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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

LEARNING MANAGEMENT PLATFORM FOR CYBERCIEGE

by

Lim Wei Chean
December 2011

Thesis Advisor:	Zachary Peterson
Thesis Co Advisor:	Mike Thompson

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REPORT DOCUMENTATION PAGE		*Form Approved OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE December 2011	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE Learning Management Platform for CyberCIEGE		5. FUNDING NUMBERS	
6. AUTHOR(S) Lim Wei Chean			

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
    Naval Postgraduate School
    Monterey, CA 93943-5000
		8. PERFORMING ORGANIZATION REPORT NUMBER	

9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB Protocol number _____N.A_____.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release, distribution is unlimited	12b. DISTRIBUTION CODE

13. ABSTRACT (maximum 200 words)

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14. SUBJECT TERMS CyberCIEGE, Computer Security Education, Assessment Module, Summary Report, Learning Management Platform			15. NUMBER OF PAGES 61
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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LEARNING MANAGEMENT PLATFORM FOR CYBERCIEGE

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN COMPUTER SCIENCE

from the

**NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

In order to enhance the usability of the CyberCIEGE to assess the student's learning experience and achievement of the scenario objectives. This thesis investigated how to improve the current student assessment module, report generation process, report format and also integrating of CyberCIEGE with Naval Postgraduate School's (NPS) Learning Management System (LMS). Based on the researched, enhancements such as additional summary view on Event Log Analyzer with game selection features, report generation feature on the Campaign Analyzer, various levels of reports and the process of linking to the Collaborative Learning Environment (CLE) was implemented.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAR	After Action Review
CLE	Collaborative Learning Environment
CSS	Cascading Style Sheet
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
IDE	Integrated Development Environment
LMP	Learning Management Platform
LMS	Learning Management System
NPS	Naval Postgraduate School
SCROM	Sharable Content Object Reference Model
VBS	Virtual Battlespace System
VPN	Virtual Private Network
WebDAV	Web-based Distributed Authoring and Versioning

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ACKNOWLEDGMENTS

The successful completion of this thesis would not be possible without the support from many individuals in various ways.

I would like to thank Prof. Peterson Zachary and Mike Thompson for their inspiring and invaluable guidance during the development of this thesis. Thank you for your patience and support.

I would also like to thank my fellow Singapore classmates for assisting me in all aspects of school and thesis work.

Finally, I would like to thank my wife, Pelicia, and our son, Kayden, for all the love and unwavering support through the course of my study.

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I. INTRODUCTION

A. THESIS STATEMENT

The purpose of this thesis is to create a Learning Management Platform (LMP) for CyberCIEGE. The LMP will provide the instructor with tools and an environment to better analyze the student learning experience and achievement of the scenario objectives. This would include investigating how to improve the current student assessment module, report generation process, report format and also integrating of CyberCIEGE with Naval Postgraduate School's (NPS) Learning Management System (LMS).

In the process of creating the CyberCIEGE's LMP, the following questions will be answered:

- What is the required information in each game scenario such that a meaningful assessment on students' understanding of the course materials can be carried out?

- How can the student logs be better documented and visualized on the LMP so that the assessment of objectives for respective scenarios can be clearly seen?

- How best can the CyberCIEGE's LMP reports be integrated into Naval Postgraduate School's LMS to enhance the teaching experience?

B. RELATED WORK

CyberCIEGE's analysis module was designed by Tiat Leng, Teo as part of his thesis research on "Scenario Selection and Student Assessment Module for CyberCIEGE" in 2003. In his thesis, he highlighted the need for an analysis module for training system so that it would allow the proper conduct and review of the training session with the students. However, due to the wide scope of his thesis, he only managed to implement part of the analysis module, which will be described in detail in Chapter II.

C.   CHAPTER LAYOUT

The scope of this thesis is to enhance the current analysis module in order to allow a more efficient and effective assessment to be conducted by the various instructors of courses that incorporate CyberCIEGE scenarios. The thesis chapters are laid out in the following order:

Chapter I   Introduction

This chapter highlights the thesis statement and related work in the research topic. It also gives an overview of the thesis layout.

