The Integration of Ruby on Rails As An Agile Teaching Tool in IT Curricula

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ABSTRACT:

Ruby on Rails (RoR) is an extensive framework of Model-View-Controller (MVC) architecture comparable to Java's use of Tapestry and Struts and Microsoft's .NET frameworks. The ease of its use and productivity make it an obvious choice for agile web development that is being confirmed in the web marketplace. Its ease of use made it a prime candidate for trial training of Information Technology (IT) students for multiple technology purposes beyond just web development. RoR has proved to be a multi-faceted agile teaching tool in IT courses from an elementary to very advanced level. It is database agnostic and allows students to easily switch databases from MySQL to MS-SQL and Oracle and experience an immediate comparison virtually impossible with other frameworks. It functions ideally under virtualization and in this context is the perfect tool for working under both Windows and Open Source environments and in being the vehicle for implementing problem-focused learning scenarios. Of equal importance, RoR teaches proper application development formality using the RESTful approach that increases performance and resilience and reduces latency. RoR ease of use by students to learn quite different IT skills is demonstrated in introductory IT, database, security and Web system architecture courses.

Key words: Agile, Agile Teaching, Problem Based Learning, Problem Driven Teaching, Agile Problem Driven Teaching, Agile Programming, Agile Software Development, Agile Project Development, Ruby on Rails

1. INTRODUCTION

IT educators are challenged to remain current in a dynamically changing technology environment and a knowledge-based economy. Providing beneficial instruction in current technology to IT students at an increasingly accelerated pace is demanding and challenging, but "a lot of fun." National University (NU) has an advantage over many other institutions of higher learning in that its teaching model is based on "one-course-per-month", its students are largely employed in industry, and the instructors are "up to date" with current technology because the majority are simultaneously employed in the IT industry. The majority of the students, likewise, are IT professionals, bringing with them many advanced skills, and are highly motivated toward obtaining a degree in order to advance in their profession. At NU the BS IT Management (ITM) program offers classes both in-person and on-line. Specific challenges of the NU teaching model, as they apply to IT, are its accelerated pace, long instruction class periods, the lack of the traditional laboratory experience and the increasing demand for on-line instruction. The transition of industry toward using Agile ("ease of movement") techniques in programming and project development has motivated the faculty at the National University (NU) School of

Engineering and Technology (SOET) to introduce agility into pedagogy. Agile Problem Driven Teaching (Dey et.al., 2009) as used in teaching IT is described in this paper.

1.1 The IT Industry Evolution Toward Agility

It has been fascinating to watch the evolution of IT project management (PM) from the rigid structure of the 60's through the early 90's to the triple-time paced agility of the Internet era. The pace of change has accelerated phenomenally and the current IT manager is under "ever-increasing pressure" to produce quality product even in circumstances of reduced development budgets. In an attempt to keep pace with change, Agile Programming (AP) techniques were introduced by various developers but 2001 signaled the date of the "Manifesto for Agile Software Development (ASD)" (Agile Manifesto, 2001). The ASD Manifesto states:

"We are uncovering better ways of developing software by doing it and helping others do it. Trough this work we have come to value:

Individuals and interactions over *processes and tools*
Working software over *comprehensive documentation*
Customer collaboration over *contract negotiation*
Responding to change over *following a plan*

That is, while there is value in the *items on the right*, we value the items on the left more."

Dave Thomas (Thomas, 2005, 2007) and Martin Fowler, two of the creators of the ASD Manifesto, are noted Ruby on Rails developers. An Agile Project Management (APM) framework that uses AP and helps move from chaos to order was proposed by Jim Highsmith (Highsmith, 2004), another contributor to the ASD Manifesto. Raising a project manager from the level of "uninspired taskmaster" to that of "visionary leader" can effectively be achieved by employing APM (Ccpace, 2009). Additional perspectives on APM as applied to IT projects are provided by Alleman (Alleman, 2002, 2009).

