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Prism: the Development of an Online Repository for Information Security Education Resources

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PRISM: THE DEVELOPMENT OF AN ONLINE REPOSITORY

FOR INFORMATION SECURITY EDUCATION RESOURCES

A THESIS

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TO THE DEPARTMENT OF INFORMATION TECHNOLOGY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF MASTER OF SCIENCE IN

INFORMATION ASSURANCE

BY

Vincent Garramone

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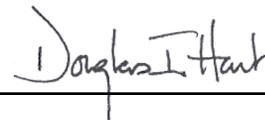
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Abstract

The goal of this study was to develop, implement and evaluate an online system that would allow

intuitive sharing and retrieval of information security (IS) education materials, and a

corresponding taxonomic system relevant to common contexts in which IS concepts are taught.

After determining initial requirements, popular open-source content management systems were

evaluated. The most suitable solution was customized, and implemented as the Public

Repository for Information Security Material (PRISM) website. An initial organizational

taxonomy was developed, and the repository was populated with resources from several sources.

Evaluations of PRISM suggest that core functionalities have been suitably designed and

implemented, have provided guidance regarding the next phase of development, and have

affirmed the scientific value of the PRISM design artifact.

Acknowledgements

Many thanks to Mr. Dan Likarish for his guidance and patience throughout the research and writing process, and to Dr. Dino Schweitzer for the initial vision and content for the project. I would also like to express my gratitude to Mr. Erik Moore and Dr. Steve Fulton for their input and expertise, and to Mr. Rick Cisneros for his time evaluating the PRISM website.

On a personal note, a heartfelt thank you to my mother, who lovingly proofread two separate drafts of this paper and identified a considerable number of errors that my word processor did not, to Dr. John LeMond, who graciously agreed to perform a final inspection on very short notice and saved me from committing several grammatical faux pas in this final draft, and to my wife, who has patiently supported this endeavor and helped me to stay on task despite the many "distractions" life has to offer.

Table of Contents

List of Figures

List of Tables

Chapter 1 - Introduction

As people's dependence on information technology (IT) grows, educating those who develop and manage IT systems about security concepts becomes increasingly important. Unfortunately, tuning mature educational programs to include security topics has not proved straightforward. For example, some institutions report success adding security specific courses to existing curricula. This is not always feasible, however, due to a lack of resources or expertise (Null, 2004). When it is not practical to add security specific courses, relevant activities and lessons can be integrated with existing courses to teach security concepts (Irvine, Chin & Frincke, 1998). For this to be effective, the supplemental materials must be highly available, be able to be integrated into many different types of courses and curricula, and have a high usability factor for students and teachers unfamiliar with the subject matter.

Because the development of these resources is dispersed among many individuals and institutions, it is important that the developers have the ability to make their products available to each other and to the general public. Although many educators share their materials on personal or university websites, there is no cohesive method of searching these small, disparate repositories. Also, search engines may index many of these sites, but without a standardized set of metadata (data that describes other data) or a semantic approach to content description, keywords alone will not consistently return accurate results when searching for these materials.

Even within existing educational material repositories, locating IS-related resources to match a particular educational need is not straightforward, as the necessary metadata are not often employed. When presenting security concepts, many higher education institutions have specific learning objectives they must address. For example, undergraduate and graduate IS

program developers may be working to satisfy requirements for a National Security Agency

(NSA) Center of Academic Excellence (CAE) designation, which entails meeting a rigorous set

of curricular criteria. Community colleges and professional schools, driven by job market

requirements, often strive to cover topics necessary to achieve industry-recognized security

certifications from companies like Microsoft, Cisco, and the International Information Systems

Security Certification Consortium (ISC)[2]. High school teachers might not be so focused on

domain learning, but instead wish to engage students by augmenting lessons with hands-on

exercises that require little preparation or technical skill.

In addition, information security is a broad and complex field of study, and one can

quickly become mired in results irrelevant to their interests when conducting keyword searches.

It may also be difficult to identify which terms will be most useful in locating specific materials

within any given repository (Dicheva & Dichev, 2006). Wikiversity presents a table of metadata

systems used by some popular repositories (n.d.) that shows a tendency to use very general

metadata definitions. Although these simplified systems might work well for a broad range of

subjects and make management easier, a deeper level of specificity may be appropriate for a

specialized repository for IS education materials. The author anticipates a more efficient method

for locating relevant material will be realized through the use of carefully crafted taxonomies that

allow for target content location based on curricular drivers and learning environment

constraints.

This research addresses these perceived gaps in services through development of a web

portal to store and index information security education materials from disparate sources, and an

investigation into the most useful way to classify and organize resources available on the site.

Both literature review and the design science methodology were used.

The design artifact, termed PRISM (the Public Repository for Information Security

Material), was developed using technologies that allow for flexibility in the implementation of

functionalities while requiring minimal programming expertise and maintenance effort. These

technologies were selected based on analysis conducted by the author and resource constraints

imposed by the sponsoring organizations. Two build and evaluate cycles were completed to

bring PRISM, to its current state.

Chapter 2 - Review of Literature and Research

During the course of this study, three primary topics were investigated. The first dealt

with drivers for, and methodologies of, teaching IS concepts in both IS and non-IS programs.

This was an important area to understand, as it would point to categorical descriptors for content

organization.

The second topic was focused on identifying effective ways to represent and present

educational resources (often referred to as "learning objects") to students and teachers,

potentially those with a non-technical background. This information led to a pilot

implementation of the taxonomic structures derived from research into drivers and

methodologies, as mentioned above. Lessons from these two areas were combined to synthesize

a plan for the development of a repository tuned especially for IS education within various

learning contexts.

The final topic of investigation was of a more technological nature, and explored existing software components which were ultimately used to build the PRISM content management system (CMS) and the underlying server architecture.   The rapid pace of change in the open-source software market, along with a sparsity of current, relevant publications investigating CMS and collaborative learning material repositories, made it necessary to conduct a full comparison of alternatives based on current, primary sources (i.e. developer websites). The steps taken during the planning and implementation of PRISM will be discussed under the "Build Phase" headings in the Design Process section.

Topic I: IS Curriculum Considerations

It is broadly agreed that a general understanding of information security concepts is becoming increasingly important in an increasingly broad range of computer-related disciplines. (Cooper, et al., 2009; Schweitzer & Boleng, 2009; Null, 2004; Petrova, et al., 2004). In this section, those things that motivate the inclusion of information security concepts in some existing curricula will be examined. Also, the various sources of content criteria (i.e. which concepts are necessary and sufficient for a complete education for a particular educational context) will be discussed, along with methods of integration with existing course programs.