Chapter II   Background

This chapter highlights some of the key comparisons with other educational games' assessment modules. Then it covers the background information for the reader with an overview of the current assessment module and the report generation process.

Chapter III   Requirement Analysis

This chapter discusses the need to identify the various objectives of the designs of individual CyberCIEGE scenarios. It also looked into the impetus to further enhance the current assessment module and what level of detail would be required by the various course instructors.

Chapter IV   Development Strategies and Concepts

This chapter describes in detail the implementation of the improvement to the log analysis and how various levels of reports can be generated by filtering the required information from the logs.

Chapter V   Implementation and Testing

This chapter discusses the implementation methodologies and the test objectives to ensure that all requirements to enhance the instructor's module have been implemented correctly.

Chapter VI   Conclusions and Recommendations

This chapter provides recommendations and suggestion for future development of the CyberCIEGE's LMP and concludes the thesis.

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II.   BACKGROUND

A.   ANALYSIS MODULE OF AN EDUCATIONAL GAME

Education through games allows students to apply what was taught during lessons in a simulated real life scenario. The general concept of educational game requires students to complete certain tasks and apply the acquired knowledge in resolving the issues that were played out in the game [1]. Many serious games [2] were developed over the years for the various industries *e.g.,* Virtual Battlespace System (VBS) game series [3] were developed for the defense industries, History of Biology was developed for the bio-science industry, CyberCIEGE was developed for the IA committee, X-Plane for the aviation industry *etc*. However, most of these games were developed to create some level of awareness on the particular topic for the student and therefore the analysis module mainly comprised a simple playback function. The games that have a more comprehensive analysis module were actually VBS game series and CyberCIEGE.

When VBS first rolled out its initial game mission in 2004 [4], the analysis module or After Action Review (AAR) module features were limited. It only comprised a summary of the mission accomplishment status. When this game was adopted by the US Army and US Marine Crops as the basis for their indoor tactical training simulator, it was realized that a more comprehensive AAR module need to be incorporated into the system to reinforce some learning objectives [4].

Therefore, in the recent series of VBS2 missions, a more robust AAR system was integrated into the VBS2 modules allowing the performance of the crew and their equipment *e.g.,* coverage of the weapon systems, field of view of the night vision devices, to be shown during review. The AAR module adopted the U.S. military AAR framework [5], which aims achieved the following:

- To identify strengths to be maintained and built upon
- To identify potential areas for further improvement
- To recommend necessary follow up actions

The AAR module basically collects all the game information *e.g.,* movement, hit, fire weapon, killed, getting in and out of actions, voice communication, *etc*. and recreates the scenario. The replay scenario can be viewed from any player's perspective in two- or three- dimensional view. All transcriptions that were created during the game, reports and forms, were also embedded in the AAR file, which can be viewed during the playback. However, the game system does not provide a summary review of the game played.

B.   CYBERCIEGE

CyberCIEGE is an educational game system designed with the intention of educating personnel in an academic setting. The game exposes the player to realistic cyber threats that a network administrator might face in real-life situations. The player will have to decide on the most efficient and effective measures to prevent the loss of any confidentiality, integrity and availability of a fictional company's critical resources.

Ever since the rollout of this game, hundreds of educational institutions worldwide have used it to enhance the delivering of network security education [6]. CyberCIEGE is built with various campaigns to include the wide range of network related scenarios. Details of the CyberCIEGE framework will be discussed in Chapter III. To date, improvements to the game system and scenarios capturing new threats and security initiatives have subsequently been created to make the game more comprehensive and realistic. However, the development of the analysis module was much slower as compared to the scenarios development. Therefore, this thesis explores how the current analysis module can be improved to further enhance the teaching experience using CyberCIEGE.