1.2 National University as an Agile Incubator

Instructors at NU increasingly have been introducing agile concepts into undergraduate and graduate instruction. In ITM courses this was done by the author in order to meet the specific NU challenges specified above. Additionally, it is being done as IT tools have developed in the marketplace based upon the Agile concepts introduced in both AP and APM. Ruby on Rails (RoR) development framework is one of these tools. The author has used RoR as such a tool in two different university settings for the past four years. As RoR has been deployed it becomes self-evident that APM is introduced into the projects that use RoR. The net results are Agile teaching solutions that meet the specific NU challenges. RoR introduces Agile Programming, projects demand Agile Project Management, and the introduction of problems in class assignments leads to Agile Problem Driven Teaching (APDT). APDT effectively uses APM and the agile tools like RoR and simultaneously trains the students to use AP and APM concepts in their workplace.

1.3 How Agility Addresses the National University IT Teaching Challenges

Specific challenges of the NU teaching model as they apply to IT are 1) its accelerated pace, 2) long instruction class periods, 3) the lack of the traditional laboratory experience, and 4) the increasing demand for on-line instruction. Many IT concepts are best learned by many students through "hands on learning" (HOL) (Crowley, 2003). The absence of a laboratory experience and the ever-increasing percentage of on-line instruction severely handicap the student who learns best from HOL.

1.3.1 *The Need for Virtualization*

The development of a transportable lab (referred to in this paper as a Virtual Lab) that can be used both inside and outside of class begins to replace the lack of a physical laboratory with all of its supportive technology. The Virtual Lab uses virtualization software installed on a USB connected hard drive in excess of 10 Gbytes supplied by the student. The Virtual Lab is even used in selective on-line courses. The virtualization software used has been both Microsoft's Virtual PC and VMware and their respective virtual machines. Virtual machines (VM) typically consist of an operating system and associated application software. It is normal for an instructor to provide a VM to the class that presents the problem to be solved in an already operational computer environment. Hence, students are not constantly building and rebuilding the base computer environment used to present the specific problem. Virtualization saves many hours spent in the traditional lab repeating previous effort to simply create the base computer environment. Frequently, in the traditional lab, some students never even get to begin solving the assigned problem because of having to initially first restore a system to a useable configuration.

A student particularly appreciates the fact that she can receive a VM from her instructor, install it on her USB drive and execute it from her laptop without interfering with the resident build on her laptop or desktop at home, or the classroom workstation that is constantly used by sequentially scheduled classes. In Windows environments this means her registry does not get modified in order to check out this new VM the instructor wants her to work with. If she messes things up, only the VM space and not her entire laptop is affected. The ability to work with a VM outside of class is significant for experiential learning. HOL is restored to all students. Virtualization is a powerful tool that helps resolve all four of the NU IT challenges.

1.3.2 *Virtualized RoR Facilitates Agility*

The Ruby on Rails (RoR) framework, as a tool for Agile Teaching, helped introduce by example a multitude of IT concepts that were used in the most elementary ITM course, ITM 320, and then used throughout the entire ITM program instruction including the most advanced training for the ten CISSP security domains (Harris 2008). Web development with RoR is considered to be "agile web development" (Thomas 2007) and follows the AP and APM concepts. Agile RoR actually accelerated IT teaching and helped more successfully to include all the material required in the NU model of "one-course-per-month." Beginning students in ITM 320 prepared their Virtual Lab USB drive that was used in subsequent 300 and 400 series classes. In ITM 320 they received a VM that included a RoR build that operated under Windows XP and actually put a

web server and database server through its paces serving up browser pages. Components of a web system began to take life in their own Virtual Lab. These same students over a year later built upon their initial elementary experience and used RoR in advanced security configurations. Combining RoR with virtualization (VRoR) led to the creation of many lab experiments that will be presented in Section 4, Agile Problem Directed Teaching using VRoR.

2. RUBY ON RAILS (ROR)

Ruby on Rails is a combination of Ruby, a programming language (Fulton 2006), and Rails, a web support framework (Holzner 2007). An application development framework delivers working software early in the development cycle. Rails, as an agile framework, encourages developer and customer collaboration (Thomas 2007). Instant Rails is a preconfigured, ready to run software solution containing Ruby, Rails, Apache (web server), Mongrel (Rails development web server) and MySQL (a relational database system) (Instant Rails, 2009). This runtime version does not modify the base system configuration for Windows, OS X and Linux environments. Instant Rails version 2.0 was used in the projects described in this paper and facilitated an instant installation of a working RoR system, even for a neophyte IT student.

