Facebook Meets the Virtualized Enterprise

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Abstract

"Web 2.0" and "cloud computing" are revolutionizing the way IT infrastructure is accessed and managed. Web 2.0 technologies such as blogs, wikis and social networking platforms provide Internet users with easier mechanisms to produce Web content and to interact with each other. Cloud computing technologies are aimed at running applications as services over the Internet on a scalable infrastructure. They enable businesses that do not have the capital or technical expertise to support their own infrastructure to get access to computing on demand. They could also be used by large businesses to more efficiently manage their own infrastructure as an "internal cloud".

In this paper we explore the advantages of using Web 2.0 and cloud computing technologies in an enterprise setting to provide employees with a comprehensive and transparent environment for utilizing applications. To demonstrate the effectiveness of this approach we have developed an environment that uses Facebook (a social networking platform) to provide access to the Fire Dynamics Simulator (a legacy application). The application is supported using Virtual Appliances that are hosted in an internal cloud computing infrastructure that adapts dynamically to user demands. Initial feedback suggests this approach provides a much better user experience than the traditional standalone use of the application. It also simplifies the management and increases the effective utilization of the underlying IT resources.

1. Introduction

The "Web 2.0" era has brought us technologies such as blogs, wikis and social networking platforms. These technologies provide users more feature rich environments, make it easier for users to generate and share Web content, and increase online social connectivity. The popularity of social networking sites such as Facebook [6] is a clear indication of the perceived value of these technologies.

We believe that an improved user experience would also be beneficial in an enterprise setting, as it would make tasks more enjoyable and less time consuming to complete. It would likely also appeal to the new generation of enterprise employees, who are intimately familiar with the Web 2.0 experience.

However, such technologies have not been widely adopted in enterprises due to concerns over security, productivity and suitability in the workplace. In fact, many businesses block employees from using social networking sites at the workplace [24].

The purpose of this paper is to (1) examine the lessons we have learned from the Web 2.0 era, (2) articulate the needs of enterprises and (3) recommend an IT model that merges the two in an acceptable manner. We have implemented a demonstrator to illustrate the potential benefits to enterprises of the approach we are recommending.

The remainder of the paper is organized as follows. Section 2 describes lessons we have learned from the Web 2.0 era and Section 3 examines the IT requirements of enterprises. Our proposed IT model, which leverages the benefits of Web 2.0 while addressing the needs of enterprises, is presented in Section 4. Section 5 introduces our demonstrator, which highlights the utility of our approach. We conclude our paper in Section 6, with a summary of our work and future directions.

2. Lessons Learned from Web 2.0

In the past few years, the "Web 2.0" wave has provided new, simple ways for users to create and share content or applications, and communicate with one another. These capabilities have been enabled by tools such as blogs, wikis,

and social networking platforms. Our particular interest is in online social networking. Sites such as Facebook [6] and MySpace [18] have become extremely popular with Internet users, in part because of the simplified interfaces they provide to desired capabilities. Simple yet powerful interfaces are extremely valuable as they make the power of IT accessible to almost everyone, with little or no training required.

The "Web 2.0" wave has also brought users "choice" of applications. Among social networking sites, Facebook was the first to release an application development platform in May 2007. The Facebook Platform provides an API that allows third party applications to be integrated into Facebook. Users are easily able to access and share a large variety of applications. By September of 2007 there were over 3,500 applications and as of April 2008 this number has increased to over 22,000. Consumers like choice of applications as it enables them to personalize their experience, without requiring application providers to do extra work.

As an indication of the perceived value of an application development platform, many other social networking sites have followed suit. Friendster [7], MySpace and hi5 [10] have recently launched their application development platforms and orkut [9] is in the process of rolling its out. The Friendster, MySpace, hi5 and orkut platforms are or eventually plan to use the OpenSocial API [8] being developed by Google. This is in contrast to the proprietary platform being used by Facebook. Applications developed using the OpenSocial API will be able to have more rapid and widespread deployment on all of the sites that support the API.

A major problem facing application developers for social networking platforms is that it is very difficult to predict the popularity and lifespan of applications. Figure 1 shows that most applications on Facebook are very unpopular; of the 15,036 applications that we had data for on April 21, 2008, 13,838 (92%) had less than one thousand active users, compared to the top 3 applications that had over one million active users. We expect a similar trend to exist for applications in an enterprise. A flexible IT infrastructure to support applications in a cost effective and scalable manner is needed.

