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ABSTRACT

An Information Technology department in a large urban state college is challenged to meet the needs of a very diverse population of students, faculty, administrators, and staff. The computer user ranges from the barely computer literate to some faculty members who have far more technical expertise than many of the Information Technology staff. Levels of computer literacy range from novices to experts. The users are geographically dispersed, ranging from main campus lab users to satellite campus users, to online students who rarely are on any of the campuses. This pilot revolves around a problem solution to meet the needs of more advanced distant users without overwhelming the average user, and without allocating the major portion of IT's budget for relatively few users. It required a scalable solution and a varying number of users.

Keywords

remote computing, server farm, remote server, application service provider, 24/7 accessibility, scalability

INTRODUCTION

An Information Technology department in a large urban state college was challenged to meet the needs of a very diverse and dispersed population of students, faculty, administrators, and staff. A significant portion of the enrolled students took online courses and were rarely on campus to use the student labs. Campus labs closed by 10 PM, and evening classes ended before that time. The computer user ranged from the barely computer literate to some faculty members who had far more technical expertise than the Information Technology employees. The institution departments ranged from sociology in school of Language Arts and Sciences to computer information systems in the School of Business—with every variety of discipline in between. One user was happy with word processing and simple formulas in spreadsheet applications; another needed all of the latest and most powerful hardware and software available. Levels of computer literacy ranged from many novices to experts, with the former dominating.. This pilot problem revolves around how to meet the needs of more advanced geographically dispersed users without overwhelming the average user, and without allocating the major portion of IT's budget for relatively few users. This was clearly a problem not of pleasing all of the people all of the time, but one of pleasing some of the people most of the time.

THE PILOT PRESENTATION

The Organization's Background

The organization this pilot revolved around is a state institution of higher learning — a popular urban four year college with an ethnically and economically diverse student population. The college bills itself as the "state's best kept secret" for higher education. It was founded in the only city in a southwestern state of the United States with a population greater than one million (Population, 2007.) It was founded in the mid-1960s as primarily an adult education facility where working citizens could earn college credit and even obtain a bachelor's degree (Chronicle, 2007.) It was chartered by the state legislature and received funding based on enrollment. The physical campus was shared with two other state higher educational institutions (a community college and a university with graduate program), enabling classroom buildings, library and other support facilities

to be shared among the three organizations. The college quickly grew, and soon housed one of the largest undergraduate Schools of Business in the country. At the time this pilot was presented, the college had an enrollment of over 22,000 and was forty years old. For several years, the institution received national attention when it was showcased in U. S. News and World Report magazine as one of the best affordable state schools for baccalaureate degrees (America's Best Colleges, 2004.)

Developing The Pilot

The use of computers — from desktop to PDAs — in higher education has increased dramatically. Students and workforce alike have entered an era that Bergeron has referred to as "pervasive computing" (Bergeron, 2001.) Their main tool for productivity is some variety of computing device, and the likelihood that the modern student would enroll in a school that does not offer network connections and full computing services is remote. A good number of undergraduate schools even require students to purchase laptops when admitted to a program (Hardware, 2007.) The Information Technology (IT) divisions in institutions of higher learning have moved from providing computing resources for administrative work to hosting servers for computer science and computer information systems students, to managing and administering Web sites, to providing and manning computer labs for all enrolled students. They are expected to provide remote access, host portals, provide email servers, and even train users. The end user support services division in IT has mushroomed, while the operations and systems development divisions have not decreased (Jessup, 2007.) Clearly, Information Technology today is expected to do more — often with comparatively fewer resources (Stair, 2003.)

The Problem

The situation for IT at a large urban college in a metropolitan area of the Southwest had reached crisis proportions. The student population numbered more than 22,000. There were more than 500 online courses being offered each semester by the institution, in addition to the offerings of classes on the main campus and at satellite locations. In this urban non-residential college, classes were scheduled at non-traditional times — at night, and on weekends as well. Ninety per cent of the students were employed — either part or full-time. The full–time status was set at a 12 hour load; a large number of the students took 6 or 9 hours for part-time status. The average time to complete a four year degree was seven years (Chronicle, 2007.) This revealed the demographic of adult students balancing school with work and family lives. Their schedules were full, and their need for access to technology was 24/7 (twenty-four hours a day, seven days a week.).