Ruby is an interpreted, object-oriented programming (OOP) language. It is a radically object-oriented "pure" OOP language in that every entity in the language is an object, every primitive type is a full-fledged class, and both constants and variables are recognized as object instances. It is agile as it may be extended and encourages easy refactoring (Fulton 2007). Ruby on Rails is based on the Model View Controller (MVC) architecture shown in Figure 2.1.

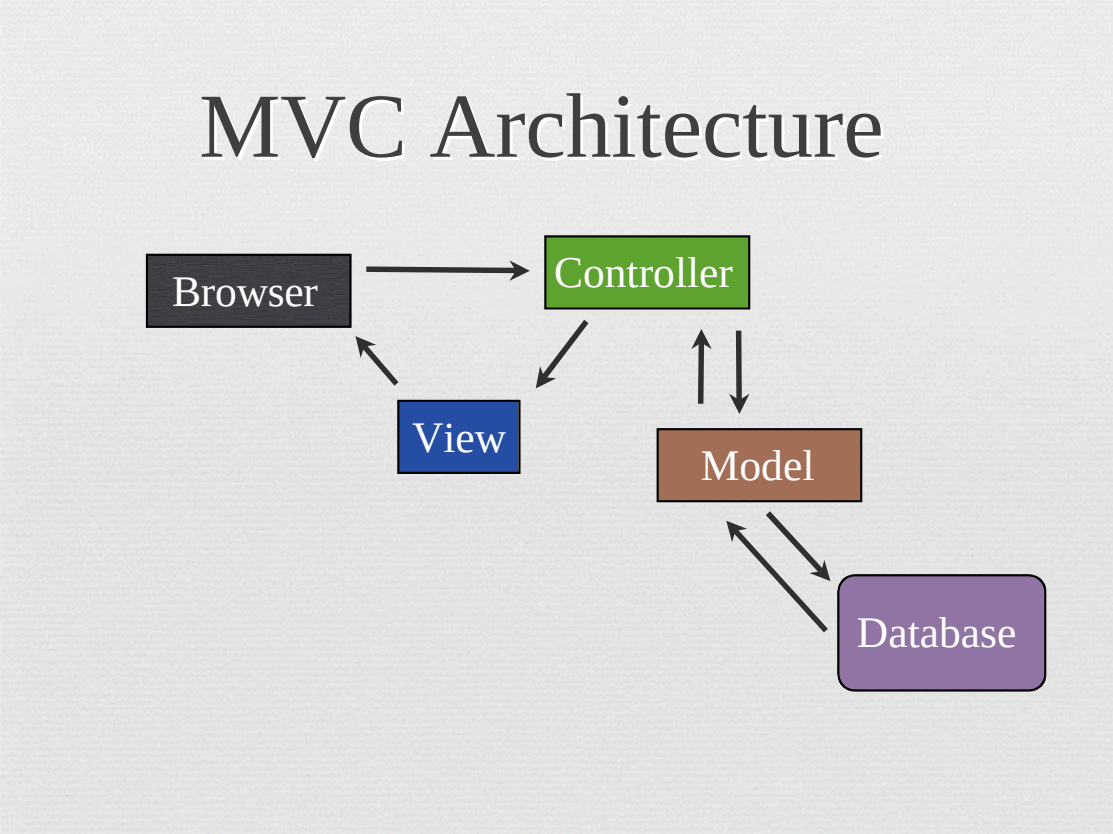

Figure 2.1. MVC Architecture of Ruby on Rails Framework

The MVC paradigm, also, is used by .NET, WebObjects, Struts, JavaServer Faces and Sun Microsystems' JRuby. A model enforces all of the business rules; a view generates the user interface; and a controller receives events from the user, interacts with the model logic and displays the view to the user.