C.   CURRENT ANALYSIS MODULE

The current analysis module for CyberCIEGE, the "Campaign Analyzer," was initially developed in 2003 [7], [8]. The Campaign Analyzer was designed to provide the instructors with a tool to reconstruct the key events of the game so that a student's progress and decisions can be reviewed.

The Campaign Analyzer basically allows an instructor to select a specific campaign and scenario. It will then search for the available student logs files that contain the game progress of the scenarios. The Campaign Analyzer will then summarize the raw logs data and package them into more comprehensible form, as shown in Figure 1.
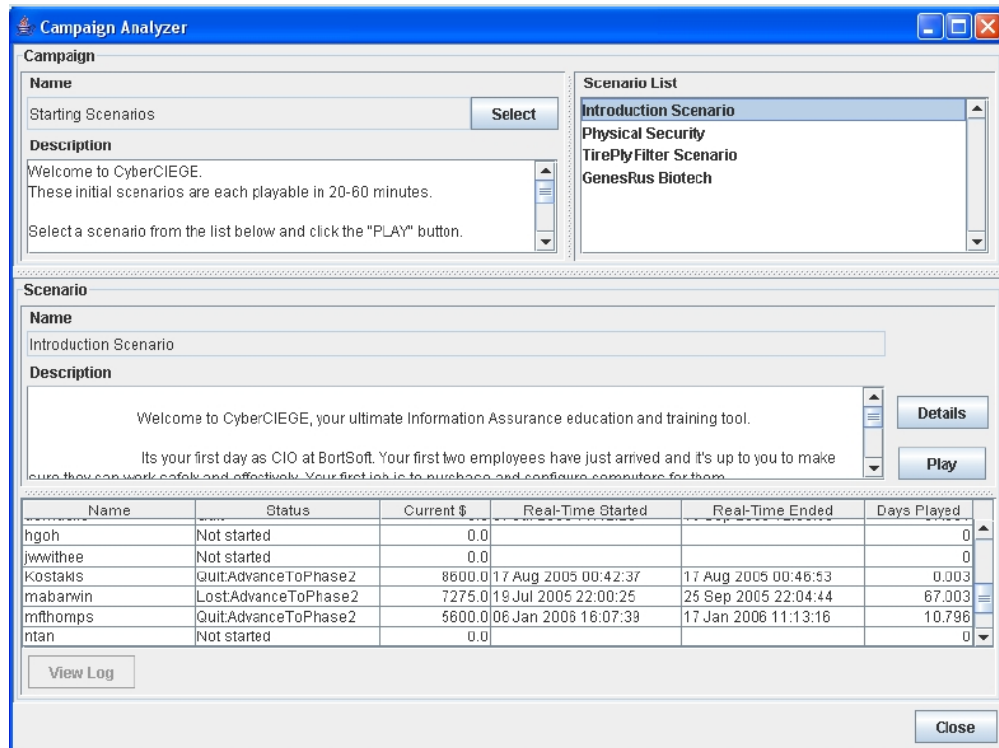
Figure 1.   Campaign Analyzer.

The Campaign Analyzer is divided into three main windows, Campaign window, Scenario window and the Summary window, from the top to bottom, respectively. The Campaign window encompasses the functions for the instructor to select the campaign and scenarios within the campaign to be viewed. The description window in the Campaign window gave an overview of what the campaign is about.

The middle panel includes the Scenario window, which gives the name and description of the selected scenario. It also allows the instructor to play the scenario by clicking the "Play" button.

The last panel on the bottom presents the summary of all the available logs collected for that selected scenario. The summary table provides key information, *e.g.,* the status, the time spent, the number of times played for that scenario. This information would allow the instructors to know the progress of his students and make necessary assessments.