Curriculum Drivers. There are several drivers for IS curriculum development, mostly stemming from an increased demand from government and private industry for individuals with IS knowledge and skills (Yuan, et al., 2010). Offering students IS components in their education can both increase the prestige of a diploma, and generate revenue streams via scholarships and industry partnerships. For example, designation as a National Center of Academic Excellence in Information Assurance Education (CAE/IAE) allows students to apply for federal scholarships,

and assures students a skill-set that is currently in high demand (National Security Agency,

2009b).

Similarly, many four-year universities, technical colleges, and professional development

programs are inclined to teach skills and knowledge that will provide students with strong

employment opportunities (Cooper, et al., 2009). These curricula are often constructed to

convey information necessary to pass both vendor-neutral (such as those offered by (ISC)^2,

CompTIA, and Systems and Network Security (SANS)), and vendor-specific (from companies

like Cisco and Microsoft) certification exams.

Content definitions. Clearly, information security is gaining attention and importance in

a number of educational settings. Exactly what topics should be covered in a given course of

study is still a matter of debate, and relies heavily on whether the student plans to serve in private

industry, academia or national defense upon completion. Standards bodies are making efforts to

draw from each of these contexts to develop a general set of curricular requirements for various

levels of education (Cooper, et al., 2009; Abernathy, et al., 2005). Contributions in this area are

too numerous to treat comprehensively in this paper, but several influential and substantial

documents will be discussed in this section.

Cooper and his co-authors (2009) offer the most up-to-date assessment of prominent

efforts to develop curricular standards for information security. According to their paper, IS

curriculum development has strong roots in government agencies like the NSA and National

Institute of Standards and Technology (NIST). These efforts have culminated in a series of

standards developed by the National Security and Telecommunications Information Systems

Committee (NSTISSC) (now the Committee on National Security Systems (CNSS)) that outline

the required competencies for six types of government security professionals. These standards, 4011–4016, are currently used to accredit institutions as CAE/IAEs.

The Department of Homeland Security (DHS) has released a more generalized set of essential knowledge and skills for IT security practitioners called the Essential Body of Knowledge (EBK) (Cooper, et al., 2009). This document provides a context-neutral (i.e. is not specific to private sector, government, and academia) articulation of competencies required to perform IS jobs (Department of Homeland Security, 2008). Furthermore, it attempts to place the various certification criteria into an overarching framework so they can be more efficiently compared and evaluated.

Integration methodologies. The best way to introduce IS concepts into existing curricula is still a topic of debate. While some programs may opt to provide dedicated security courses to augment their curriculum, some institutions will simply not have the resources to do this. Many programs are already highly compact, and the addition of "extra" courses would lead to the reduction in core content instruction (Null, 2004; Petrova, et al., 2004). Some institutions may not have teachers with the required expertise to administer a course on information security, even if time would permit (Null, 2004). It seems that even some programs that offer dedicated courses in IS topics feel students would be better served by integrated material throughout the academic career (Du & Wang, 2008). Thus, the strategic addition of readings, labs or similar materials that tie information security concepts into an existing program may prove more effective for many educators. These materials can be viewed as complementary assignments and exercises that both enhance, and are enhanced by, the existing lessons, without significantly disrupting the traditional course curriculum.

In order for this type of integration to occur, however, it is necessary for educators to be able to locate relevant resources that fit into their curriculum both technologically and contextually.

For those who teach nontechnical courses that could benefit from IS lessons (such as management, legal or clerical), the available resources are even more elusive. Nearly all of the learning modules, laboratories and other resources outlined in the literature (Benjamin et al., 2003; Yuan and Zhong, 2008; Li et al., 2009; Yang, 2009) are aimed at students pursuing degrees in information technology (IT) or computer science (CS). Not only do these resources require a high level of technical skill to utilize, but considerable knowledge is often necessary to install, configure, and manage the environments in which the exercises are to be conducted.

For example, Li, et al. (2009) have described the construction of a laboratory for collecting packet traces for use in information assurance courses. The setup consisted of a virtual network using VMWare Workstation to host various Linux, BSD and Windows guest operating systems. Both "regular" and "irregular" traffic was then generated on the network, and captured into trace files using tcpdump (http://www.tcpdump.org/). This is a fairly time-consuming process, even for tech-savvy individuals, to generate material for IS students to analyze. Furthermore, without accompanying documentation, the resulting trace files require a trained individual to interpret and describe to students. This kind of exercise is very difficult for classes that are looking to augment their existing curriculum with IS concepts. Interestingly, Li's motivation to construct this lab was a perceived lack of publicly available packet capture (pcap) traces, but there is no mention in their paper of making the resulting traces available to the community at large.

Schweitzer and Boleng (2009) developed a series of web labs and accompanying text intended to provide a meaningful IS learning experience without the need for significant technical background knowledge. Outside of their contributions, it seems there is a notable lack of documentation regarding materials useful for teaching complex or difficult IS concepts to non-IT or CS majors.

Conclusions. Several conclusions can be drawn from the literature on IS curriculum in relation to presenting educational materials in an online repository. First, IS curricula are driven by various standards devised by government, industry and academia, often to serve employment demand. Actual content requirements have been offered by a number of organizations, and the decision to use any particular guideline assumedly depends on the educational goals of the institution. Also, materials must be modular to allow educators to easily fit them into already packed curricula. Finally, it cannot be assumed that those teaching IS concepts are experts themselves.

Topic II: Presenting Resources

An investigation was also made into methodologies used to engage students and teachers in the utilization of online repositories and ways to optimize the end-user experience. Existing repositories were assessed, along with pertinent publications.

Merlot (http://www.merlot.org) is one of the most popular repositories for educational materials, and is therefore an obvious place to begin examining methodologies for their organization and presentation.

Merlot offers more than just educational materials, but these resources are outside of the area of interest for this research. IS materials can be found as a sub-category of the Information

Technology section. Each material is presented along with author, material type, add and modify

dates, technical format, and review information. A description is also provided, along with a

"More Information" area that presents audience, language, copyright, source code, and cost

information. An advanced search function allows search by keyword, title, url, description,

language, material type, technical format, learning management system (LMS), usage rights,

author information, date and associated community content. As of the time of this writing, no

subcategories exist within the "Security" subcategory, requiring keyword searches to locate more

granular topical materials within the broad field of IS.