Major companies that use Ruby on Rails are Amazon.com, BBC, Cisco, Google, NASA, New York Times, Oracle, Siemens, Sun Microsystems and Yahoo! (RoR Companies, 2009) Sun Microsystems has based much of its future upon RoR in the form of JRuby that is a compiled version of RoR that interoperates with Java platform applications. Regarding Ruby and JRuby, Sun states, "it combines the best features of many compiled and interpreted languages, such as easy development of large programs, rapid prototyping, almost-real-time development, and compact code. Ruby is a reflective, dynamic, and interpreted object-oriented scripting language, and JRuby is a Java programming language implementation of the Ruby language syntax, core libraries, and standard libraries." (Sun JRuby, 2009)

3. VIRTUALIZED RUBY ON RAILS (VROR)

3.1 Operating System Virtualization

Operating system virtualization is where the operating system kernel allows isolated, contained, user environments (called containers) that limit the impact of one container upon another. In this instance the host operating system was Windows XP and the container consisted of either Microsoft (MS) Virtual PC (Microsoft Virtual PC, 2009) or VMware Server (VMware Server, 2009) installed under XP as its own virtual partition (Virtualization, 2009). The container is basically an isolated software duplicate of a real computer – operating system and all of its applications. The software running inside of a Virtual Machine (VM) cannot break out of its virtual world, or container. A container is a VM and its image may be saved (Virtual Machine, 2009). A VM image size, in the present examples, is less than 6 Gbytes. Hence, the need for the Virtual Lab portable hard drive to have a capacity in excess of 10 Gbytes. Research at NU used both MS Virtual PC and VMware Server for creating Virtual Machines. Ruby on Rails (VRoR) in the form of Instant Rails (Instant Rails, 2009) was installed on a VM and is referred to as Virtualized RoR or VRoR.

3.2 Microsoft Virtual PC

MS Virtual PC (Microsoft Virtual PC, 2009) was used for classroom instruction and the majority of student Virtual Lab (Refer to Section 1.3.1) implementations since the NU classroom standard workstation environment is Windows XP. The VRoR installation works well for students at all levels of IT expertise.

3.3 VMware Server

VMware Server (VMware Server, 2009) was used for performance evaluation and the general system architecture for the robust WebPortal application created in advanced ITM courses that involved multiple servers and is discussed in greater detail in Section 8, WebPortal Architecture.

3.4 Incompatibility of Virtual Machines

VM machines created on operating system virtualization software supplied by different vendors, in this case Microsoft and VMware, are not interoperable or interchangeable. Standards organizations are currently specifying operating system virtualization interoperability. VMware, however, does supply conversion software for MS Virtual PC to VMware VMs (Virtual Machine Converter, 2009).

4 AGILE PROBLEM DRIVEN TEACHING USING VROR

Agile Problem Driven Teaching (APDT) was addressed by Dey (Dey et.al., 2009). APDT, as used in ITM similarly to Problem Based Learning (PBL), focuses on real-world problems. "Agility" components are introduced to more closely simulate the real-world workplace that students encounter. These agile components introduced are a) including multi-faceted problems that require multiple teams, b) adjusting the defined problem to available skills, and c) allowing team-members to discover alternate solutions and "work-arounds" while discovering the solution to a problem. ITM frequently requires redefining the problem in order to achieve a workable solution. Employing APDT methods in instruction better prepares students for the workplace.

Where PBL is based on a defined problem with usually one solution, APDT is based on the premise that agility, and creativity are required to redefine the problem in order to achieve a successful solution. VRoR facilitates Agile Problem Driven Teaching because RoR is based upon agile concepts. Furthermore, virtualization allows the development team to try a multitude of options in the same timeframe as the traditionally structured development of a single solution. The following courses are instances in which APDT was progressively used in the BS ITM program at National University:

ITM 320 Introductory IT Management
ITM 440 Database Systems Concepts and Data Modeling
ITM 470 Information Security Management
ITM 475 Information Security Technologies

5 INTRODUCTORY IT MANAGEMENT (ITM 320)

In this introductory ITM course, the text was management, as opposed to technology, focused. The challenge was the absence of HOL or experiential learning. The students wanted to get their hands on Web components but there was no lab associated with ITM320; only a classroom workstation, and perhaps a laptop or desktop at home. *The "Problem" introduced as part of APDT was "How can I as a student actually make the Web work for me?"* Here the instructor had to help them "think outside of the box." Was there technology that they could use that would help them? The agile component identified was the introduction of the Virtual Lab – a USB drive that could work both inside and outside of the classroom. MS Virtual PC was placed on the classroom workstation and the students created their first Virtual Machine (VM) and loaded Windows XP onto it. This VM-1 was then copied onto their individual Virtual Lab USB drive. The instructor gave the students another pre-configured VM-2 with RoR on it that was