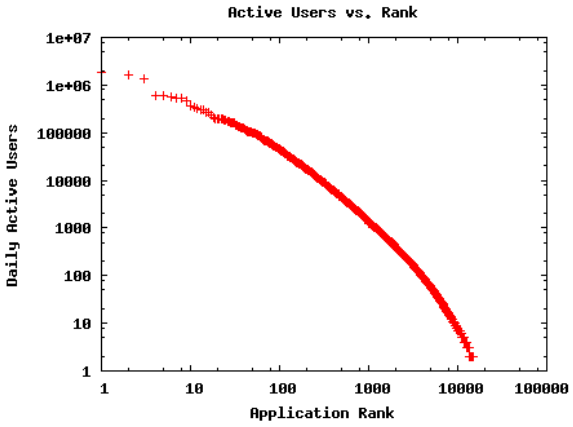

Figure 1. Daily active users vs. rank of Facebook applications

3. Requirements and Concerns of Enterprises

We consider the requirements of enterprises from three different perspectives; CXOs (i.e., company executives), employees and IT organizations. CXOs have a variety of business goals that directly affect the way their IT infrastructure is managed. These goals could include things such as "reduce costs", "increase business flexibility" and/or "provide business continuity". CXOs are concerned about security and risk. They regard data as a significant asset of the company and do not want that information shared with the world.

At the opposite end of the spectrum, employees want an easily accessible and complete set of tools that enables them to more effectively do their jobs. Members of generation Y are the new enterprise employees. They grew up with the Internet and are quite familiar with social networking technologies. Use of these technologies in enterprise would therefore be very appealing to this new workforce.

In the middle is the corporate IT organization, which must try to support this conflicting set of requirements. A common approach today is to make the IT infrastructure (including applications) very static and controlled. This helps reduce cost (the easiest goal to measure), but can limit flexibility and restrict the tools available to users. Much of IT infrastructure is underutilized much of the time. Methods to consolidate and make more efficient use of resources are always being sought. Enabling business continuity requires the maintenance of legacy applications which are typically not easily adapted to newer and more efficient IT management approaches. While many new technologies are emerging, enterprises are more conservative than consumers. They need slower migration paths in the adoption of new technologies.

Enterprises also have many concerns when it comes to adopting general consumer social networking platforms. Adoption of such platforms has been limited in enterprise due to the lack of a professional feel, security concerns, and access to applications that so far, are typically more of a distraction than benefit to the workplace. The lifecycle of applications is more dynamic and less predictable than enterprises are used to dealing with. Furthermore, applications can be developed and shared by anybody so concerns over who continues to support and update applications becomes an issue. Enterprises have typically had a great deal

of control over the application environment provided to employees.

There are many social networking tools that have been developed with enterprise users in mind. However, most focus on networking, collaborating and/or sharing information and not on providing a platform for accessing applications. Some of these tools include Huddle [11], Microsoft Office Sharepoint Server [17], VisiblePath [26], and solutions from SelectMinds [23] and LeverageSoftware [14]. Another enterprise centric social networking tool called LinkedIn [15] has recently released the Intelligent Applications Platform [16] that uses the OpenSocial API. LinkedIn still seems focused on networking and job searching but the new platform could lead it in new directions. There have also been some efforts to make some of the general purpose social networking tools more appropriate for enterprise. Huddle has a Facebook application called Workspaces [12] and WorkLight has a Facebook application called WorkBook [27], both aimed at enabling more secure use of Facebook in an enterprise setting.

We argue that it is important to identify methods that make useful applications and services more accessible to employees (to improve productivity), enable more rapid deployment and dynamic configuration of these services (to increase flexibility), while allowing IT organizations to retain or increase control over the infrastructure they manage (to maintain cost accountability). Solving these issues could reshape how computing is done within enterprises.

4. IT Model

In this section we first explain in more detail our proposed IT model for accessing and hosting applications for enterprises. We then discuss the benefits that this approach will have for enterprise employees, IT organizations and CXOs. Finally, we discuss some related efforts to our proposed approach.

4.1. Proposed Approach

Figure 2 shows a diagram of our proposed IT model. It is based on the use of a number of existing technologies, the combination of which provides the potential for a revolutionary improvement in enterprise IT.

On the user side we propose the use of a Facebook-like social networking platform that is more tailored to enterprise use. Employees would be able to search, access and use applications, share documents and other important information, and maintain/establish contact with other employees. Although some enterprises use portals that support some of these functionalities, the social networking aspects are largely lacking, as well as the simplified interface to (legacy) applications, the self/group help capabilities, etc. We realize that it may not be possible or appropriate to have all applications accessible from the social networking platform initially. The goal would be to first migrate simple, non-critical applications to this environment. Over time, additional and more critical applications could be added.

On the IT management side, we propose that applications be hosted with the aid of cloud computing technologies. These technologies are aimed at scalable hosting of services in the Internet "cloud" transparent to the knowledge of the user. Example cloud computing offerings include Amazon Web Services (AWS) [1] and Sun Microsystems's Network.com [25]. Both enable computing power to be purchased on an on-demand basis, with the ability to easily scale services up or down as needed. This enables applications to be supported without the need to have an existing infrastructure and helps address the application popularity problem.

The grand vision of cloud computing is that all applications will be supported remotely, and accessed on demand from the Internet. However, for the foreseeable future, many enterprises will be reluctant to relinquish that degree of control over their business. Instead, we propose that an "internal cloud" model be followed, allowing enterprises to retain control, but at the same time place them on the path that would facilitate simple migration to selected Internet-based cloud services.