A second, highly notable repository was created by Ken Abernethy, George Piggery, Han

Reichgelt, and Kevin Treu to hold learning objects for introductory IT courses (http://

cs.furman.edu/~kabernet/cte/). Abernethy's repository used metadata sets reflective of several

aspects identified in this paper's section on curriculum drivers. In particular, "Relationships to

Model Curricula" is included to show where the material fits in with the Association for

Computing Machinery (ACM) IT Model Curricula published in 2005 (http://www.acm.org/

education/education/curric_vols/CC2005-March06Final.pdf) (Abernethy, et al., 2005).

Abernethy also outlined several other content descriptors that could be very useful to

educators looking for material to add to their classes. A "cognitive level" element was included

to place materials within the context of Bloom's taxonomy of cognitive skills, which could be a

useful complement to grade level for gauging educational appropriateness. Granularization,

given in minutes, describes how long it should take to complete a lesson (also called "objects" on

the website). This is the equivalent of the duration value available in the PRISM metadata set - a

descriptor not often seen in learning object repositories.

Although the data model seems very well constructed, without a search function the repository could become difficult to navigate over time. No automated system for content submission, and the apparently flat nature of content organization, suggest significant content management requirements. Finally, and quite unfortunately, the repository does not appear to have been updated since November of 2005.

Conclusions. Considering the drivers identified for teaching IS concepts, it seems there could be more relevant metadata added to educational materials that would describe how they fit into various IS curricula, particularly in relation to standards developed by government, industry and academia. At least one repository (Abernethy) has made this effort in the area of general IT, but the author has yet to identify such an effort relating to IS.

Chapter 3 - Methodology

A combination of historical research and design science methodologies was used in the execution of this research. Historical analysis of literature revealed current drivers for information security curriculum development, sources of curricular criteria, and aspects of integration into existing programs. Design science build and evaluate cycles were used to develop PRISM as a design artifact solution to the need for a flexible system capable of storing and organizing information security education materials from disparate sources.

Research Environment

The PRISM website was developed in a virtualized environment hosted on Regis University's Academic Research Network (ARNe) infrastructure. The use of virtualization technology allowed the author to build and configure the required software independent of the

server hardware that would ultimately be used to host the website. It also gave the sponsoring

institutions the flexibility to relocate the server operating system and website files to a more

robust physical hosting location if necessary, without moving any hardware.

PRISM Working Group and Evaluators

The PRISM working group consisted of five individuals from Regis University and the

United States Air Force Academy (USAFA). Dr. Dino Schweitzer from the USAFA brought the

initial vision and content for the PRISM website to the group, and was the primary source for site

requirements. Mr. Dan Likarish and Mr. Erik Moore from Regis University were also

instrumental in developing site requirements and reviewing features as they were developed. Dr.

Steve Fulton (USAFA) participated in requirements development, and actively utilized several

site features. He was therefore able to offer a strong end user perspective to the group. The

author participated as a developer and addressed technical feasibility and implementation issues.

Finally, Mr. Rick Cisneros (Regis University) did not participate in requirements development,

but has website design and usability experience and acted as an objective evaluator during the

second evaluation phase.

Instruments and Materials

There were two tangible components to the PRISM study. The PRISM artifact was the

subject of build and evaluate cycles, while the evaluation form provided a scoring rubric and

evaluation framework.

PRISM. The PRISM website was developed using the open source content management

system Drupal (http://drupal.org/) and consists of various types of IS materials that are organized

using the taxonomies developed as a result of literature review and working group discussions.

PRISM functionality and design were the targets for site evaluators.

      Evaluation form. The second evaluation phase was conducted via email, and evaluators

were given an Excel worksheet (see Appendix) as a framework for their assessments. The form

asked for both numerical ratings and explanatory comments regarding six requirements defined

by the PRISM working group. Additionally, evaluators were asked to comment on the value of

PRISM as a design science artifact, and to optionally note any issues they had with the problem

definition.

Chapter 4 - Design Process

      This research used a design science methodology, and consisted of a requirements

gathering stage, followed by a series of build and evaluate cycles. Requirements were defined

by the working group in a series of meetings and occasionally via email correspondence. In the

first build phase, a review and selection of software was conducted, along with a survey of

content organization systems used by existing educational resource repositories to identify areas

of potential improvement. A draft implementation of the PRISM website was then constructed

with core functionalities and a basic taxonomy. The artifact was evaluated by the working group,

and areas in need of improvement were identified. A second build phase addressed these issues

and implemented additional functionalities on the site. The artifact was then evaluated a second

time in a more formal manner.

Problem Definition and Requirements Gathering

During the first meeting, the working group discussed immediate needs for an educational materials repository. Dr. Schweitzer was interested in making a set of educational tools available to the general public, but did not currently have an appropriate online space to publish them. These tools, termed the Visualizations for Information Security Education (VISE) toolset, consist of Java applets and HTML pages.

The initial requirements for hosting a predefined set of tools, all of a similar format, were fairly straightforward. In general terms, a publicly accessible website would act as a repository for the VISE toolset and any subsequently developed materials, as well as an interface for educators and students to locate and make use of the digital resources. A physical server to host the website and a reliable connection to the Internet with adequate bandwidth to support the PRISM user base would also be required. Finally, a plan for system administration and site maintenance would be necessary to ensure continuous availability and integrity.

As the project progressed, subsequent discussions yielded an expanded problem domain and set of requirements. Given that there appeared to be few, if any, outlets for educational institutions to publish their resources in a public, aggregated and organized way, it was decided that the site should act as a space for institutions other than those involved in the working group to publish IS education resources. This expansion of the project scope prompted a corresponding redefinition of goals and requirements.

Front End. Certain characteristics and functionalities driven by the new goals of the project were identified as vital to the utility of the PRISM website. An intuitive interface would be necessary to allow students and educators to locate desired resources effectively and

efficiently, and a simple procedure to create new content would give individuals of various

technical proficiency levels the ability to contribute meaningful content to the site. Collaboration

was also discussed as a potentially useful functionality, and would necessitate some form of

communications mechanism on the site.

