

Cloud Computing's Software-as-a-Service (SaaS) Delivery Model Benefits Technical Courses in Higher Education

Janet L. Kourik and Jiangping Wang

Abstract—Software-as-a-Service (SaaS) is a form of cloud computing that relieves the user of the burden of hardware and software installation and management. SaaS can be used at the course level to enhance curricula and student experience. When cloud computing and SaaS are included in educational literature, the focus is typically on implementing administrative functions. Yet, SaaS can make more immediate and substantial contributions to the technical course content in educational offerings. This paper explores cloud computing and SaaS, provides examples, reports on experiences using SaaS to offer specialized software in courses, and analyzes the advantages and disadvantages of using SaaS at the course level. The paper contributes to the literature in higher education by analyzing the major technical concepts, potential, and constraints for using SaaS to deliver specialized software at the course level. Further it may enable more educators and students to benefit from this emerging technology.

Keywords—Cloud computing, software-as-a-service, e-service, higher education.

I. BACKGROUND AND MOTIVATION

STUDENTS in technical courses often would benefit by having experience with the same specialized software as used in industry. This is especially true in computer science and related computer application courses where advanced software is often required to help students understand important principles. Yet, budget constraints may rule out such software purchases. Some vendors offer free downloadable software for educational use. However, downloaded software still requires sufficient computing resources to install and make use of the software. Further, software installation, configuration, and routine maintenance often requires the time of skilled information technology (IT) staff, another scarce resource in higher education. In the case of specialized software, the limited number of students served makes it more difficult to justify the expense by the university.

Another problem has been the difficulty students have in obtaining, installing and configuring software in a timely fashion, particularly during accelerated 8 or 9-week course format. Typically many hours of faculty support are required to assist students in this situation. When the course is offered in a distance education format, it becomes even more challenging in order to help students get up to speed fast enough for course demands.

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To circumvent such problems, some vendors responded by offering access to their software via the Software-as-a-Service (SaaS) model. SaaS, sometimes called e-service, is a form of cloud computing that delivers software and its associated data via a web browser or a thin client to relieve the user of the burden of hardware and software installation and management. From vendors that offer specialized software via SaaS delivery, the products may be rapidly incorporated into a course, often at little or no expense to the instructor in higher education.

II. CLOUD COMPUTING AND SAAS

Cloud computing actually is a broad collection of ideas. An analogy at this point may be helpful. Consider "TRANSPORTATION" as a broad collection of ideas. Transportation encompasses many different components of moving a person or object from point A to point B, as listed in Table 1. Transportation includes movement on land, water, and in the air. Wind, gasoline, electricity, etc. may be used to generate force for movement. A variety of vehicles may implement transportation. The elements of transportation components may be combined in many ways. For instance, wind may be used to move a sail boat on water. Another example would be a diesel engine may be used to move a bus on a roadway.

TABLE I
TRANSPORTATION COMPONENTS

Component	Examples
Characteristics	Move objects on land, water, air, etc.
Power source	Gasoline, wind, electricity, etc.
Vehicle	Automobile, sail boat, plain, etc.

In a similar manner, cloud computing refers to three sets of components that describe many possible combinations for computing. The three primary sets are grouped as: A) essential characteristics, B) service models, and C) deployment models as shown in Table 2 and described below [1].

The National Institute of Standards (NIST) definition of cloud computing that follows is the accepted standard: "Cloud computing is 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.” [1]

TABLE II
CLOUD COMPUTING COMPONENTS

Component	Examples
Essential characteristics	Broad network access, rapid elasticity, measured service, on-demand self-service, and resource pooling.
Service models	Software-as-a-Service (SaaS) Platform-as-a-Service (PaaS) Infrastructure-as-a-Service (IaaS)
Deployment models	Community, public, private, and hybrid.

The essential characteristics of cloud computing distinguish it from timesharing and other forms of networking. Cloud computing still requires standardized access via a network. The remaining characteristics, on-demand self-service, rapid elasticity, and measured service convert computing into a utility. Therefore, cloud computing delivers services (or e-services) rather than products, where software and computing are provided through measurable service over a network or the Internet. The user requests computing as needed. The requests may vary from small to very large at any point in time and are charged in much the same way as electricity usage. Resource pooling in this case means that the cloud provider's resources may have many occupants at one (i.e. serve multiple tenants) using the same hardware and software. Occupants should not be aware of one another nor do they know about the physical architecture or location of computing systems.