If the instructor would like to further understand what happened to a particular student's game, he only need to select the student's name and click on the "View Log." Once the "View Log" is activated, an Event Log Analyzer window will be displayed as shown in Figure 2.
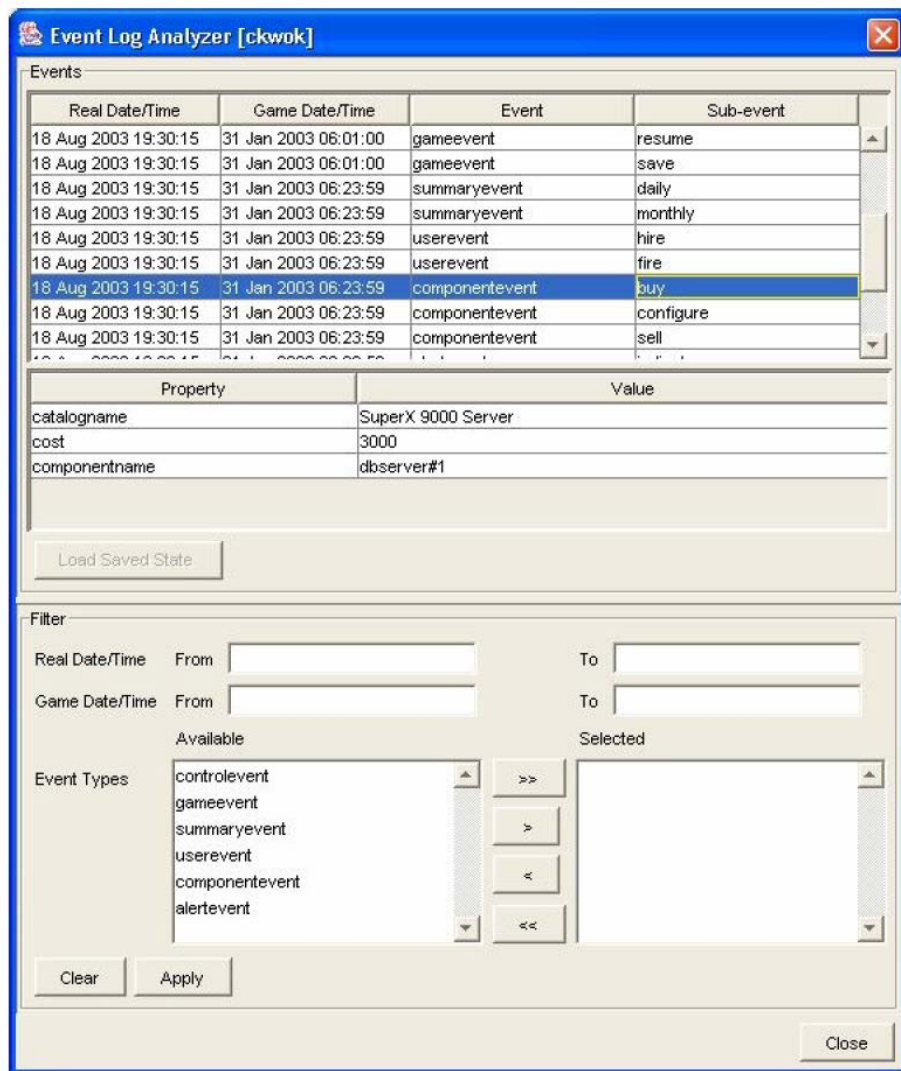
Figure 2.   Event Log Analyzer.

The Event Log Analyzer displays the details of the game played ranging from the game engine triggered event to the player actions. The instructors would be able to select to number of games to be viewed for the particular student. This allows the instructor to step through what the student has encountered and look into what actions were carried out during the game play. If a game was saved at a certain stage, the instructor is able to replay the game to understand the student's situation better. The Event Log Analyzer also provides an Event type filter for the instructor to filter out any information which is not critical for his analysis. This function would be handy if the instructor knows exactly what type of information he wants to search for.