Furthermore, the ability to define access control levels would allow administrators to

specify different permissions for anonymous users, authenticated users, content contributors,

moderators, and site administrators. This would help to ensure each user had permissions

proportional to the level of trust between the user and the site administrators.

Finally, the software should be flexible in terms of site functionality to allow for growth

and change inherent in a newly developed resource and have a license compatible with the

PRISM organization and budget.

Back End. Similarly, certain desirable hosting conditions and information management

system attributes were considered. First, a framework for the organization and categorization of

resources should be employed to allow users to easily locate materials that suit their needs, and

to foster categorical expansion and changing search contexts. Essentially, this means a tagging

system that allows vocabularies and terms to easily be added, updated, and associated with those

that already exist.

For hosting, a suite of supportive applications (database, web server, etc.) that are secure,

reliable, manageable, and offer free or inexpensive licensing would be required. Adequate server

hardware would also be necessary to fulfill requests from visitors to the website at an acceptable

level of performance.

To protect the integrity and availability of the website, secure configurations should be implemented to protect from hackers or rogue applications, while redundant power, storage, processing, etc., would be required to eliminate single points of failure.

Finally, the site should be able to handle files of essentially any size and type that educational resource developers might use. No actual list of filetypes or size requirement was defined, so the site should have the flexibility to adjust these parameters as users' needs change.

Personnel and Procedures. Personnel would be required to monitor the hardware, maintain the site, and manage PRISM activity and administrative tasks. Ideally, a group of PRISM organizational leaders would provide direction, and solicit participation and support. It would also be necessary to have a group of individuals able to monitor and maintain the software and hardware powering the website. A site moderator would enforce site rules, preserve integrity and scope, and offer help to users and contributors. An IS expert should be employed to configure the server, test software for vulnerabilities, and plan for failures and recovery. Finally, a published set of rules and procedures for submitting and reviewing content, determining content appropriateness, and expiring content should be developed to make contributing to, and maintaining the website a straightforward process.

Because PRISM would be physically hosted at Regis University, it was tentatively decided that students and faculty would be responsible for maintaining the infrastructure and server hardware and software. The author would continue to maintain content and website software as long as possible, and be replaced by volunteers or Regis University employees at some future date.

First Build Phase

As with most projects, budget and availability of resources was a constraint in the planning and implementation of PRISM. Cost of hardware, software licensing or development, bandwidth and communications services, and maintenance of each component of the hosted website had to fit within the available budget. Since no funding was available to purchase software for the PRISM project, open-source software solutions were strongly preferred and ultimately implemented.

While an extended discussion regarding the pros and cons of open source software (OSS) is beyond the scope and intention of this paper, it is worth noting that given the "right set" of requirements and resources, OSS can offer many benefits over closed proprietary systems (Ellis & Van Belle, 2009; Dedrick & West, 2003). For PRISM, the cost, security, and performance requirements of the software, combined with a plan for a team of graduate IT students to manage the project for the foreseeable future, made an open source solution both desirable and cost-effective.

Content Management System. After consideration and comparison of alternatives, Drupal was chosen as the content management system (CMS) for PRISM. Drupal was selected for its flexibility in terms of appearance, administration and functionality, and its fairly respectable security record, all of which are driven by a large, active user and developer base that has fostered the creation of many customizations (called modules) and responsive security patching. A major advantage of this level of participation is that even those without skill in software development can benefit from its openness, and sidestep the lack of extensibility

problem in proprietary systems that is discussed by Masuda, Murata, Yasutome, Shibuya and

Nakanishi (2008).

Only the most extensible and well supported products that had been successfully used in

similar applications were considered. A great amount of flexibility and community support were

desired for ease of continued development and maintenance of the PRISM website, and

consistent reports of others' success with a product suggests it has the capabilities it touts. Other

CMS and LMS (Learning Management System) solutions that were seriously considered include

Joomla (http://www.joomla.org/), Moodle (http://moodle.org/), and Plone (http://plone.org/).

Although it boasts a very impressive feature set and a dedicated user-base, Plone's

orientation toward application driven sites, more complicated software stack, and relative

unfamiliarity of Zope (http://www.zope.org/) and Python (http://www.python.org/) compared

with Apache (http://www.apache.org/) and PHP: Hypertext Preprocessor (PHP) (http://php.net/)

made it less appealing than the other products. Moodle, a popular LMS with a structured focus

on delivering online classes and learning content, seemed less appropriate than Joomla or Drupal

for the kind of general content management required for PRISM. Joomla, though anecdotally

easier to set up and more visually appealing, appeared to trail Drupal in security response and

quality of code and documentation. Also, as the author explored each solution, modules and

how-to documentation required to achieve the desired initial functionalities for PRISM were

consistently easier to locate and of apparent higher quality in the Drupal space. This suggested

that Drupal was also likely to offer more opportunity for extension in the long term.

Table 1 outlines some of the core features of the CMS's that were considered during the

comparison. The author rated the four "finalists" in each category based on information gleaned

from user forums, developer websites, personal experience and other sources. Values range from

1 to 5, with 1 being the most desirable and 5 being the least. The CMS with the lowest total

score (Drupal) was considered the best candidate for the PRISM website.

Table 1

Comparison of popular content management systems.

CMS attribute	Content Management System (CMS)			
	Plone	Moodle	Drupal	Joomla
Out of the box functionality	1	4	2	2
Functionality Availability (modules)	2	3	1	2
Familiar Technology	4	2	1	2
Difficult to configure / maintain	4	2	2	1
Documentation Availability and Quality	2	2	1	2
Code quality and Security	1	2	2	3
Size of user-base	3	3	1	2

Note. Lower scores indicate preferability.

Software stack. The selection and configuration of PRISM's underlying software stack

was based on a substantial existing knowledge base, and did not require the development of any

new processes or products. Figure 1 shows the software stack that comprises the PRISM website

and underlying server.

The selected CMS partially dictated requirements for the server software stack, and

selections were made within those constraints based on popularity, reputation, quality of

documentation, and lab precedent (i.e., when possible, products already in use in the lab were

utilized). Linux (CentOS), Apache, MySQL and PHP were used to create a typical LAMP web

server configuration. Each of these products is industry standard, and available with free or open

source licenses.
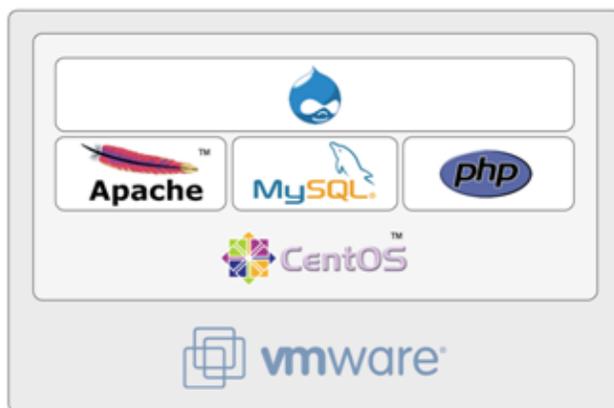
Figure 1. The PRISM software stack.