Although there were student labs where all of the software needed to complete one's education was available, the practical reality was that there were a high percentage of students who worked on their own systems — or their systems at work — to complete assignments. Software licenses for the institution did not include giving copies of the programs needed to the students to load on their own computers. Selected classes' materials sometimes included educational versions of the software with the textbook if it was purchased new, and the Computer Information Systems and Computer Science departments had membership in Microsoft's Academic Alliance program where their students could download or order certain software programs for a nominal fee (MSDN, 2007.) That opportunity was only given to computer and engineering related departments; these were only two departments out of many. The software did not include the popular Office suite, nor statistical software, or professional Web authoring applications or other horizontal software offered in the campus labs. Also, because Academic Alliance was a Microsoft supported initiative, the software offering was limited to their products. There was a significant amount of other software that was not available to students unless they purchased the applications. Educational versions of the software needed often were not comprehensive enough for class requirements (Marold, 2007.)

The mission of the institution stated that "an affordable high quality" program would be offered (Mission, 2007.) Owning a personal computer was not a requirement for admission; hardware and software needed was available, albeit inconvenient, for some students.

The network hardware configuration for the school also made public drives available for both faculty and students. There was a drive available for faculty to load class notes, needed data files, PowerPoint presentations and so forth for selected classes on a Read Only basis. There was a public drive where students could temporarily store files they created if they did not have removable media (a disk or flash drive) available at the time they were working. That network drive was cleaned over the weekend. There were protected drives for staff, faculty, and administrators where required forms and schedules, catalogs, and so forth were available. These network drives provided only local access, and were not available once the individuals left their desktops on campus. Therefore, not only were some individuals in need of software programs, they also needed access to campus drives and storage space on a 24/7 basis.

Keeping versions of the campus software current on faculty and staff desktops consumed a huge amount of Information Technology's time. For security reasons, faculty and staff did not have administrative rights on their institution issued

desktop machines. IT would have to respond to individual Help Calls to install additional programs, or update versions for college employees. Understandably, students did not have administrative rights on the lab computers. Though IT took advantage of Remote Desktop access to respond quicker, the process was slow, tedious, labor intensive, and not at all politically popular. User credentials and each machine configuration would have to be checked before an installation took place. Each computer on campus was auditable; however, the reality was that the process was not efficient. There were serious management challenges for an already strapped Information Technology Division.

The campus hosted a secure Web enterprise portal where all users in administrator and academic groups could access the college's Web site, manage their email accounts, log into an individual course Web sites and obtain materials for each course they were enrolled in, receive campus-wide announcements, engage in Discussion Forums and Chat Sessions, share calendars, and have access 24/7. Anyone who had an account, with a Web enabled computer and an active Internet Service Provider could access the school's portal. The portal was widely used by all departments and classes; students received instruction in using it during Orientation, and even learned how to use some of the tools in lower level classes. The software applications offered on campus desktops and in student labs were not available on the portal, however. It was evident that IT had a resource and service problem that required a cost effective, timely solution so that the mission of the institution to provide an affordable high quality education to its students could be fulfilled. Some of the people needed 24/7accessibility on an application service provider (ASP.)

Technical Constraints

The state college had a reputation for providing technically current resources. The policy for hardware replacement was two years (Procurement, 2007). The operating systems and application suites were implemented within a year of release, unless there was major user dissatisfaction with a software product. Since the school served primarily working adults, the desire to keep the hardware and software on campus current was deemed of prime importance. The smart classrooms and campus labs may not have been as new and as expensive as in a corporate environment, but they were certainly above many of the academic environments in the state. The solution implemented had to be platform independent: there were several platforms offered and maintained by IT. There were as many MAC users who needed 24/7 access to applications as there were Windows users — with different OS versions. Providing applications for one group without doing so for the other was an unacceptable solution. The solution would have to be platform transparent.

As the number of users and their requested platforms and software packages increased, the college had recently begun experimenting with virtual environments. The faculty requests for Administrative Rights on IT issued computers had been increasing, and the diversity of software needed on college computers was fragmenting the support staff. The variety of platforms to maintain was unwieldy. Training IT support technicians on all platforms was expensive and took too long. Yet maintaining security on the IT provided computers was paramount. Virtual environments on partitions of IT issued computers showed some promise. However, this did not solve the situation for the students — only the staff and faculty. The students who had their own computers or worked on their employers' computers still did not have access to the applications they needed: this required a trip to campus to work in one of the academic labs when they were open. In the era of distant education via online courses and secure Web access to anywhere at any time to any place with a Web server, the problem begged for a solution that required the user to have only a high speed Internet connection and a browser.