The service models describe the distribution of responsibility between user and vendor. In the IaaS model, the vendor provides access to a pool of hardware and optionally an operating system. The user is responsible for buying or building, installing, and managing their own software applications. In the PaaS model the vendor is responsible for setup and management of all hardware and the operating system. In the case that is our focus, SaaS, the user has no control over the software, operating system, or hardware. The user simply purchases time and space on an established software application. The greater the vendor responsibility the fewer the technical demands on the user [1] [10].

A given SaaS product, e.g. database management system or web application development system, may be offered in different ways including public access, educational access, and restricted access that requires confirmation of qualifications and credentials. The fee structures for SaaS products vary enormously from free to premium pricing. However, some SaaS vendors are beginning to offer free or low cost access for education.

III. EXAMPLES AND EXPERIENCE

There are a number of examples of specialized or technical software provided at no charge to educational users via SaaS. The software products available over SaaS for higher education range from database systems, application development, and business intelligence, to analytics.

IBM, as a major vendor of software and consulting services, provides a vendor-hosting approach to make its DB2 relational database management system available for university educators for free as part of the IBM Academic Initiative global program. All software is available through its connection center and is entirely hosted by IBM sites that can be accessed through a web interface or via a thin client interface, providing server navigation and management operations. We have implemented this program in some of our web-based technical courses using its specialized software. Accounts for instructors and students can be set up by IBM professional support offered through the Academic Initiative program. The instructor is assigned administrative rights and supervises individual accounts for student use. The instructor has complete access to student accounts which makes it easy to populate schema and data for certain classes as well as simplifying the evaluation of student work at the end of the course. This set up is advantageous because the university IT department does not need to install the server software, commit expensive server resources, carryout system routine upgrade, or provide ongoing support [3], [4].

Oracle, as a market leader in relational database management systems, offers its software through Oracle Application Express (APEX), a web-based environment, which provides capabilities for educators and students not only learning database manipulation, but also developing data-driven web applications [3] – [5]. Oracle offers APEX on the Internet free of charge, for non-commercial use, or as a no-cost option of the Oracle database through its Oracle Academy program. Fig. 1 presents the web interface of Oracle APEX that delivers capabilities in building applications, manipulating database with SQL workshop, and performing other administrative tasks.

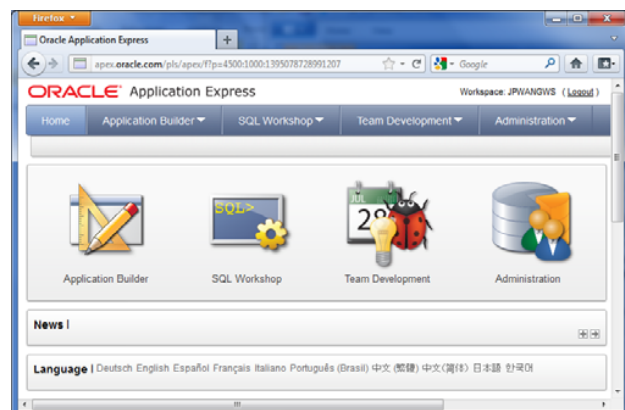


Fig. 1 Oracle application express (APEX) web interface

We have incorporated Oracle APEX in several courses including database concepts, database applications, database systems, and data warehousing. The web-access software provides a significant advantage in that client software is no longer needed for the university lab or student personal computers. The burden of purchasing, downloading, installing or configuring software has been lifted from students and therefore they may concentrate more on the course concepts and applying those concepts. The software can now be readily accessed from computers in labs, students' home, internet cafes, and even their workplaces. The improved access is more beneficial to distance learning environment for the online courses, such as database systems and data warehousing, where students usually use many different hardware and operating system platforms, which makes it more complex to support installation of the client software. Software offered via web access and common web browsers makes it much easier to teach in the heterogeneous environment of distance learning.