likewise loaded onto their Virtual Lab. With VM-2 and MS Virtual PC on the classroom workstation the students could immediately start a Message Board web application and test it by bringing up a Browser window. They now had an operating Web Server and Web Database Server and could witness the role of each kind of server. Just reading about the servers in the text now became reality. The next in-class assignment was to actually download RoR Instant Rails (Instant Rails, 2009) and load it onto the VM-1 that they previously created. The proof of success was being able to compare the operation of the upgraded VM-1 (on which the student installed InstantRails) to VM-2. which was supplied by the instructor.

The real fun was taking the Virtual Lab home, installing MS Virtual PC on a desktop or laptop and using the Virtual Lab VMs without conflicting with any of the desktop/laptop registry settings. Virtualization now became a reality to each student as they witnessed the protection of the virtual container. *The Learning Outcome was learning how to bring up an active Web Server and MySQL Database Server, and witnessing first-hand how the Web functions.*

6 DATABASE SYSTEMS (ITM 440)

In this introductory Database course, ITM 440) the text was focused on MS Access and dealt with a very complicated healthcare database. It did little to prepare the students for their Senior Capstone project where they would have to create their own application; and operational Relational Database, normalize it and make it work; and most likely, use a Web interface. *The "Problem" introduced as part of APDT was "How can I as a student work with not only Access but MySQL?"* Again, the Virtual Lab and VRoR to the rescue. VM-2, used previously, was now installed and operational in minutes. None of the usual loss of several class periods just trying to get a common operating base to begin the actual assignment – wasted time frequently due to a multitude of driver problems introduced by different hardware configurations. RoR, because of its framework and MVC structure, provides basic data-entry and editing of all data fields which facilitates establishing an immediate data test-bed for checking out the database tables. SQL queries could now be performed from command line, PHPMyAdmin or by inserting SQL code directly in Ruby to produce custom reports. Class time could now be spent on solving database problems. Issues of how to handle foreign keys and properly normalized databases could now be dealt with firsthand. RoR additionally provided complete backup and recovery processes that could be evaluated. Furthermore, not only Access was learned, but MySQL was introduced which would be much more helpful in Senior Capstone projects. *The Learning Outcomes were a) learning how to bring up Access and MySQL database servers, and b) witnessing first-hand how a complete Web application functions and depends upon a robust relational database.*

7 INFORMATION SECURITY (ITM 470/475)

The sequence of security courses, ITM 470 and ITM475, deal with the ten domains associated with Certified Information Systems Security Professional (CISSP) preparation (Harris, 2008) and are taken just prior to the Senior Capstone sequence. The IT triad of effectively managing People, Technology and Processes emphasizes the dynamic nature of the project development cycle. The ability to complete a specific assignment where the problem has one solution no longer is the rule. Clients change their minds on what they want, technology does not always work the way it should and processes are frequently ill-defined. The IT professional must learn

to adjust quickly and dynamically in order to meet specified deliverables and timeframes. This is the domain of Agile Project Development and illustrates the need to introduce Agile Problem Driven scenarios to students who are soon to be in the accelerated "Internet-time" workplace. *The RoR component of the"Problem" introduced as part of APDT was "How do I as an IT professional architect and implement a VRoR that a) works with both MySQL and MS SQL and b) allows the data to interface with Windows SharePoint Services (WSS) 3.0 on a secure WebPortal?* The students found that agility required the problem to be divided into two sub-projects to be undertaken by two teams.

Team A successfully implemented VRoR under VMware Server but had to adjust from previous experience because of two issues. First, they had implemented a functioning application that tracked performance statistics for adjunct instructors at NU on a VM machine that ran under MS Virtual PC. The problem required a VM machine that would run on VMware. This required the team to evaluate several options and make a decision – an agile maneuver. RoR code is interchangeable, but they elected to go with a MS Virtual PC to VMware VM machine converter (Virtual Machine Converter, 2009) This was a good exercise in agility and APDT. The second issue was interfacing the RoR application to MS SQL rather than MySQL. Again, another exercise in agility because the solution was not handed to them. The agile design of RoR, however, facilitated the insertion of another type of relational database.