Given general security concerns for public-facing web servers, each component was

individually hardened before exposure to the Internet. Apache, MySQL and PHP were

configured according to best-practices published by the developers. CentOS was secured

according to the NSA Linux configuration guide (National Security Agency, 2009a).

Virtualization technologies were also leveraged for the project, providing increased

flexibility, reduced hardware and power consumption, and more efficient change management

and disaster recovery, by installing the PRISM server on a VMware ESXi (http://

www.vmware.com/products/vsphere-hypervisor/) host. Consequently, PRISM can be co-located

with other virtual servers on a single physical machine, and relocated to different geographic locations with minimal effort. Snapshot functionality allows administrators to roll back undesirable results from updates, intrusions or other unforeseen network events, and retention of up-to-date clones allows for quick recovery from catastrophic system failures. Finally, in the process of developing the PRISM site, a hardened, gold-master LAMP server was created, which can easily be repurposed for future projects that require a similar web-server configuration.

Hardware. Major hardware considerations were guided by ESXi 4 (http://www.vmware.com/resources/compatibility) requirements - essentially a 64-bit Intel-compatible processor and supported storage adapter.   Our solution was a Dell PowerEdge sc1425, with a RAID5 storage array. Although this configuration includes redundancy for storage devices and network interfaces, total failure of the server would result in a service outage. In the future, PRISM will likely be replicated at multiple physical locations for better resilience against environmental risks.

With these foundational components in place, a draft of the PRISM website artifact was constructed. Only core functionalities and a model user interface were implemented at this stage, resulting in a working repository containing the VISE toolset. A second physical meeting was then arranged to evaluate progress and identify areas that could use improvement.

First Evaluation Phase

Several weeks after requirements were discussed, a working prototype of the PRISM artifact was completed and the first evaluation was conducted at Regis University with the working group. The initial version of PRISM was displayed using a projector, and successful and unsuccessful aspects of the artifact were discussed.

Two visual themes were presented to the group and the most appropriate design was selected by majority vote. User interface elements were demonstrated and several modifications were suggested to simplify interaction and make navigation more intuitive. Examples of changes at this stage include moving the navigation menu from the right side of the screen to the left, and placing the Home link at the beginning of the navigation menu instead of the end. Underlying software and hardware architecture was also described to the group to general approval.

Second Build Phase

After the server architecture, CMS software, and core design elements had been evaluated and approved, major functionalities were implemented. Some of these functionalities were enabled by the installation of Drupal extensions, often referred to as modules.

Extensions. As PRISM is a newly defined community resource, it is likely that requirements will change over time, and that initial requirements will become obsolete.   Because of this, a platform for PRISM was chosen that has the ability to grow with the requirements of site users. Extensions or modules can be added or removed fairly easily by administrators to alter functionality. Components like forums, polls, chat, wikis, shopping carts, and social networking are not currently part of the site, but can be added with minimal to no programming knowledge.

As part of the initial development, a number of modules were added to the PRISM Drupal installation. Most notably, the Content Construction Kit (CCK), Views and Content Template modules were used to create custom resource content types and practical displays. CCK and Content Template modules also allow for complex content types to be added to the site using simple form-based input. The Views module lets the site designers prefabricate complex search

queries and present the results to users in customized displays. These features make it easier for

nontechnical users to add materials to the site and find the resources they are looking for.

Other modules include the Five-Star rating module, which was added to allow simple

content rating functionality and a quick method for users to ascertain the quality of a given

resource; Google Analytics, which integrates this popular tool with the Drupal system; and

several other modules that enhance the usability and presentation of the PRISM website.

Although installation of new functions (modules) is generally straightforward,

configuration is often not, and sometimes requires considerable research and a good general

understanding of the CMS to achieve the desired results. For example, creating views (content

displays) based on content ratings requires manipulation of esoteric settings in various modules.

The knowledge required to accomplish this task was garnered through the use of instructional

materials contributed by the Drupal user-community.

It should also be noted that with the addition of each module comes an increase in the

complexity of site maintenance and operation, so it is important for administrators and designers

to weigh benefits of each module installation, and only install and enable modules required for

critical functions of the site.

Access control. Drupal allows for fine-grained access and administrative controls. This

allows the owners of the site to delegate site moderation and maintenance responsibilities to

various groups participating in different ways. For PRISM, five primary levels of user access

(called roles) are designated: anonymous users, authenticated users, trusted users, moderators,

and administrators. Anonymous users can only view content, authenticated users can post

comments and rate content, trusted users can create and edit some types of primary content, and

moderators have the ability to edit and remove content posted by other users. Administrators

have full control over the site, which means they can change any content, modify site settings

and module configurations, and manage users. It should be noted that trusted users and site

moderators must have their privileges manually elevated by a site administrator.

Figure 2 illustrates the nature of privilege allocation. Higher trust users have all the

privileges of users in lower-trust groups, as well as permissions to perform potentially higher-

risk actions. The ability to create additional classes of users gives PRISM the ability to adapt to

future needs as the site grows.
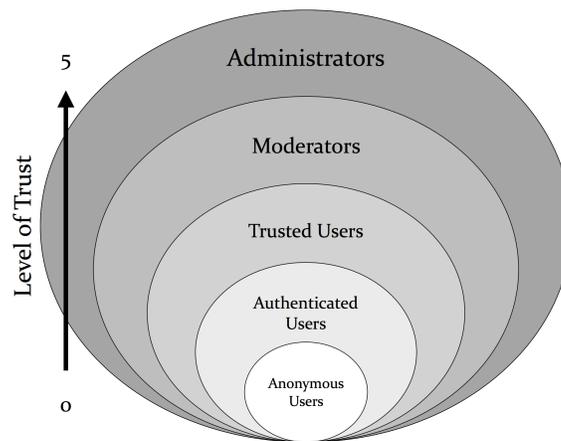
Figure 2. User class privilege sets on the PRISM website. More

trusted users' privileges include those of less trusted users.