The internal cloud would be maintained as a static and homogeneous set of physical resources. Applications would be packaged in Virtual Appliances that could be dynamically launched to scale appropriately to the demands of popular and not so popular applications. A Virtual Appliance is the combination of a virtual machine, custom operating system and application into a single image.

Virtual machine technologies are employed in cloud computing solutions such as AWS. They make it possible for a single physical machine to be transformed into multiple virtual machines which can each be customized with their own specialized and streamlined operating system and application software. The use of virtual machine technologies provides many advantages. They allow for more efficient use of resources aiding in resource consolidation. They also allow heterogeneous services to be supported in a single physical environment. Furthermore, checkpointing and migration capabilities allow movement of virtual resources among the physical nodes of a data centre enabling the accommodation of new service requests, system maintenance without disrupting services and balancing of workload among data centre nodes.

Social networking platforms like Facebook allow anybody to develop and share applications. This is in contrast to the current IT model where the IT organization is very restrictive in the applications that are made available to employees and who they are developed by. With the

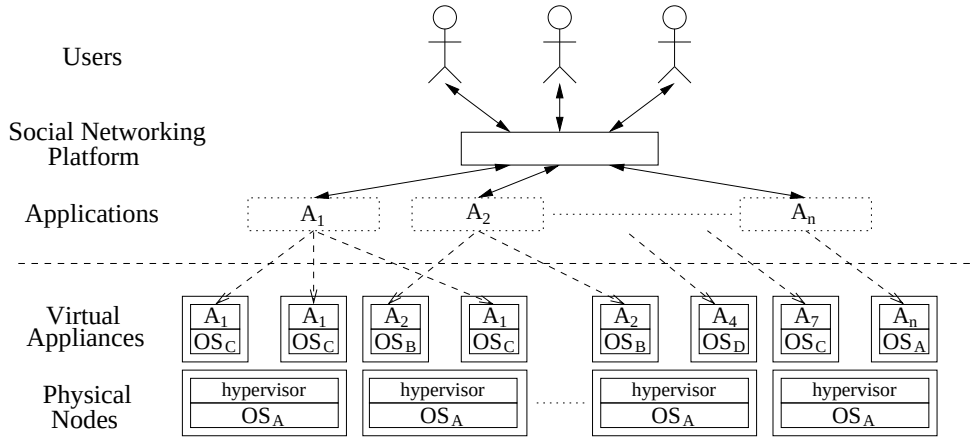

Figure 2. Proposed IT model

open model like Facebook a big concern for IT organizations would be how and by whom applications continue to be supported and upgraded. We propose a model somewhere in between these two that balances the need for increased choice by users and control by the IT organization.

Ideally, developers of applications would provide prepackaged Virtual Appliances with the applications and related components, as well as the interface for accessing the application via the social networking platform. This may not be possible initially, or for legacy applications that no longer have development support. The IT organization or a third party could be responsible for creating and maintaining Virtual Appliances for these applications. With minimal effort these applications could be made accessible via the social networking platform as is (i.e., using existing user interfaces) by running a desktop sharing program such as VNC [22] in the Virtual Appliance. Users could be provided access to the VNC session and also provided with additional features to enable easier use of the application.

4.2. Benefits for Employees

Management of applications and IT infrastructure as proposed in this paper could provide many benefits to employees. First, the use of a social networking platform will enable simpler use of applications. Employees will be provided with a simple and intuitive interface for accessing applications, including legacy applications. All applications will be accessible with a similar "look and feel" in a single integrated environment. The technical details of where the application is running and how it is accessed will be transparent to the employee. Not only should it reduce the time and effort for an employee to learn how to use an application, but it may enable employees to be comfortable in utilizing a much larger number of applications than they traditionally do. Employees will also be able to share experiences they have had with applications, rate them and learn from others.

Second, exploiting social networking features will enable employees to leverage knowledge/expertise already in the enterprise, in as simple a way as possible. They will be able to more easily find and collaborate with other employees that have similar expertise, are working on similar problems, or that have the expertise they need to aid in the completion of a task. They will be able to more easily share documents, presentations, events and other information. This will provide employees with extra sources of knowledge and allow them to build on what others have done. It will help them to be better aware of what is going on in the company and help improve their productivity.

4.3. Benefits for IT Organization

IT organizations will also greatly benefit from adoption of the approach proposed in this paper. First, the approach aids in more efficient use of resources which could help to significantly reduce infrastructure costs. Instead of establishing the required infrastructure for each application separately, which can result in many underutilized resources, all applications can share the same infrastructure. The environment is dynamic and flexible; it can quickly scale and adapt applications based on demand. Applications that are in high demand can be allocated a large number of resources and applications that are not popular can consume little or no resources.

Second, the approach allows IT to maintain control of the infrastructure while avoiding the need to manage operating systems. Instead, IT would be responsible for maintaining the underlying physical infrastructure and hypervisors on which the Virtual Appliances will run. This will be a relatively static, homogeneous environment, with dynamics and heterogeneity pushed up into the virtualized environment. Virtual Appliances could automatically register with a management service, enabling IT to ensure the appli-

ances are updated (i.e., patched) appropriately. This would differ substantially from patching of operating systems handled by IT today, as the developers of the applications, not IT, would be responsible for ensuring the patches worked before deploying them to the IT infrastructure. This could dramatically reduce support costs for IT. Testing would also be simplified, as the developers only need to test on the specific appliance platform that they use.