The solution that would offer the majority of campus applications, the portal, email and network drives would necessitate giving the user secure storage space and tools for file management and maintenance. The interface would have to be a GUI (graphical user interface) and possess a navigation system with which users were already familiar. The user environment had to be clear enough so that users could quickly master access themselves without formal training sessions. Geographically dispersed students, faculty, and staff at varying levels of computer literacy needed a solution, and they needed it soon.

Political Constraints

The state institution was governed by a Board of Trustees appointed by the governor. In addition to installing a new college president and provost within the two years prior, in 2007 the state governorship was assumed by a different political party, replacing the party that had been in power for eight years. As the terms for trustees expired, the new governor appointed replacements (The Board, 2007.) Newly installed trustees and administrators were anxious to find a solution to the problem: pleasing taxpayers and students (many of whom were also the taxpayers) was critical. It was politically expedient to find a solution to the problem of 24/7access to all resources that IT offered — for those people who needed it. Recent security breaches in the college system and theft of student data incidents resulted in nervous administrators who were cautious yet very anxious for a secure solution. Assuring all students complete and safe access to IT resources was paramount. At state institutions, political campaigns, and elected and appointed positions depend upon timely solutions to such problems. In

addition, the newly elected youthful mayor of the city where the college was centrally located took many opportunities to showcase the institution and bestow accolades showcasing their contribution to the metropolitan community (Merritt, 2007.) He and the governor of the state put high on their agendas educational reform and delivering high quality affordable education to the 20% Hispanic population (Couch, 2007.) Pleasing some of the people most of the time without an expensive solution was politically correct. Administrators and politicians were soundly behind a creative solution that Information Technology could provide.

Economic Constraints

The state where the Information Technology of the college operated had recently gone through a decade of economic downturn. The dot.com bust of the late 90's , the Y2K non-crisis, and the recent high tech deflation had taken its toll on state resources (Mawhinney *et al.* , 2006.) Amid national and local recession, state tax revenues were down. State laws required a balanced budget. The council of higher education of the state legislature who allocated operating funds for the college was strapped to provide what they had in the past, let alone allocate funds for huge technology outlays for any of its dozen state colleges. Resources for Information Technology for the college were limited, and every major project had to be justified. A cost-benefit analysis must be prepared and be presented for the solution. A scalable solution must be offered — as users, services, and support could vary.

Components and Management of Resources

Managing computing resources for a campus of 22,000 students was a constant challenge. Information Technology had grown from a small staff with two main divisions of Operations and Support, to a very complex multi-level hierarchical organization (see Figure 1: Stair and Reynolds, 2003.) The academic computing division had grown from offering and staffing three student labs to more than 550 computers available in 10 labs throughout the main campus, supporting wireless services, portals and Web servers, a Help Desk, and maintaining a staff size that rivaled large organizations. The accountability and reporting that a state institution must complete to justify its funding requires close management of all computing services. The ROI (return on investment) of all projects must be clear. Benefits obtained from a solution to this pilot had to be clearly delineated before the project could proceed. The solution had to improve management of IT resources.