This hierarchical segregation of duties also creates an environment where individuals

who have more credibility and expertise in the area of information security have more avenues of

contribution to the site. Those who have not been vetted in any way (anonymous users) cannot

contribute at all. This reduces the likelihood of irrelevant or dubious content being posted to the

site.

Because PRISM is a relatively small operation, the ability to publish content can be granted to just a few individuals within the organization without degrading site quality. This makes control easier, since most new content is submitted directly to moderators via web forms for review before posting. Although this requires some up-front effort on the part of the moderators, it obviates the need to monitor the site for inappropriate postings (which can be tedious and time consuming) and is conducive to a healthy inverse relationship between set population and level of trust.

Content management. The major focus of PRISM is on categorizing content and presenting it to the end user in an intuitive way, and substantial effort was made to create an efficient and effective system of resource organization and presentation. Protocols for content acquisition and consistent methods of content categorization and review were also defined to promote sustainability. Finally, measures were taken to prevent abuse of the site through link spamming or the posting of malicious software.

Acquisition. Content for PRISM is acquired in one of two ways. It is either located by those who maintain the site, or submitted by end users and content developers. Content appropriated by PRISM staff is generally acquired in the form of links to external sites. In this case, the staff are responsible for evaluating the resource, attributing ownership, and categorizing appropriately.

Third parties can submit content directly to the site moderators, and it is subsequently handled in the same manner described above. Alternatively, a content developer can petition for special designation as a Trusted User on the site. This privilege level allows the user to upload and categorize materials autonomously, with final publication approval by moderators. This will

ostensibly help to improve accuracy of metadata, as the developer of a resource is likely the most

qualified to describe it. Regis University and the USAFA are both considered primary content

contributors and have the privileges required for direct content submission.

Categorization. The process of categorizing content is guided during the creation

process within PRISM. Each content type (e.g. link, publication, activity, etc.) has a set of

associated taxonomies that consist of predefined lists of meta-tags. Depending on the content

type, some values are required to maintain a minimum level of organization on the site. Initial

values are chosen at the time of creation, and can easily be updated by the creator or site

moderators.

Static metadata categories (also called "vocabularies" within PRISM) and descriptors

(also called "terms") were chosen for their relevance to drivers identified by historical review of

literature described in the section entitled Topic I: IS Curriculum Considerations.

Currently, a tailored subset of the Dublin Core (http://www.dublincore.org) combined

with additional elements is being used to organize PRISM content. Figure 3 shows a sample

mapping of some of these metadata (the information available to match queries with results) to

search drivers (those issues users might want to address as they attempt to locate resources) in

order to illustrate considerations the author has identified as necessary to make IS teaching
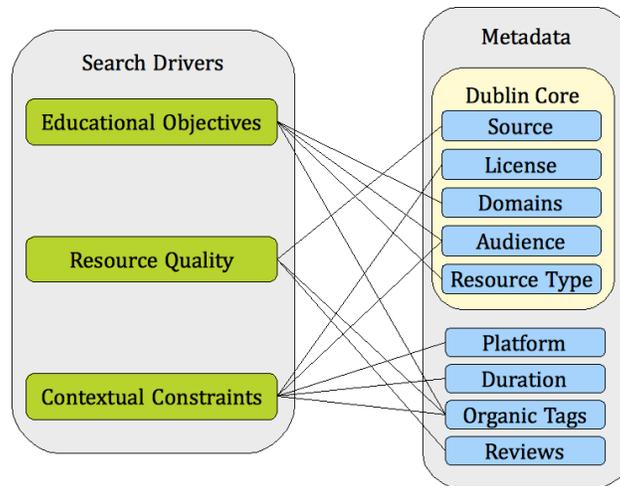
materials more available.

Figure 3. A sample mapping of search drivers to metadata associated with resources indexed by PRISM.

In addition to the Dublin Core descriptors, initial definition and development of an information security concepts ontology was completed. The ontology will define relationships between popular IS vocabulary terms. The integration of this structure will allow content to be tagged using any defined nomenclature, and to be subsequently located using any related term in the ontology. Currently, terms must be manually selected from each vocabulary and assigned to content.

The addition of multiple independent IS vocabularies to common metadata is, to the best of the author's knowledge, a novel approach to making IS educational materials accessible to a wide range of educators and students, not all of whom will be familiar with the same IS terms.

Review. There are two types of review that can occur on the site that deserve note. First, site moderators review content submitted by entities who are not trusted users to determine suitability for posting. Relevance to information security education and completeness are

considered, and scans are conducted on submitted files to identify software that could be dangerous to a user's system.

The second type of review is conducted by end-users. Currently, materials can be rated on the five-star basis and reviewed in the form of published comments. A slightly more fine-grained approach to content review is slated for implementation in the future to allow for more information about the potential utility to be visually encoded with the materials.

Branding. Another major concern for developers is branding (Koppi, Bogle & Bogle, 2005). PRISM, like other repositories, provides full disclosure of ownership and copyright status. If the developers prefer, they can opt to host the material on their own servers, and link directly to the resource, or to their own descriptive content.

Second Evaluation Phase

The second evaluation was conducted via email, and the evaluators were asked to formally assess the PRISM artifact against the problem space and the goals and requirements set by the group in earlier discussions. Six primary properties of the site (see Table 2) were chosen for evaluation based on their relevance to the success of the artifact and their familiarity to the evaluators. The evaluators were not asked to assess aspects of the artifact about which they had little knowledge. The evaluation request form can be referenced in the Appendix.

Specifically, four members of the working group, along with one individual unfamiliar with the PRISM effort but experienced in web site design evaluation, were asked to rate six separate properties of the site in its current state using the following scoring criteria:

0 = does not appear to be implemented

1 = does not meet expectations (major changes required for next build cycle)

2 = barely meets expectations (minor changes required for next build cycle)

3 = meets expectations (no changes required for next build cycle)

4 = exceeds expectations (no changes required for next build cycle)

While Table 2 gives a summary of the raw scoring results, evaluators were also asked to provide comments regarding each score. These comments helped to bring more meaning to the number, and point out specific successes and shortcomings of the artifact in its current state. They were concurrently asked to comment on what innovative contributions, if any, PRISM makes to the community and whether the given problem definition was accurate. Since the fourth individual did not have any "expectations" for the project, numerical ratings were not requested, only comments on the six categories and the question regarding innovative results.