D.   REPORT GENERATION PROCESS

The initial analysis module did not have a report generation function. Therefore, in order to overcome that limitation, SQL database and programs were developed to generate a simple report for the instructors, as shown in Figure 3. The programs basically extract the required summary data using the Campaign Analyzer modules and place it into the database.

```
Student              lab 3      lab 4      lab 8      lab 10
================|=========|=========|=========|=========
jc              | WON(10) | WON(13) | ----    | WON(16)
acoo            | (20)    | WON(14) | (752)   | ----
kl              | WON(18) | WON(19) | WON(76) | WON(17)
mdb             | WON(22) | WON(18) | (59)    | WON(23)
sed             | WON(6)  | WON(38) | ----    | ----
jcdo            | WON(12) | WON(18) | WON(16) | WON(34)
mcf             | WON(9)  | WON(16) | WON(28) | WON(15)
ckers           | WON(10) | (30)    | WON(27) | WON(9)
cgl             | (20)    | (12)    | (40)    | ----
tng             | WON(5)  | WON(19) | WON(32) | WON(23)
rae             | WON(6)  | WON(47) | WON(132 | WON(26)
csins           | WON(20) | WON(45) | WON(48) | WON(29)
xng             | WON(12) | WON(36) | WON(26) | WON(19)
kc1             | WON(12) | WON(16) | WON(37) | WON(14)
wl1             | WON(15) | WON(13) | WON(15) | WON(45)
tg              | WON(16) | WON(19) | WON(33) | WON(17)
sla1            | WON(7)  | WON(24) | WON(58) | ----
sfi             | WON(40) | WON(153 | WON(55) | ----
trol            | WON(32) | WON(34) | WON(129 | WON(37)
mik             | WON(78) | WON(65) | (73)    | WON(27)
bran            | WON(27) | WON(20) | WON(297 | WON(73)
kfe             | WON(24) | WON(23) | (67)    | WON(32)
```

Figure 3.   Sample of Summary Report

9

In this summary report, the top row shows the lab number and the extreme left column contains the user names. The report is comprised of the status of each game with the minutes spent in brackets. The "----" indicates that the student did not attempt the lab. This summary report only provides the most basic set of information for the instructors.

On top of that, in order for the script to work, the user must be able to manually edit the following parameters within the script file:

- Set classpath—The classpath directs the script to pull the relevant java class so that required information can be generated.

- Set student list—The student list contains the name of a particular class. It will direct the script to pull out information from the relevant student's log file.

- Set game—Setting the game would direct the script to pull the necessary information from the respective campaign and scenario.

- Set output path—This gave the script an output file name for the summary report.

This approach to generating the summary report is not user friendly, as not all the instructors would know how the script can be edited and the correct syntax of the file format to be included for the script. Also the report only provides sufficient for the instructor to assess which student has completed the lab assignment. In the event where the instructors want to look into the details for individual student, he would have to view it from the Campaign Analyzer module with the student's log file. Thus, an improved summary report with sufficient details captured is required for better assessment by the instructors.

E.   SUMMARY

As we move into a new era of education through digital games, the analysis module is one of the key success components to ensure that the required knowledge was correctly and clearly transmitted through the game play. Likewise, a clear and concise summary report is also handy when the game is deployed in an academic setting where various classes of students will play the game in the lab.

III. REQUIREMENT ANALYSIS

This chapter discusses three key approaches, game design, summary report design and integration with the Sakai CLE, to enhance the analysis of the student learning experience and achievement of the scenario objectives. In order to have a meaningful student assessment, the planning starts from the game design to ensure that all the intended knowledge and information are correctly embedded into the game play. The first section will review the scenario design framework and recommend some improvement to it. Following that, the next section explores how the key information can be captured and presented in a relevant report structure. The last section discusses the possibility of integrating the CyberCIEGE game system into Sakai Collaborative Learning Environment (CLE).

A. GAME DESIGN

This section reviews the structure and context of game design for the purpose of exploring ways of assessing whether learning objectives are met. Objectives identification should be conducted before the commencement of the scenario design, as the objectives will eventually shape the design of the scenario.