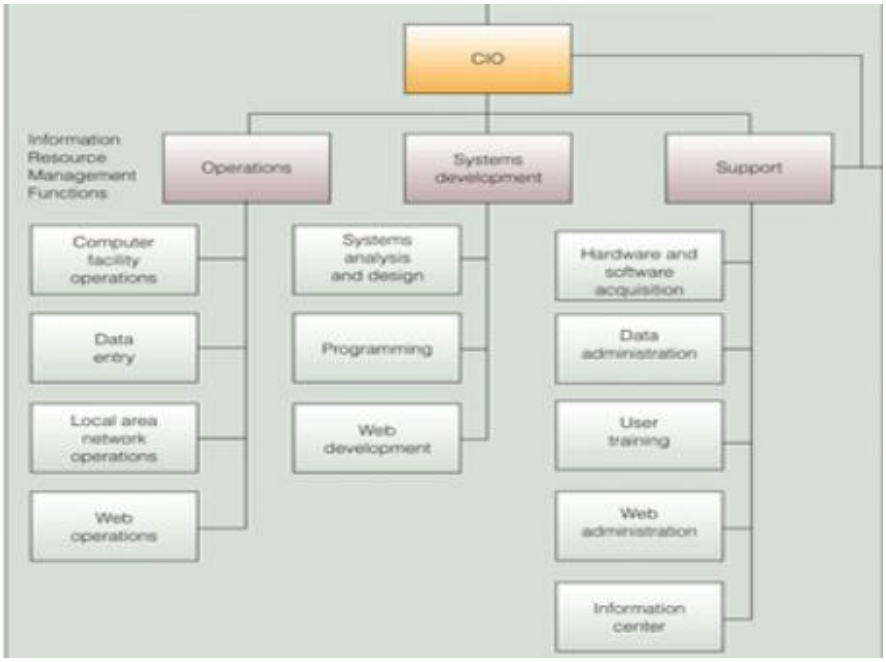

Figure 1. IT organizational chart

THE FRAMEWORK FOR THE PILOT

History of Computing At The Institution

The history of computing solutions at the institution followed the general trends of technology development. The early computer applications were mainframe based, and users could access the applications through terminals. The services were limited to the programs that were available on that particular platform, and the resources were centrally managed. It only required a small number of system administrators and maintenance personnel. As personal computing became popular (and affordable) local area networks connected an increasing number of users offering file sharing, network printing, advanced authentication and user access control, virtual LAN (local area network) solutions, application distribution over the whole campus. Offices were furnished with personal computers, and IT departments built student labs and extensive infrastructure. They supported many applications on different operating systems (UNIX, Solaris, Linux, Novell Netware, Windows, Macintosh). Last semester the general purpose academic student labs had a configuration image with almost 200 different applications. To meet higher operational standards storage area networks (SAN), backup facilities, and network segmentation were implemented. There was a need for an increased number of specialized professionals to cover a decentralized setup in a heterogeneous environment. The situation was complicated by wireless access options and increased security requirements.

Remote Solution

The solution for this large southwestern state college was implementation of a remote *Citrix* server that was an application service provider and a connection to campus drives for faculty, students, and staff on a 24/7 basis. The introduced *Citrix* solution provided several advantages for the users and also IT. The programs were distributed over a server farm that helped with load balancing. The unified platform represented fewer challenges during the installation and administration. The resources were centrally managed and controlled so the implementation team could take advantage of the existing resources and expertise, and be highly efficient in service, application, and user support. Offering remote access to programs through a Web based environment created a platform independent solution. The available communication between the client machines and the servers was standardized through the browsers. The applications run on the remote site so from the user perspective it created an economically preferable situation since the resource requirements were shifted from the client to the servers. Computing power could easily be balanced by IT with more centralized hardware serving more clients. As the students and faculty who were using the *Citrix* solution, more memory and hard drives could be added simply by increasing the number of blade servers. Therefore, more computing power could be delivered in the form of extending the server farm, or by virtualization.

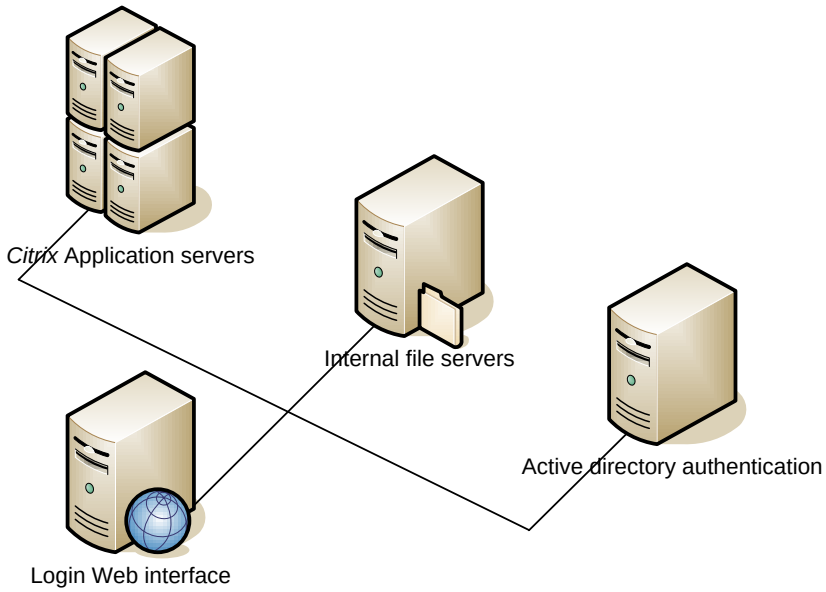

Figure 2. Logical setup of the *Citrix* solution

Benefits For The College

The college as a whole benefited at several levels. IT has provided an economically feasible solution that gave students 24/7 access to applications from anywhere. The resource requirements on the user side were minimal: an existing Internet connection with a common browser. Since the client machine did not download the applications (only the user commands and the resulting screen updates from the server were exchanged) the college lived up to the "affordable education" goal, and increased overall student satisfaction.