Table 2

Average scores for site properties and functionalities selected for the second evaluation phase

Property	Average Score
Intuitive, uncluttered interface	3.5
Access to site commensurate with trust (security)	3.5
Ability to host many file formats and sizes	2.75
Usability for wide range of technical skill levels	3.25
Content logically organized and easily searched	3.5
Allow users to communicate among themselves	2

Note. Score range is 0-4; higher scores reflect higher goal attainment.

Intuitive, uncluttered interface. In general, the interface received mid-high marks for intuitiveness and simplicity. Although all ratings returned were three or higher, some changes may be warranted. Existing issues identified by the evaluators included visual consistency and placement of the "quick-search" field with regards to the rest of the site, and readability of text on a handful of pages. In particular, font size and graphical organization used in the Category Browser (http://www.prismhome.org/taxonomy_browser) has not been optimized for readability. The author also expects search results could be presented in a more informative and readable manner.

In order to make the quick search field more noticeable and consistent with the site design, a new background image will be employed. Font size on the Category browser page will be reduced to prevent some wrapping that occurs, and layout of options will be adjusted so that category contents are displayed vertically instead of horizontally.

Access Commensurate with Trust. No changes to this feature were suggested, but one evaluator thought it would be useful to make the trust model known to site visitors. This information could be tied in with information regarding the benefits of creating an account (another feature suggested by one of the evaluators).

Ability to host many file formats and sizes. This is an area that requires significant attention in the next build phase. First, the requirements and restrictions for uploading files to the site are not published for users to see. This will have to be remedied using documentation. A frequently asked questions page would be a standard response to this and other common questions users might have. Therefore, the next build phase will include the addition of a

description of acceptable file types and sizes, and how to go about getting help with special cases (i.e. file parameters not on the list).

Second, when using the PRISM content creation interface, the current maximum file upload size is two megabytes (2MB). Site administrators are able to move files of virtually any size to the web server using tools like secure copy (http://man.he.net/?topic=scp&section=all), but there is no way for end users to do this themselves. Several possible solutions are currently being evaluated to resolve this issue, and that which is most reliable and easy to use will be implemented.

Usability for wide range of technical skill levels. No changes to this feature were suggested, and none are planned. However, as more users engage with the site, their feedback will dictate future modifications to usability components. Information may also be gathered with analytics tools that will allow site designers to see which pages might be causing users to leave the site, and which navigation paths require too much effort to traverse.

Content logically organized and easily searched. Content organization mechanisms scored very high. The only concern expressed was that moderators are needed to maintain proper organizational structure. In the future, content will be organized using an ontological framework currently under development. This framework will contain information about relationships and equivalencies between various vocabularies and terms. The implementation of such a framework will automate the description of content to some extent, and only require tagging with regard to one or two vocabularies instead of all vocabularies. Furthermore, users will be allowed to tag and flag content they feel is mis-categorized in some way. This should make it easier for moderators to identify and rectify categorization problems.

Allow users to communicate among themselves. This feature has only been

implemented in the most rudimentary form, as current onsite communications requirements are

vague and incomplete. Currently, each authenticated user is given a contact page through which

other authenticated users may contact them via email. In the future, collaboration technologies

such as forums, chat and meeting spaces, or shared documents may be implemented, depending

on the perceived interest from the user community.

PRISM innovations. Many of the evaluators felt that having an online repository

dedicated to IS education was itself an innovative application of existing technology. One

evaluator shared the author's view that innovation lies within the deep integration of educational

drivers with content organization and presentation of search results.

Problem definition. No issues were raised with the problem definition, which was

described in the evaluation form as "a need for an online educational materials repository space

tailored to the information security domain" that meets the requirements listed in Table 2.

Chapter 4 - Results and Objective Evaluation

In the sections below, current status of the PRISM site will be summarized, and an

evaluation of the artifact from the developer's perspective will be given.

Current Status

The PRISM site is fully functional and may currently be accessed at http://

www.prismhome.org (Figure 4). After two build and evaluate cycles, four out of the initial six

primary requirements have been met to the satisfaction of the evaluators. The communications

requirement needs further definition before it can be fully addressed. Solutions to the file size

and type requirement are under evaluation and will be implemented in the next build phase. Other site features related to administration and content management also deserve attention so that the backup and upgrade processes are more automated.

      Content. Existing content consists of a selection of tools and papers from the sponsoring institutions and other educational resource developers, as well as links to a number of popular websites and resources that may be of interest to IS students and educators. As part of the initial set of tools available on the site, several visualization and simulation applets, along with instructional materials and suggested exercises, are available for viewing and download. These materials demonstrate and exemplify the types of resources PRISM is designed to accommodate.

      Site content is currently tagged to express a number of attribute categories. IS domain information is represented by (ISC)2 Certified Information Systems Security Professional (CISSP) Common Body of Knowledge (CBK) definitions (https://www.isc2.org/cbk/default.aspx?terms=CBK). In order to provide educators with the necessary information to locate appropriate materials for their curricula and classroom capabilities, attributes such as exercise duration, grade level and platform compatibility have been added to a subset of the Dublin Core metadata element set.

      With modules properly configured and a content organization scheme in place, actual maintenance of content within Drupal can be achieved without any programming experience. However, a strong working knowledge of HyperText Markup Language (HTML) is beneficial for managing some types of content, and the ability to read, edit, and write PHP allows for the inclusion of functionalities not already captured in prepackaged modules or snippets (small scripts written in PHP that can be included in content).

Considering that IS education drivers described in the literature often mention meeting

the needs of private industry and government employers, it seems natural that educators would

find it useful to be able to search for teaching materials using descriptors found in the standards

defined by these entities. For PRISM, taxonomies based on such standards have been infused

with more common metadata sets, like the Dublin Core and community reviews. Creating

explicit relationships between discreet materials and curricular standards allows for more

directed searches, and reduces the need to rely on keyword searches alone to return resources

that fulfill a given requirement.

Objective Evaluation

Because the individuals who provided the evaluations discussed above are not familiar

with technical back end details of PRISM, it was not feasible to solicit feedback on these aspects

of the artifact. Therefore, a brief evaluation of server architecture, system configuration, Drupal

administrative tasks, and several other aspects will be given as objectively as possible.