4.4. Benefits for CXOs

Due to the numerous anticipated benefits to employees and the IT organization, we expect that CXOs would also see many benefits. With simplified access to a wider variety of applications productivity of employees could be increased (not decreased, as is commonly feared). The more efficient manner in which IT infrastructure is being managed will allow costs to be reduced, business flexibility increased and business continuity supported all at the same time. As the infrastructure is kept in control by the IT organization, security and protection of valuable data is maintained.

4.5. Related Efforts

In the general consumer and academic areas, there are several related efforts that combine a social networking platform with cloud computing infrastructures. As far as we know, there are no similar efforts being undertaken for enterprise.

Amazon has recently teamed up with Facebook to help developers build scalable applications that can be run using Amazon Web Services [2]. Joyent recently partnered with Dell to provide a scalable on-demand infrastructure to launch Facebook and OpenSocial (only for hi5 currently) applications that can scale to millions of users [13]. Both of these efforts apply to the general consumer area and are examples where an external cloud computing infrastructure is employed to support applications.

Perhaps the most closely related work to what we are suggesting is nanoHUB [19], a social networking platform aimed at the nanoscience academic community. Users are able to share publications, presentations, teaching materials and get access to large variety of nanoscience applications. However, it currently lacks many of the social networking features common with Facebook and MySpace, and is targeted at a specific domain. A prominent feature is the ability to access and run a wide range of applications right from your Web browser, transparent to the underlying computing infrastructure that is used. nanoHUB makes use of local virtualized resources, TeraGrid, Open Science Grid, and any other resources that it can get a hold of. VNC is used to provide access to application GUIs and visualization tools. Considering the small domain that is being targeted, popularity of nanoHUB has really taken off with over 60,000 users from over 180 countries and over 270,000 simulations run in the past 12 months.

5. Fire Dynamics Simulator Demonstrator

To demonstrate the effectiveness of our proposed approach we developed a comprehensive environment for the Fire Dynamics Simulator (FDS) [20], a "legacy" application developed by NIST. Our environment makes use of social networking technologies to provide a user interface and an internal cloud computing infrastructure to host the application. The demonstrator runs on an HP BladeSystem C-class environment. A video of the demonstrator is available at *http://grid.ucalgary.ca/projects/DataCentre/*.

5.1. Demonstrator Infrastructure

Figure 3 shows the infrastructure used to support the demonstrator. One of our aims in developing the infrastructure was to make use of as many existing tools as possible to simplify the development. The physical infrastructure is homogeneous as is the platform for hosting the Virtual Appliances. We developed a Utility Provider Orchestrator (UPO) to orchestrate the provisioning of virtual resources. It enables dynamic scaling of services based on the current level of demand. The UPO makes use of PBS/Torque [4] to manage the physical resources, Xen to virtualize the resources and Moab [3] to schedule the virtual resources. The UPO, Moab and Torque all run on a Virtual Appliance (VA) as indicated in the diagram.

There are three services supported by the infrastructure; a Web interface for FDS, a service for running FDS simulations and a service for running interactive Smokeview visualizations. Smokeview, also from NIST, is a companion tool to FDS for visualizing results. The Web interface is integrated into Facebook using the Facebook API. It interacts with the FDS simulation and Smokeview visualization services. The FDS simulation service uses Condor to run simulation jobs and the Smokeview visualization service uses VNC to enable interactivity through a Web browser. Each simulation node of the Condor pool and each visualization node is a Virtual Appliance with the necessary software installed. Virtual Appliances are started from a clone of a pristine image (SimClone or VizClone), which is exported as an iSCSI target. OpenSolaris ZFS [21] is used to provide clones of images. The appliances could be maintained by a third party. IT may require a list of software components so that they can automatically determine which VAs need updating or replacing.

We developed Service Provider Agents (SPAs) for the FDS simulation service (SimSPA) and Smokeview service