Team B was tasked with facilitating the interface of MS SQL and MySQL with WSS 3.0. The reason for this was to allow the development agility of RoR to work with MS SQL databases since SharePoint (WSS) is based on MS SQL and is very restrictive on the Web logic that it permits. Microsoft designed WSS to perform specific functions but did not allow generalized access to its underlying MS SQL database engine. Members of Team B felt that they had no possible solution. Again, exercising agility they searched until they discovered MS SharePoint Designer (SharePoint Designer, 2008), an application that facilitates interfacing external database engines such as MS SQL, MySQL and Oracle to WSS 3.0. This also allowed the use of SQL scripts to extract selective data from the external databases. Team B met the deadline of providing its solution in time to integrate with Team A's VRoR environment in meeting the project deliverables. Success, but not until after having spent many days, seemingly, without a solution to the problem and experiencing frustration with the instructor for giving them what was perceived as a problem with no valid solution. At the conclusion, one student declared to the instructor, "It is now obvious that you have been teaching us in an Agile manner!" The *Learning Outcomes were a) installing a VRoR under VMware with both MS SQL and MySQL database servers, b) interfacing SharePoint (WSS) with external MS SQL and MySQL databases driven by RoR agile applications, and c) dividing the project labor in order to leverage skills and meet deadlines.*

8. WEBPORTAL ARCHITECTURE (ITM 470/475)

The network topology of the WebPortal architecture produced by the security courses ITM470/475 is shown in Figure 8.1. The five real servers are in gray and the seven virtual servers (VMs under VMware) are in beige. The contribution of virtualization and agile RoR was described in Section 6. There were other APDT components that produced this end product, but

success resulted from agility in adjusting to a) the skills of the students, b) the availability of team members where work assignments out-of-state created conflicts, c) stable, functional hardware, and d) compromise by the client (instructor) when non-essential features could not be implemented.