The solution created a safer working environment. When users connected to the presentation server the first time, the initialization and configuration process provided a security certificate that was added to the browser's configuration. This setup assured an encrypted communication between the two computers and increased user safety. Each user has been provided with a controlled individual working environment, and no sensitive data has been made available through the solution. With the configured applications and network access students had more campus resources available without the physical constraints — they did not have to come to the campus or to the student labs to work, and their files were stored in separate folders on the campus network so they did not have to carry them around. The storage area was dedicated and attached to their user name so users did not have to save their files in temporary public folders which were deleted on a regular base.

The centralized setup and configuration options had the benefit of always providing the latest updates and upgrades to the applications. Users did not have to change anything on their own computers. The server environment separated the applications from each other and they were executed in their own setup. This individual configuration enabled the existence of multiple versions of the same application and they could be offered next to each other without run-time conflicts. That opportunity did not exist for most programs in a PC based environment. By making the latest technology available also for a financially challenged broader audience, the college reduced the technology gap and gained support from the Board of Trustees.

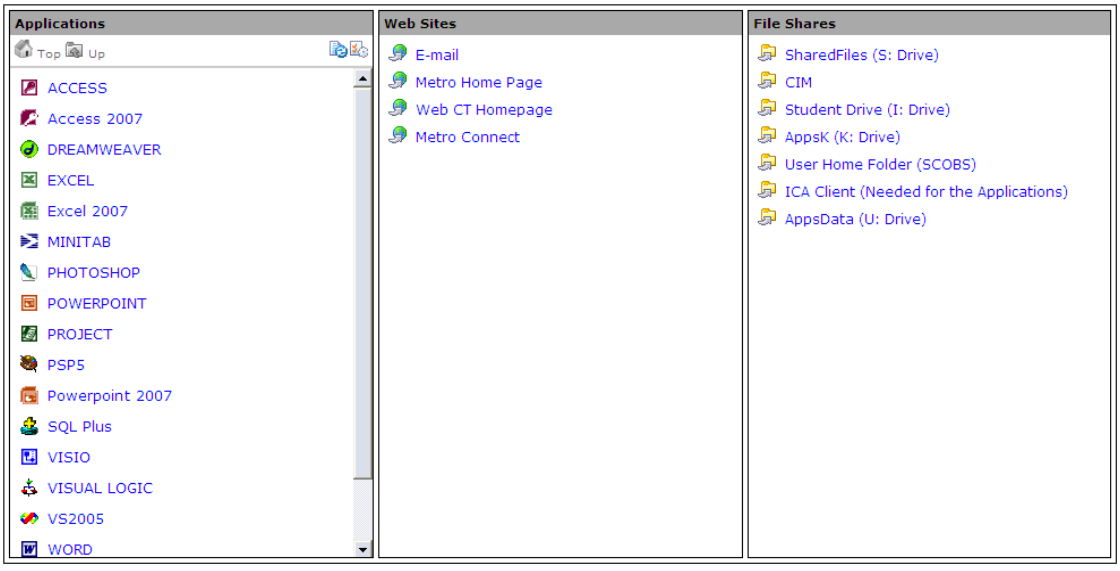

Figure 3. Resource availability in the *Citrix* solution

IT Management Benefits

The solution gave the IT department of the institution new opportunities. Campus computer labs were financed by student fees. The distribution of the monies was planned by the college, the spending and budgeting was proposed by IT, and the Student Government Assembly had to approve it. That included hardware and software license purchases, and part of construction costs as more student labs were built. In general, student labs were configured the same and provided the same set (almost 200) of applications (Applications, 2007.) Except for a limited number of fairly expensive special programs, everything was purchased with a campus license. The special programs were managed by license servers to limit the number of users who had access to them. From users surveys it was known that not all installed applications were used with the same frequency and some had only a small number of users. But students demanded that all labs were the same so they did not

have to waste time walking from one location to another when they want to use a particular program. But this was hardly the optimal use of the available money. Also, when a program was updated or a new version came out, all the lab computers had to be re-imaged to distribute the changes to the whole campus.