Our experience covers implementation of Oracle APEX and IBM DB2 relational database management systems in several undergraduate and graduate courses, in conjunction with on-ground, hybrid, and online courses. We have used this software delivered via SaaS with computer science majors and non-majors including MBA and MA students. Web-based database labs are used in online classes to teach students practical skills in database modeling, design, query language, applications, and data warehousing. An immediately successful implementation occurred in several decision support distance learning classes for non-majors, where students have much less experience in installing and configuring application software. Support requests essentially vanished during the first weeks of the course. Software provided via SaaS, in our experience, has effectively supported a variety of technology-oriented classes.

Other SaaS vendors are available as well. Teradata University Network (TUN) provides free access for university faculty and students via its web-based environment to support technical courses at different levels. The software that is included in the offerings covers areas in database management, decision support, and data warehousing. TUN is let by academics, connecting academic and business communities. An additional feature, pre-populated datasets from textbooks for some instructional materials, is a plus and makes teaching in these courses easier. Through the TUN web-based portal, large scale datasets from industry are accessible for university instructors and students to experience a unique blend of technical insight and practical hands-on exercises on a scale typically only found in industry [2], [6] – [9].

SAS, as a leader in business analytics software and services, offers SAS software to educators and students via SAS Global Academic Program. The software available can be used for courses in data mining, analytics and business intelligence. Software offered by SAS has been used in higher education in many disciplines including operations research,

economics, and social sciences [<http://support.sas.com/learn/ap/>].

Amazon Web Services (AWS), a cloud platform, offers a collection of computing services that are accessible on web and billed on usage. AWS in Education is a program through which educators and students in higher education can apply for grants of free usage credits to explore AWS cloud services in their specialized courses [<http://aws.amazon.com/education/>]. AWS differs from the previous software described in that it has offerings across all services models: SaaS, IaaS, and PaaS. IaaS and PaaS offerings open up additional possibilities for advanced and very technical programming and development courses.

An analysis of our experience, vendor offerings, and the literature is summarized in the next two sections that discuss the advantages and disadvantages for educators using the SaaS to deliver software for students in their courses.

IV. ADVANTAGES OF SaaS

The potential benefits of delivering software via SaaS are vast. Access to industrial strength, branded software can enhance a conceptual course and even attract students. In addition to many pedagogical benefits, SaaS offers rapid deployment, minimal expense, reduced organizational burden, as well as resource and location independence.

A. Deployment Speed and Agility

Since there is no extensive hardware and network infrastructure involved, it is merely a matter of obtaining access for instructor and students to meet technical needs for a course. In most of the SaaS cases we discussed earlier, instructors may sign-up and receive approval immediately or within 24 hours. Such rapid deployment minimizes the time-to-use, which we've found crucial for courses taught in an accelerated 8- or 9-week format. It is not always possible with rapidly changing technology or sudden changes in staffing or teaching material, to develop course contents in far in advance. We have been able to introduce new learning experiences for students in as little time as a break week or even a weekend of setup and practice when necessary. Such agility enables courses to keep up with essential changes in technology and may even afford a competitive advantage.

B. Minimal Expense

Financial benefits of SaaS can be substantial and of particular value for educators with their limited and often shrinking budgets. When vendors offer SaaS to educators under special licensing it is no longer necessary to obtain approval and have the cash ready to purchase the software or the capital to buy required hardware platforms, saving both time and expense. In addition, the expenses related to installing and maintaining software are eliminated or minimized. When the software will only be used by a few courses or small group of students, SaaS can suddenly make the impossible become feasible. It is true that some vendors such as SPSS, maker of statistical analysis software, still

require fees to use their product via SaaS. However those fees are often discounted under established market rates. Further, the expense becomes more predictable via the demand and metering features of SaaS.

C. Lower Organizational Burden

An instructor can obtain and integrate specialized software in a course without requiring an organization-wide commitment that may be difficult to negotiate. Further, shifting the IT installation and maintenance to the vendor minimizes the demand on technology resources as well as the internal IT department. In the event an organization has older personal computers for student use, hardware upgrades may not be necessary using SaaS as long as the compatible browsers are supported. And lastly, the organization is not committed to recurring licenses and future upgrade fees.

D. Location and Resource Independence

A fundamental feature of SaaS is easy access via standard methods such as a browser over the internet. This feature has two important implications. First, implementation is not tied to the hardware and operating system environment of the educational institution. Second, and perhaps more important, we've found that SaaS can profoundly improve the educational experience for students in distance education. The once traumatic process of obtaining and installing specialized software on personal or employer computers is eliminated, saving the instructor hours and days of technical support at the beginning of a course.