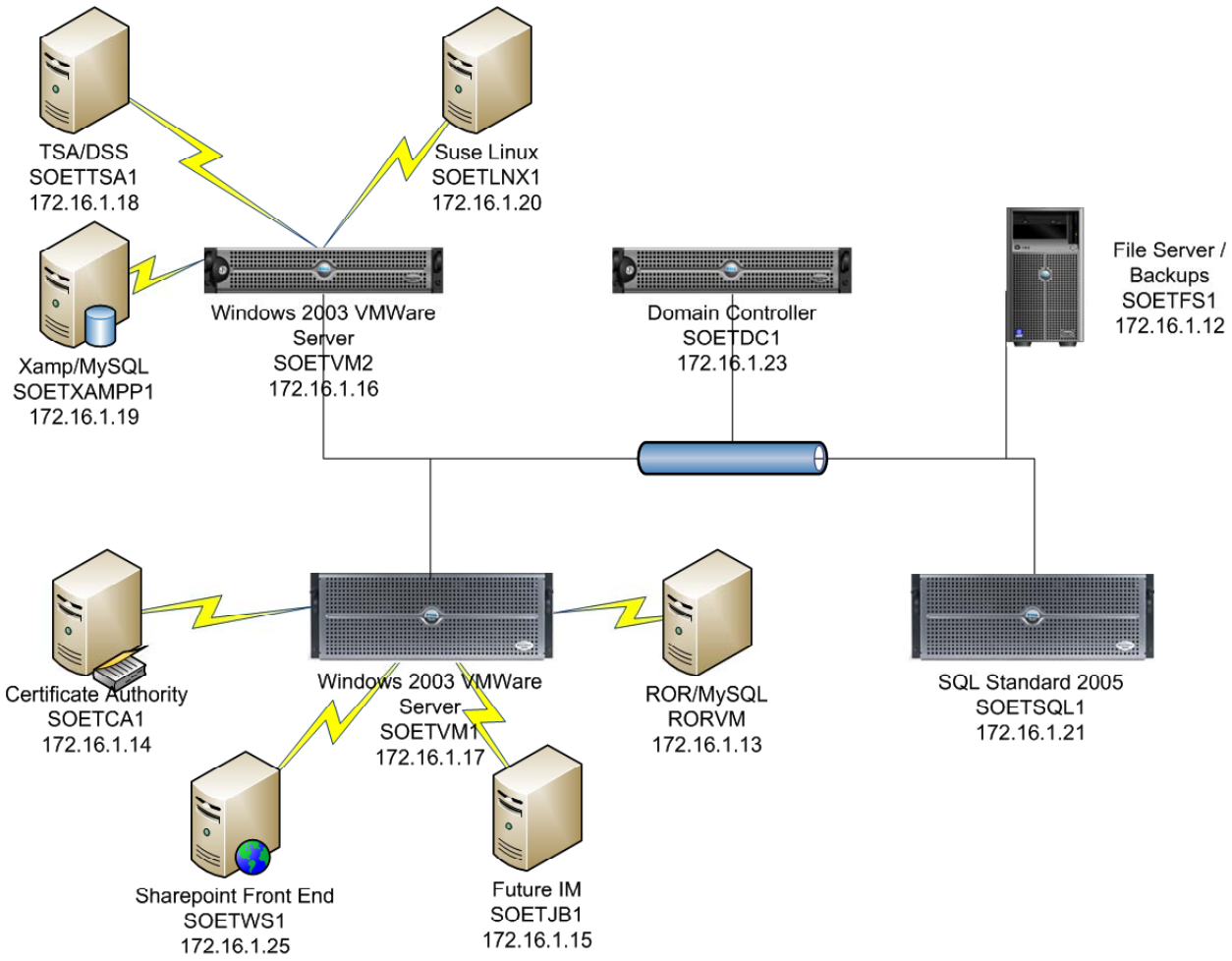

Figure 8.1. WebPortal Architecture

9. CONCLUSION AND FUTURE RESEARCH

The specific challenges introduced by the National University (NU) teaching model, as they apply to teaching Information Technology, are its accelerated pace, long instruction class periods, the lack of the traditional laboratory experience and the increasing demand for on-line instruction. Searching for tools to help meet these challenges, the author turned to a) use of a portable lab (also referred to as a Virtual Lab) in the form of a USB hard disk drive, b) operating system virtualization, c) Agile Project Development he first encountered in industry in 2002, and d) Agile Programming introduced by the Ruby on Rails (RoR) framework.

Web development with RoR is agile web development as it follows the Agile Programming, Agile Software Development (ASD) and Agile Project Management (APM) guidelines. The agile concepts specified in these guidelines have inspired the use of agile tools in the author's teaching. NU's School of Engineering and Technology has, as one of its primary objectives, the desire to prepare its students to be immediately productive in industry. Teaching students the four points of the Agile Manifesto for ASD places emphasis upon 1) individuals and communication, 2) working software, 3) customer collaboration, and 4) responding to change. Another NU objective is to prepare students for management by raising them from the level of "uninspired taskmaster" to that of "visionary leader" as emphasized by CC Pace (Ccpace, 2009). APM helps accomplish both objectives.

As described above, RoR introduces Agile Programming, projects demand Agile Project Management, and the introduction of real-world problems in class assignments leads to Agile Problem Driven Teaching. The examples given in Sections 5, 6, and 7 of specific problems illustrate the manner in which students had to exercise agility in producing a working solution within the "one-course-per-month" NU model. Experience over the past eighteen months for on-site teaching in the BS ITM program in which agility concepts have been introduced indicates that many students learn faster and better by hands-on-learning. The portable lab, virtualization, RoR and agile concepts in class problem solving appear to significantly address the specific challenges encountered at NU in the ITM program. Agile Problem Driven Teaching, at least in this limited context, appears to be most viable for the on-site classroom scenario. Only limited instances of usage of the portable lab in the on-line course scenario have been tested.

Future research will carefully deploy, monitor and assess both on-site and on-line course implementations of Agile Problem Driven Teaching. Training other instructors in the virtues of Agility and its proper usage has proved to be one of the greatest challenges to date. Hopefully, the success experienced in the NU BS ITM program, coupled with the rapid adoption by major corporations of Agility, will motivate others to seriously implement its guidelines. Students have been excited to be learning one of the most current approaches to web system development and project management. It is motivating to be current and "on the edge." Especially when one is keeping up with the likes of Amazon.com, Google, Yahoo! and NASA.

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