordingly, and the technician continued his data collection routine. Without cloud computing, the software and data would have been isolated on the primary analyst's computer. The analysis would have had to wait until he returned from vacation. In the meantime, plant personnel would be very nervous and distracted by the machine, not knowing that it was actually problem free.

**Case History 3: Cloud-based Automated System Detect Anomalies Immediately for Faster Resolution**
A steel mill had just rebuilt a large critical pump using an unfamiliar pump service vendor. This pump was previously equipped with an automated monitoring system that had been in operation for more than a year. This monitoring system gathers data on the pump and sends it securely to "the cloud" for processing, analysis, and long-term storage. After the rebuilt pump was installed and started up, an email alert was sent out by the cloud-based monitoring system. The system alerted maintenance personnel as well as the company who was hired to monitor the equipment for such problems.

It was obvious that the pump had a problem and that the onset was a direct result of the rebuild effort. The pump was removed from service and inspected. The physical inspection revealed several mistakes in the rebuild effort. Bearing fits were loose, impeller and case wear rings were not secured, and as a result,

damage to the shaft and casing had already begun. The cost of the rebuild was refunded to the mill and future pump service was not performed by this vendor.

With traditional predictive maintenance practices, it may have been several weeks before any health data was gathered on this machine. It would have been much more difficult to find a root cause at a later date. Even worse, the pump could have failed without knowing why and sent back to the same vendor for a second rebuild; likely with the same result.

Because cloud computing was already implemented for the mill's predictive maintenance program, the problem was identified, diagnosed, and the root cause was discovered within hours.

**The Future of PdM Has Arrived**

As illustrated in the three case histories, the cloud is already opening up many possibilities in the world of PdM. The benefits are quickly realized by companies who choose to leverage this technology. Organizations that make the move to the cloud will undoubtedly gain the same benefits and discover more possibilities on their own. Leading organizations are already using this technology to drive a wedge between them and their competition.

**References**


1 (October 7, 2009) The NIST Definition of Cloud Computing. National Institute of Standards and Technology (NIST) Web site. Retrieved from: http://csrc.nist.gov/groups/SNS/cloud-computing/ on August 22, 2010.

2 (April 13, 2010) Google ready to get down to business. CloudTweaks.com – The Cloud Computing Community. Retrieved from: http://www.cloudtweaks.com/2010/04/google-ready-to-get-down-to-business/ on September 17, 2010.

3 (November 20, 2008) Gartner Says That 30 Percent of New Customer Service and Support Application Investments Will Be Through the SaaS Model by 2012. Gartner Web site. Retrieved from: http://www.gartner.com/it/page.jsp?id=808112 on September 17, 2010.

4 (April 7, 2010) Saving Money Through Cloud Computing. Retrieved from http://www.brookings.edu/~/media/Files/rc/papers/2010/0407_cloud_computing_west/0407_cloud_computing_west.pdf on September 21, 2010.

5 (March 25, 2005) Faster Guide: Server Consolidation. TechTerms@WhatIs.com. Retrieved from http://searchdatacenter.techtarget.com/definition/server-consolidation on September 21, 2010.

6 Wikipedia – Hotmail. Retrieved from http://en.wikipedia.org/wiki/Hotmail on October 5, 2010.

7 (April 16, 2009) Cloud Computing Savings – Real or Imaginary. Retrieved from http://blog.appirio.com/2009/04/cloud-computing-savings-real-or.html on October 5, 2010.

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