V. DISADVANTAGES OF SAAS

As with most advances in technology, new problems may be introduced and some familiar problems remain. Experience suggests that the likelihood of encountering the following problems usually declines as the vendor increases in size and stability. Market-leading vendors may dedicate more resources to their SaaS academic programs in the interest of developing a stronger user base in the future.

The most significant problems you may encounter with SaaS originate with a vendor's instability or sudden change in financial position. Levels of technical and customer support may change during a course. Experience indicates that a workaround is often possible with an option to change the assignment specifications if needed. If the vendor is acquired by another company consequences range from minimal changes to termination of support for the product. Typically, the vendor offers some time before changes are mandatory to support an orderly transition. Another important consideration is the availability of high-speed internet access for students and labs [10]. With SaaS, lots of communication is required as all the work occurs on the vendor's system.

Instructors may find an awareness of some concerns sufficient to prevent being surprised or permit preparation of a contingency plan. Commonly the SaaS vendor may not provide any service or reliability guarantees for pro bono educational users. Furthermore, the vendor does not make

backups. Students can be forewarned about both issues. The result is a more realistic development environment and requires students to anticipate service failures and take full responsibility for backing up their work.

Security and privacy are concerns that limit the application of SaaS to administrative systems. There is less security or privacy concern for projects that do not involve proprietary design or data. Most vendors caution that their SaaS offerings may not be used for operating commercial systems and prohibit the storage of proprietary data on their servers.

An instructor needs to be aware of several common problems that affect course preparation and content. The vendor may limit the number of browsers supported when new software is released. An awareness of potential browser conflicts can simplify trouble-shooting during the course and is easily solved by specifying one or two browsers for student use. When an instructor uses newly released products there may be a limited number of tutorials, books, or other resource material available. Generally the vendor's professional documentation is available for the instructor's reference but must be adapted to match the level of the students in the course.

In only one case did we experience a change in licensing from free-for-educators to fee-based. The vendor involved was a much smaller and less-established web startup. As the number of K-12 and higher education teachers adopted the software, the fee schedule changed from a starting balance of educational credits supplemented by cash purchases to a low monthly fee of about 10 USD. Ultimately, more features were available for more frequent use by teachers under the new licensing plan. Teachers could choose to pay for a single month and further limit expenses.

Course policies and procedures are usually adequate to manage some practical issues that come with the SaaS territory. Upgrades to new releases and application of patches may occur at any, even very inconvenient, times. In one case, a vendor applied a major upgrade in the middle of the term. The graphical elements of the user interface changed quite a bit as icons suddenly appeared in menus that were previously text based. A more significant consequence was limited backward compatibility with the prior version that was still available to students on our own servers. Most students found the simplest solution was to stay with one release version for the remainder of the course including the final project demonstration.

Typical vendor-hosted SaaS offers limited configuration and customization options. This has not been a barrier to any of our student projects. Depending upon the vendor and system management features, the teacher or students may be required to install initial schemas or data sets for each account. This may be more of a concern for programs with hundreds of students enrolled concurrently. However, large courses usually have graduate teaching assistants or other supports that can assist with software administration.

VI. SUMMARY

The basic concepts involved in cloud computing and Software-as-a-Service (SaaS) were examined. Several example applications were presented along with an analysis of the advantages and disadvantages of SaaS. We found that delivery of specialized software for technical courses in higher education was an excellent use of course level SaaS, despite the constraints.

Based on the analysis, cloud computing and the SaaS delivery model may be particularly beneficial in several specific situations. First, SaaS supports instructor-initiated course enhancements or pilots without committing organizational funds or IT resources. SaaS can be very helpful when specialized software is needed to support a small number of students, provided the software vendor's approach to licensing for educational purposes supports a no-fee SaaS offering. In addition, SaaS offerings in online distance education courses proved to be particularly advantageous.

Cloud computing and the SaaS delivery model offer intriguing possibilities for educators and students. Several major vendors added the SaaS delivery model for academic use in the last few years. Further research to investigate the adoption and performance of such academic program offerings would be beneficial in measuring benefits over time. Furthermore, additional empirical research in this area may encourage more vendors to offer their software using a SaaS delivery model for academic use.

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