The configuration, management, and maintenance of nearly 200 applications was not an easy task. Some programs did require special drivers, some programs did not work well with others, and there were applications that needed extra considerations during the setup process. The separation of applications and the option that they were executed independently made the solution very flexible. The fact that the software licensing was based on concurrent users (users who used a particular application at the same time) made the solution more scalable, and resulted in a restructuring of IT costs. There were fewer expenses in the software purchase (not everything had to be bought with campus licenses — thus not every vendor supports a *Citrix* configuration for their products) and gave a better way of using student fees.

The remote server increased user security. Since all users logged in through the same interface, the rules had to be defined only at that point. User list maintenance was made easy by integrating the identification process with the existing Active Directory authentication which was fed by the academic registration system (see Figure 2). User credentials were checked through a unified login process, and everybody was authenticated against their domain policies. Before a connection was enabled to internal resources the user machines' setup could be checked for necessary security configurations (virus protection, browser type and setup, personal firewalls etc.) If the settings did not meet the established level, users received recommendations and help to update their systems (e.g. a free commercial virus protection software download under a campus license.)

Because the application pool could be tailored to the needs of users and groups (see first column in Figure 3.) academic programs and students in majors used a different set of applications. The user groups and roles could control who had access to which software and version.

The fact that the applications run on the server, and no data or program download was necessary, the college was provided with enough security. Systems could be separated from each other and all the sensitive data and applications were not available for external access.

The single sign-on location enabled full logging (user, login date and time, used applications, connection length — reporting could be generated directly and automated from the Citrix server's database), and the records were auditable.

Through the interface users could access not only the installed applications but also had access to the internal campus network drives, too (see third column in Figure 2.) The available list of drives and the individual user rights were based on the Active Directory credentials.

Extended User Options

The solution gave extended options for users in the academic area. Instructors could take benefit of the *Citrix* solution in their teaching. Shared laptops or even thin clients could be used for classroom demonstrations. Student laptops equipped with wireless network cards now had connection to lab applications. That not only increased student access, but relieved pressure on labs (seats were in high demand between 9am and 3 pm during the day, and heaviest at the beginning, around midterms, and during the last week of the semesters). The college offered a significant number of online courses, and their popularity increased over the years. The application server solution supported and complemented virtual classrooms and offered the same technical support without needing to travel to the campus (see Figure 4.) The concurrent licensing gave enough opportunities and provided balanced 24/7 access to users.

STATUS AND OUTLOOK

Current Status Of The Project

The project was implemented on a pilot basis over the last year. During Summer 2006 fifteen professors of the Computer Information Systems (CIS) Department tested the implementation. In Phase2 (Fall, 2006) the pilot was extended to instructors and students of selected upper division courses (in programming and web related areas). In Phase 3 (Spring, 2006) all CIS courses had access to the installed programs (1,000 students and instructors.) The collected data is under review to verify the most used applications and consider justification for licensing and computing resources (server farm extension, load balancing, storage allocation, technical support, possible extension of services with current budget etc.) (Figure 5.)

Next Steps

The 2006-2007 year provided enough experience for students and professors to move to the next level. Recently the Information Technology department upgraded the *Citrix* presentation server to the latest version; this provides more management options for an even smoother operation, and offers support for an extended pool of applications. The available program list will be expanded with software titles used by other business majors and departments (accounting, finance, marketing etc.)

The system managers and operators have enough experience at this point to support more users and more systems. They can review their return on investment (ROI) figures for future planning. That includes cost savings for initial lab build out, software licensing, convenience for faculty and students, less startup costs for students, and centralized data retention (see Figure 6.)