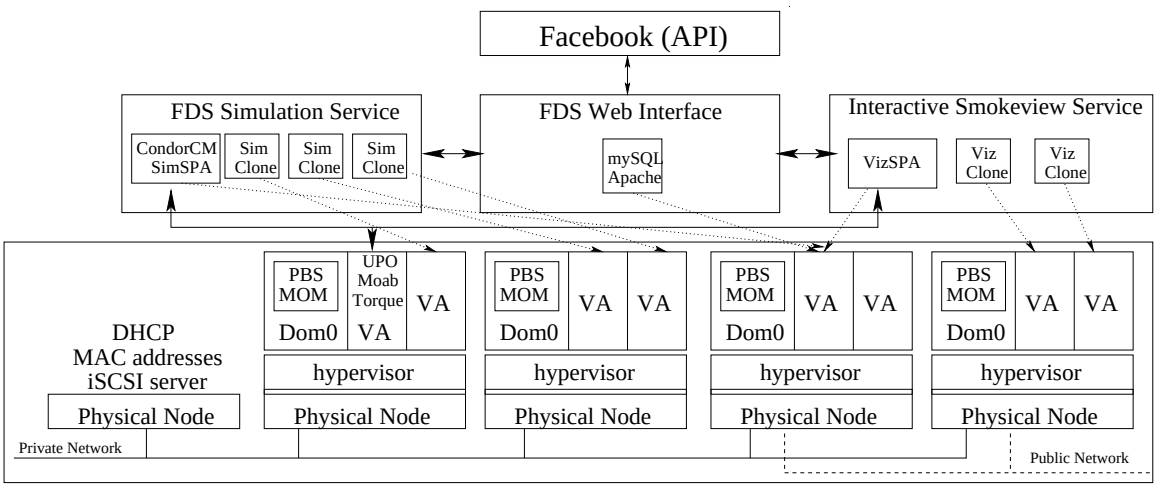

Figure 3. FDS demonstrator infrastructure

(VizSPA) to communicate with the UPO and request or release Virtual Appliances based on demand. If user demand for FDS or Smokeview increases, the corresponding SPA determines if additional resources are needed. If they are, the SPA contacts the UPO to request the allocation of another Virtual Appliance (i.e., the environment scales horizontally). Similarly, if user demand subsides, the SPA may scale down its environment, by handing resources back to the UPO. All of this happens transparently to the user.

For the demonstrator, the SimSPA requests a new SimClone Virtual Appliance for each new simulation request that is made, up to a maximum allowed by policy. A SimClone is returned to the UPO once a simulation is done and there are no outstanding simulation requests. The VizSPA always attempts to maintain one "hot" VizClone Virtual Appliance beyond that required by active visualizations (as long as the number of VizClones does not exceed the maximum allowed by policy) to accommodate new visualization requests rapidly. IT maintains control of the policy for this environment and can revise the policy if they notice an increased demand for a particular service. Moab has a well established policy engine that can be used to enforce these and other policy requirements.

More detail on the infrastructure we developed to support the demonstrator can be found in [5].

5.2. Demonstrator Features

Figure 4 shows one view of the FDS Web interface in Facebook. The interface provides many features that enable the user to do almost anything they need pertaining to the FDS application. As such, it serves as a "one-stop shop" environment for the users. Some of the features are built into Facebook while others were added as part of the FDS Web interface. This also serves as an example of how an enterprise could provide improved user experiences for legacy applications, without modifying the legacy application in any way (which would require source code that likely isn't available). This section continues by describing some of these features.

Personalization

Facebook provides users with a personalized environment and access to a list of user preferred applications. This list, seen in the top left corner of Figure 4, enables quick access to applications commonly used by the user. The FDS application (labeled "Fire Simulation") is one of these applications. Access to this application is restricted to a private group on Facebook that this user is a member of. Users are also able to search for other available applications.

Social Networking

Users are provided with several mechanisms to share information and interact with other FDS users. In addition to the ability for a user to view their own simulations, a user can also view simulations created by all FDS users. This is possible using the "My Simulations" and "All Simulations" options respectively in the view shown in Figure 4. The current view is showing the list of all simulations created by all users. The ability to access all simulations allows users to share their results with others, discuss these results and provide other feedback that could be very beneficial for all involved. Even though all simulations can be viewed by all users for this demonstrator, additional functionality could easily be added to allow a user to select if they want to share a simulation and to which users or groups of users they want to share it with.

At the bottom of Figure 4 is a general discussion board for FDS that all users with access to the application can