Server Architecture and Configuration. PRISM runs on a standard LAMP installation,

and is configured to require as little maintenance and administrative intervention as possible.

Security, system and software updates are configured to be automatically downloaded and

installed daily. A complete system virus scan also takes place daily; web folders are scanned

more often.

One major issue still exists with the server architecture: automated backup and restore of

the PRISM server configuration and content files. The PRISM server runs as a VMware guest,

and a technique called snapshotting is used to create restore points that can be used in case of

server corruption or unauthorized modification. Currently, there is no way to automate the snapshotting process, and so backups require manual intervention.

In the near future, additional VMware tools may be installed which will provide the capability to schedule and manage snapshots of the guest VM. This method allows restorations to occur very quickly in the event of a problem, but requires a substantial amount of storage space and bandwidth, as well as the use of non-open source utilities. Alternatively, system configuration files and web content could be backed up to a separate server using cron (http:// man.he.net/?topic=cron&section=all) and the rsync (http://www.samba.org/rsync/) or secure copy utilities. This method does not require proprietary applications, but entails significantly more complicated configurations and operations to execute and manage the backup and restore processes. One of these methods will be selected based on performance and maintainability, and implemented during the next build phase.

Drupal Administration. One of Drupal's biggest inconveniences is its lack of an automatic updating mechanism. While this may increase security (fewer files need to be writable by the web server), it also means that each time a security or functionality update is issued for Drupal core code, modules or themes, an administrator must manually backup the files and database, download the updated files, and copy them to the correct locations on the web server. This process can be automated to some extent using drush (http://drupal.org/project/drush) or custom shell scripts, but requires substantial technical knowledge and diligence for success.   Up-to-date snapshots reduce the potential damage a failed upgrade can inflict on the site, but certain updates (especially to core files) still require full reconstruction of the web directory.

This issue will likely be addressed in the next version of Drupal (Geller, 2010), and until then a manual or partially scripted approach will be used at the discretion and preference of the acting administrator.

Documentation. Documentation is notably lacking for almost all aspects of the PRISM artifact and should be an area of focus during the next build phases. Instructions for end users should be drafted to ensure users can quickly find information about how the site works. Moderators and site administrators should have a comprehensive set of guidelines to work from regarding content organization and editing, as well as permissions handling. System administrators must have a way to transfer knowledge to other administrators regarding server configuration and change management. Completing these sets of information and making them available to the appropriate individuals will make the site easier and more attractive to use and maintain, and make the artifact more likely to endure changes in project staff.

Content management and delivery. The main focus of the PRISM artifact is content management and delivery. Although there are many improvements to be made, the author feels that substantial progress has been achieved toward meeting the project goals. Core functionalities are in place to allow developers to share their resources, and for users to locate and access the materials they need. A solid foundation for an organizational ontology has been created, and materials are being categorized accordingly. Finally, although they are not substantially documented, backup, update and recovery methods do exist.

Chapter 5 - Conclusions

This was a very new area of study for me. I learned a great deal about the current state of IS education, and am certain that there is much more work to be done in this area. Although there appear to be many efforts to standardize IS curriculum requirements, there are few resources that exist to aid educators in meeting them. Furthermore, information security awareness has not reached a level of pervasiveness that would guarantee most, if not all, educators in relevant fields have the knowledge and skills necessary to teach IS concepts.

Based on initial evaluations and feedback, PRISM makes important advancements towards addressing the need for an IS education resources repository that is accessible by individuals of varying backgrounds and technical expertise. With continued support and participation, it could become an extremely valuable resource for students and educators that are engaged in the learning or teaching, respectively, of IS knowledge and skills. Adjustments will undoubtedly have to be made to the site configuration, and in order for PRISM to continue to be a useful resource in the future, a more complete ontological framework will have to be developed to relate content to changing IS curriculum taxonomies and contextual metadata sets.

In addition to the subject area of IS education, I feel I have also learned a great deal about the research process. In particular, I have a new appreciation for the library sciences. There is so much information available online, that it takes significant effort, knowledge and skill to achieve anything close to a comprehensive review of relevant publications. Furthermore, the topics involved in my research: education, learning objects repositories, and content classification, are very broad and popular subjects, which makes it easy to become mired in search results and increases the potential for the researcher to overlook valuable publications.

Although I feel I devoted a substantial amount of time to background research, I can't help feeling that a more effective review of existing literature may have been possible. I did find current publications, and investigated relevant and interesting references, but I was unable to positively identify many seminal works. Perhaps the scope of topics I attempted to cover was too broad, but I felt the need to get up to speed on various aspects of IS educational standards and drivers, as well as technology and theory involved in learning object creation and management. This all parallels somewhat with the problems facing those searching for IS materials: there is no single resource that can efficiently return a comprehensive set of relevant results.

Going forward, it is my hope that an active community can be developed around PRISM where a feedback loop between IS educators, educational content developers, and content delivery systems generates an abundance of highly useable resources, and that the PRISM website will become a true prism of sorts - allowing users to easily distinguish and identify useful content, out of a sea of resources, based on their particular contextual position within the sprawling domain of information security education.

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Appendix: Evaluation request form.

This evaluation is meant to be part of the design science "build and evaluate" cycle. Your ratings and comments will be taken into account during the next build phase in order to improve the utility of PRISM.

In general terms, PRISM is intended to address the following problem:
There is a need for an online educational materials repository space tailored to the information security domain, which meets a given set of requirements (blue background below). If you have any comments on the accuracy or scope of this problem definition please comment below (green background).

For each of the site requirements (blue background), evaluate PRISM (in it's current state) as a solution with a **numerical rating** of 0-4:
0 = does not appear to be implemented
1 = does not meet expectations (major changes required for next build cycle)
2 = barely meets expectation (minor changes required for next build cycle)
3 = meets expectations (no changes required for next build cycle)
4 = exceeds expectations (no changes required for next build cycle)

Also, please explain your rating in the **comments** section.

	Numerical Rating [0-4]	Comments
Intuitive, uncluttered interface		
Access to site commensurate with trust (security)		
Ability to host many file formats and sizes		
Usability for wide range of technical skill levels		
Content logically organized and easily searched		
Allow users to communicate among themselves		
If you can, please comment on how PRISM contributes to the solution of the problem in new and innovative ways.		
If you feel the problem definition is inaccurate in any way, please comment here.		

THANK YOU!!!