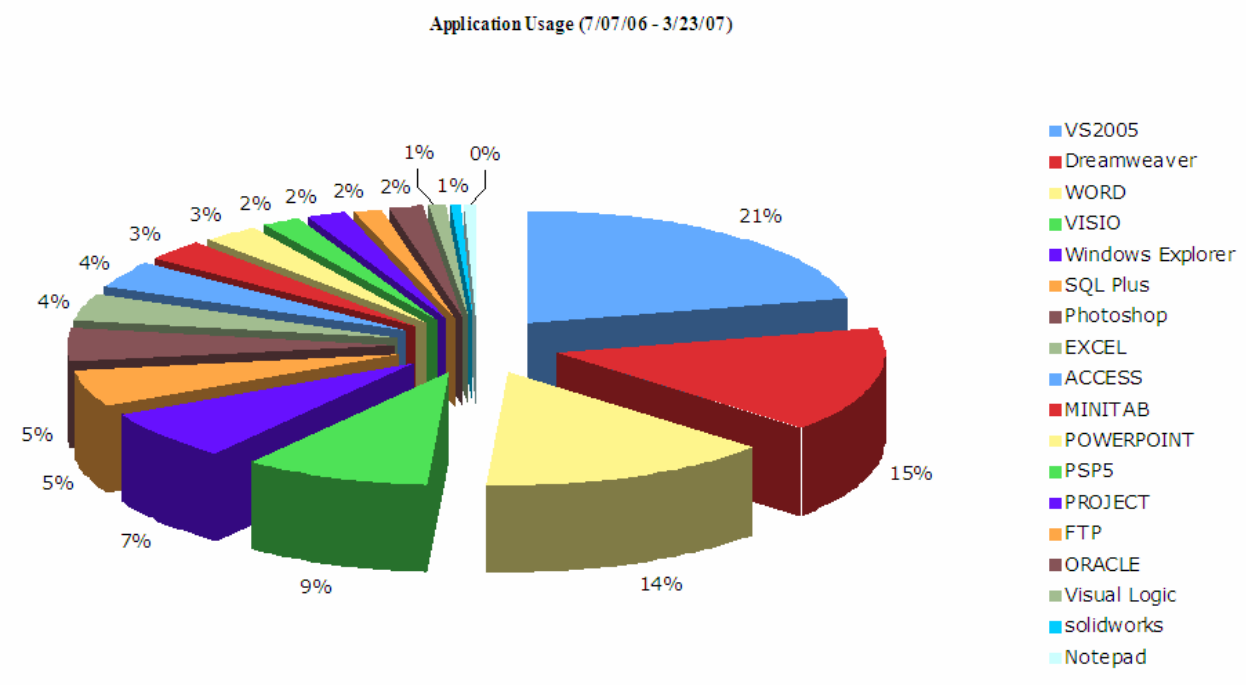

Figure 4. *Citrix* application usage

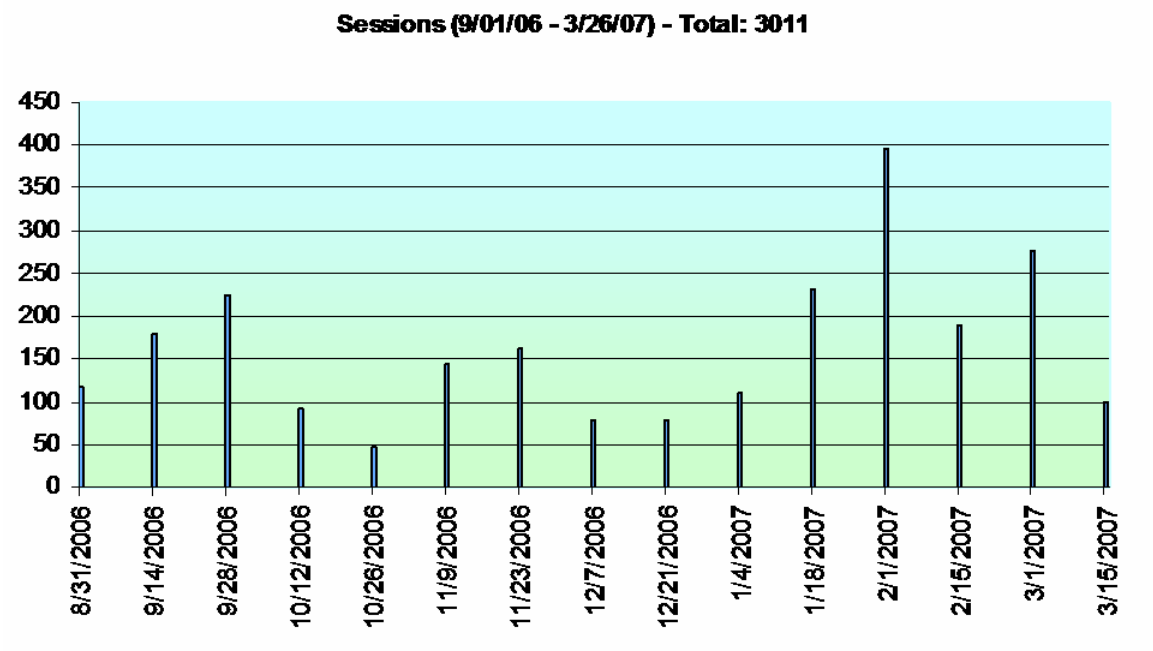

Figure 5. Number of *Citrix* sessions (in two-week intervals)

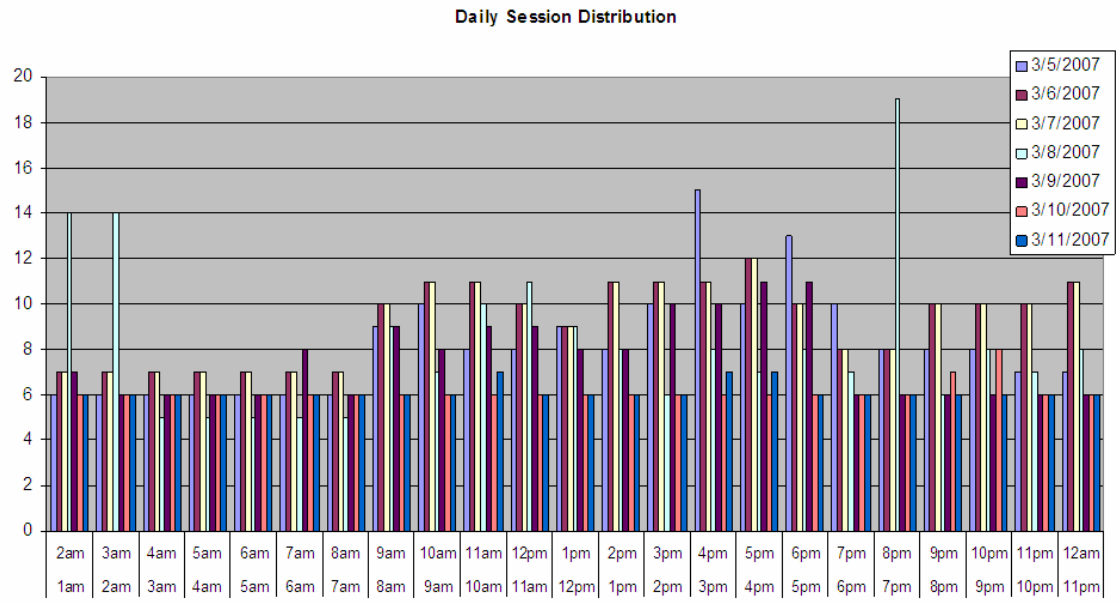

Figure 6. Daily distribution of concurrent *Citrix* sessions (sample week)

CONCLUSIONS AND RECOMMENDATIONS

The pilot solution of implementing a remote Citrix server to solve the problem of 24/7 access to applications and the campus network by some computer users at the college points to the correct choice from several available alternatives. It was a cost effective solution; it was politically popular; it maintained the security of the campus information system while providing remote users with programs and access to network drives even if they were not on campus. A personal system with Internet access and current Web browser software was all that was necessary. The interface was easy and intuitive for all users, since it was a GUI Internet browser. Students could complete assignments and access and store files on the Citrix server while working in a safe and secure environment. One thousand users were able to work remotely 24/7 on their personal schedules, benefiting from the same amount of resources which formerly took several campus labs and technical personnel to operate. Therefore, the simplest and most expedient solution to the case problem resulted in restructuring of IT services, putting less into the front-end costs, creating a more secure and manageable environment, while still pleasing users who have need of more resources. All of this was possible without compromising the needs of the others.

To further learn about the advantages and available solution from implementing a Citrix server, navigate to the company Website (www.citrix.com and support.citrix.com.) This pilot provided a solution to an ever-increasing institutional problem; may serve as a model for other organizations with a need for 24/7 secure access to their resources. Time will reveal if it was the correct choice. Being aware of limitations and the need for moderate level of user expertise, the outcome appears promising. A five year window of usage will reveal whether the implementation of Citrix can be a long-term solution.

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