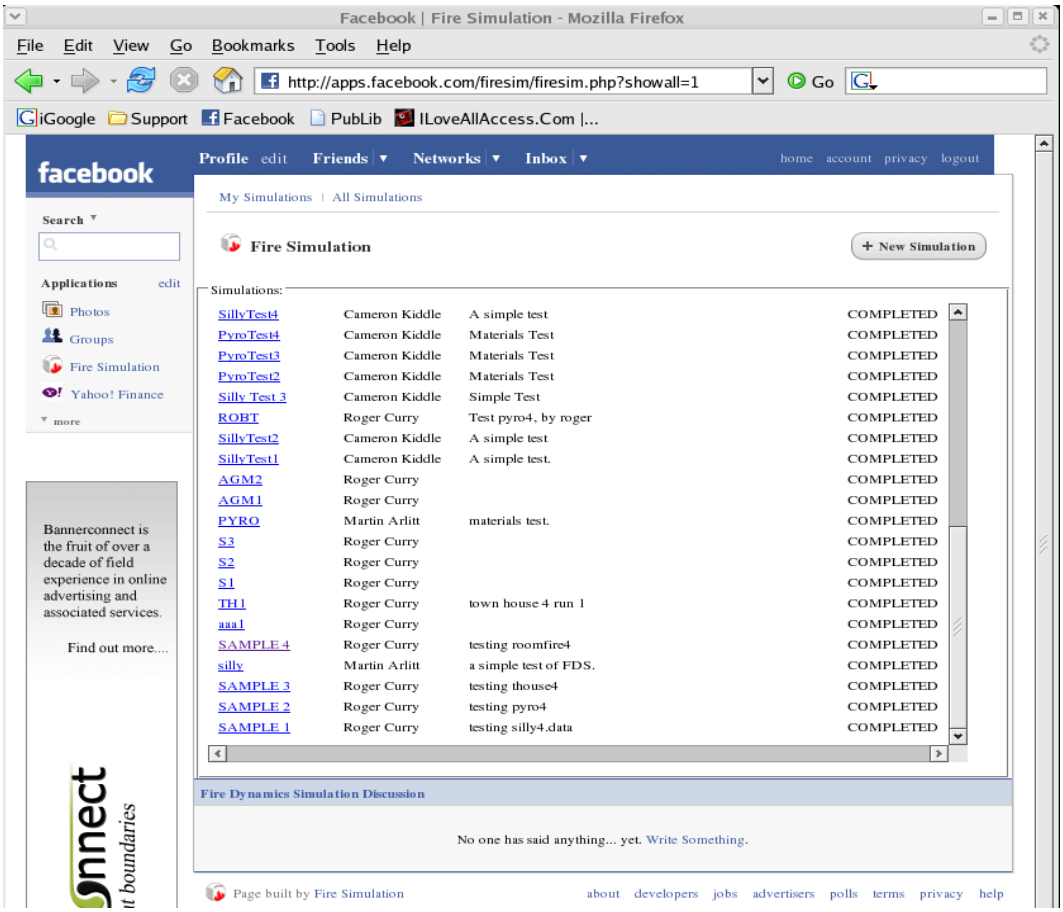

Figure 4. FDS Facebook interface

post comments to. The Facebook API made it easy to add discussion boards. The general discussion board enables users to make general comments or questions about FDS and receive feedback from other users.

In addition to a general FDS discussion board, there is a discussion board for every simulation, as shown in the bottom of Figure 6. Users can use the discussion board to discuss and make observations about results. All of these mechanisms build on the notion of collective intelligence which is a key principle of Web 2.0.

Fully Functional Application Interface

One objective of our demonstrator is to show how a simple, yet full-featured, social-network capable Web interface to a (legacy) application would enable a user to be more productive. In this section we describe several screenshots that help illustrate these capabilities.

From the view shown in Figure 4, that allows a user to access their simulation or all simulations, they can also select to create a new simulation. Figure 5 shows the FDS Web interface view that allows a user to create a new simulation. Here, the user is allowed to name the simulation, provide a description of the simulation and upload the input file for the simulation. Once this is done, the user can submit the simulation. The simulation is run on the internal cloud computing infrastructure, transparent to the knowledge of the user.

To enable quick browsing of simulations in the "My Simulations" and "All Simulations" views as shown in Figure 4, details of the simulation are hidden. The details can be accessed by clicking on the name of the simulation. Details of the simulation named "SAMPLE 4" can be seen in Figure 6. This view provides additional meta-data about the simulation such as the time the simulation was submitted. Although the demonstrator uses a limited list of meta-data it would be easy to add additional meta-data to this view.

Additional functions that can be carried out for the simulation can also be selected in the detailed simulation view. These include the ability to edit the simulation input file, re-submit a simulation, remove a simulation, and download the simulation results.

Another key functionality available from the simulation detail view in Figure 6 is visualization of the results using

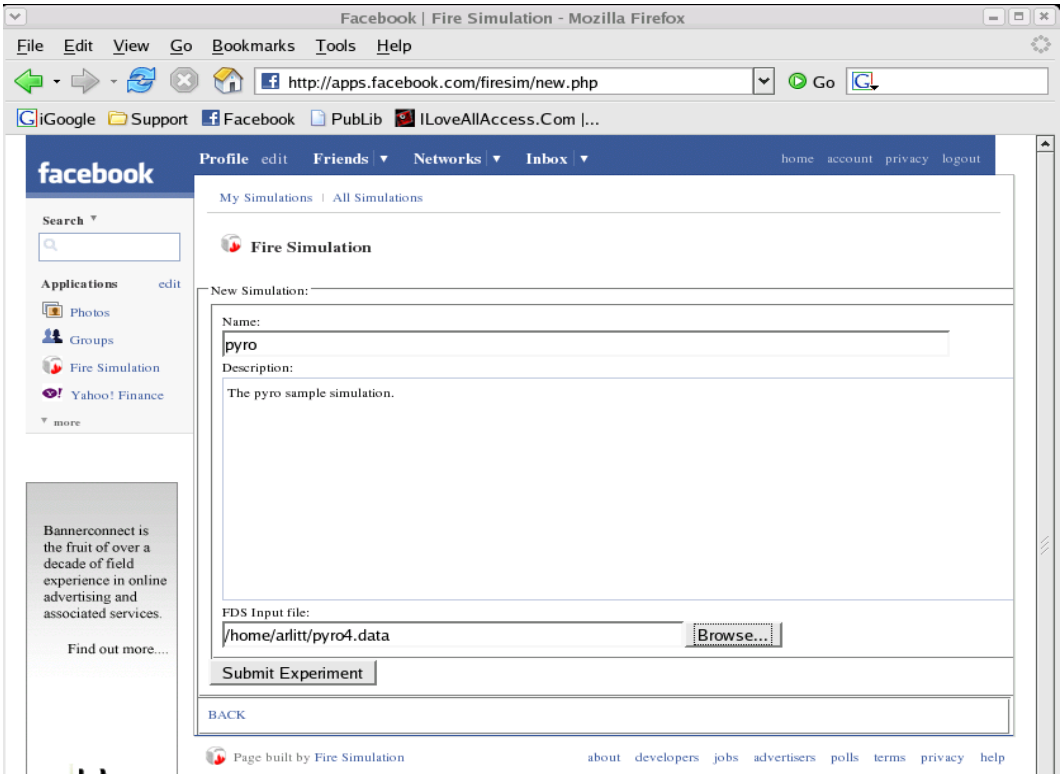

Figure 5. Creating a new simulation

Smokeview. An example visualization can be seen in Figure 7. The visualization is interactive allowing the user to rotate the view and select whether to visualize the spread of fire, smoke or other options. In Figure 7, the user is visualizing the spread of fire. Technical details of how and where the visualization is run are hidden from the user. Smokeview is actually being run remotely on a Virtual Appliance and is made accessible from the Web interface using VNC. This feature in particular demonstrates the value of integrating all functionality pertaining to an application into a single Web interface. Users can more quickly and easily switch between running simulations and analyzing the results.

5.3. Demonstrator Summary

Our demonstrator shows how enterprises and their users could clearly benefit from a more modern IT environment that couples together the best aspects of Web 2.0 with a more flexible IT infrastructure. In particular, user productivity could be improved and IT infrastructure could be utilized more effectively. Although our demonstrator included much of the functionality needed by FDS users, there are certainly other functionalities that they might find helpful (e.g., cloning an experiment, cancelling a submitted or running simulation, etc.). Similarly, other applications may require additional functionality. However, we believe that our demonstrator clearly illustrates that most useful functionalities could be provided through a single, simple interface. Leveraging some functionalities (e.g., social networking functionalities) across applications may further improve the overall enterprise user experience, as well as reduce development and training costs.

6. Conclusions and Future Work

In this paper we explored the use of a Web 2.0 social networking platform in an enterprise setting, to provide employees with an integrated, comprehensive and feature rich environment for accessing applications, sharing documents, results and other objects, and connecting with each other. In combination with an internal cloud computing based infrastructure for supporting the applications we feel that this could provide significant benefits to an enterprise. IT organizations are able to make more efficient use of their resources and provide employees with greater choice while maintaining control. Employees are provided with simple and intuitive access to applications and can leverage knowledge within the enterprise more easily using technologies that many are already familiar with.

To illustrate the effectiveness of our proposed approach, we presented a demonstrator that we developed for a legacy application. Facebook was used as the social networking

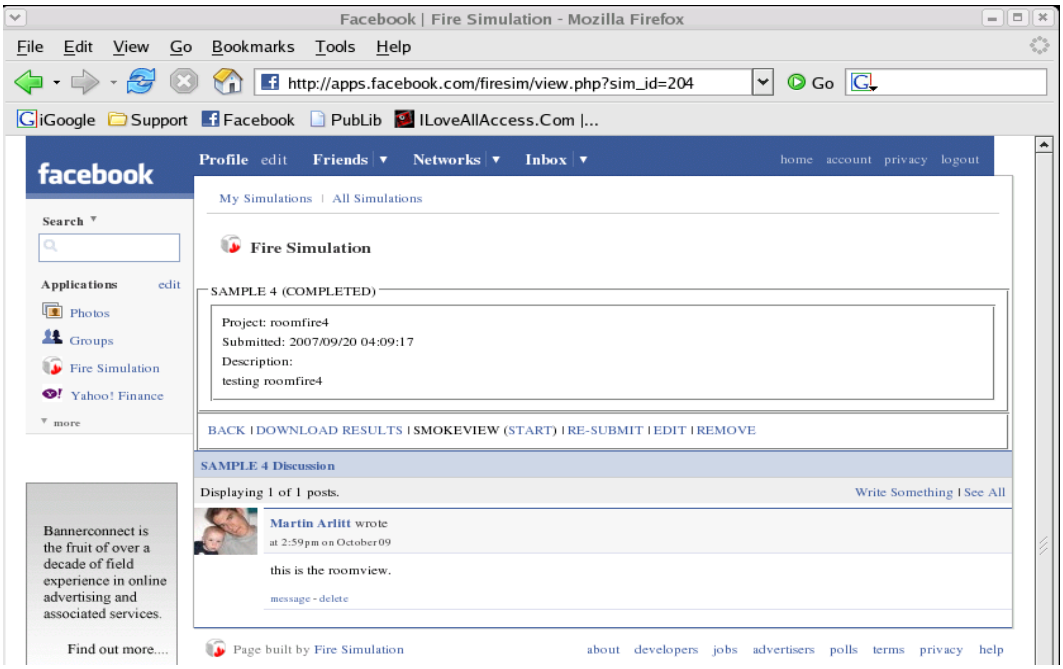

Figure 6. Simulation details

platform to create a comprehensive environment for the Fire Dynamics Simulation application. It enables users to easily access the application, upload and edit input files, submit and resubmit simulations, download results, visualize results, share and discuss results, etc., all in a single integrated environment. Simulations and visualizations were run on Virtual Appliances in a dynamic infrastructure that could scale to meet the simulation and visualization demands. In addition to showing an improved user experience and more efficient use of resources, it also shows how easily legacy applications can be integrated into such environments.

While our demonstrator has shown the feasibility of our proposed approach, many gaps in existing technologies still need to be addressed to make it a reality. New or revised social networking platforms that are more tailored to the needs of enterprises need to be developed. These tools need to provide greater security and control for IT organizations. Tools enabling support for virtualization and cloud computing infrastructures are starting to enter the market. However, the behaviors of these environments need to be studied in more detail to better determine the functionalities required to manage these environments efficiently.

In the future, we plan to more closely analyze application usage patterns on existing social networking platforms to better understand the application lifecycle and the utility of the approach discussed in this paper. We are also working on applying this approach to other academic and industry based projects to explore how heterogeneous services can be supported in the same environment and to further explore the benefits of this approach. On the infrastructure side, we are investigating how checkpointing and migration functionalities of virtual machine technologies can be used to better meet the needs of competing services and make more efficient use of resources.

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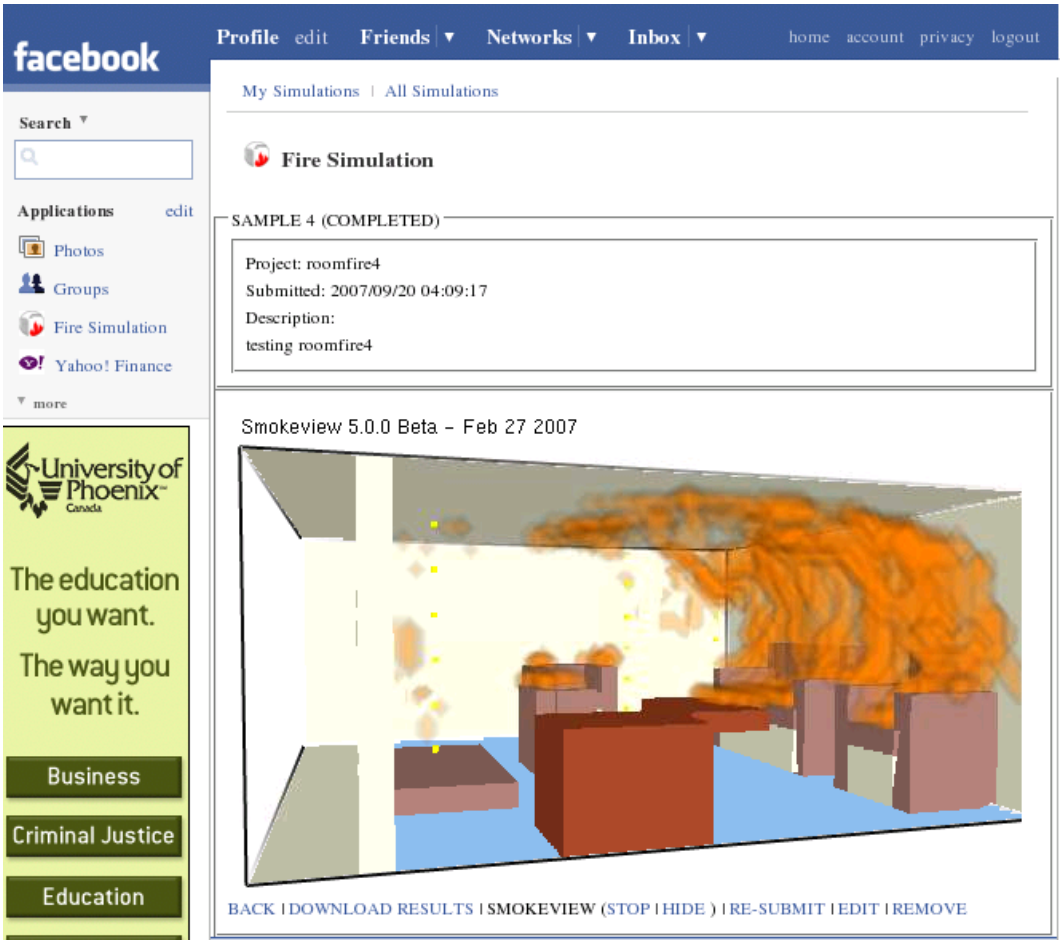

Figure 7. Smokeview visualization

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