1. Game Framework

The structural framework of a CyberCIEGE's framework is shown in Figure 4. below:
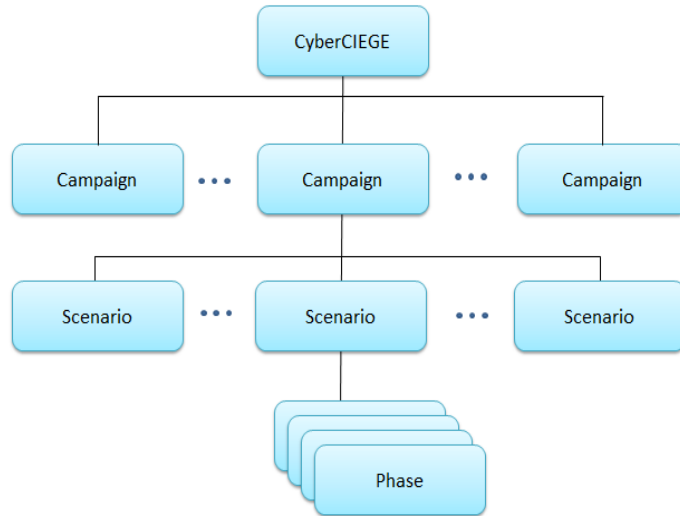
Figure 4.   CyberCIEGE Game Framework

The Campaign is the overarching title for the various scenarios that are to be grouped together. The campaign will determine the general classification of the types of attacks or scenarios that will be built within its scope. The scenario design is the development step where the designer has to carefully plan the storyline and other game details like the characters, equipment, environment layout, *etc*. Depending on the layout of the scenario, the scenario designer can then further break the scenario into various phases so that the player can progressively learn and move through the scenario. This method of breaking the scenario into phases will ensure that the student understands and able to apply the knowledge before going into the next phase. This method can also provide the instructor with an assessment of the student's understanding and an ability to provide necessary coaching when required. An example of how the framework can be laid out in the Introductory VPNs (Virtual Private Network) is as follows [9]:

CAMPAIGN DESCRIPTION	SCENARIO DESCRIPTION	PHASE DESCRIPTION
Encryption - This campaign illustrates the use of cryptography to protect communications from unauthorized disclosure and modification. This campaign also includes techniques for managing the "identity" of data, i.e., authenticating the origin of data. Topics include use of Virtual Private Networks (VPNs), email encryption and SSL.	**Introductory VPNs** - Help Lisa communicate securely over the Internet. Harry and Lisa collaborate on a critical marketing roadmap from different parts of the city. Lisa accesses the roadmap via the Internet, but the boss believes that may be risky. In particular he wants to make sure that only Harry and Lisa can modify the roadmap. Your job is to help Lisa secure her Internet communication.	**Phase 1** - Secure Harry and Lisa's communication over the internet **Phase 2** - Harry and Lisa would like to access the web **Phase 3** - Protect moderate value assets **Phase 4** - Protect high value assets

Table 1.　　Example of VPN Framework Layout

2.　　Scenario Design

The construction of the game occurs during the scenario design. Therefore, the objectives must be clearly spelled out so that the rest of the supporting elements can be built to support the objectives. In the scenario design there are two key objectives to be identified; *scenario objectives* and *educational objectives*.

The scenario objectives highlight what the scenario is designed for. It lays out the scope of the game and also the general path for how the scenario should be built. A review of previous thesis that included CyberCIEGE scenario building [10] ,[11], [12],

[13], [14], revealed that all the authors did managed to define the objectives of the scenario, thus I will not further elaborate that in this thesis. Using the Introductory VPNs scenario as an example, the scenario objective could be defined as "To create an environment for the user to practice the deployment of a VPN for a corporate network."

CyberCIEGE is a gaming tool that is designed to educate players about computer and network security, therefore, the educational objectives should be carefully crafted in order to outline the goals. The scenario designer sets educational objectives to ensure that the players will acquire the correct and intended information during the conduct of the game. This set of objectives will help the scenario developer refine the game storyboard and eventually these goals could be used to formulate the lab learning objectives as well. Some examples of the educational objectives for the Introductory VPN scenario are:

- To illustrate that unprotected internet connection can be hijacked by attackers.
- Risks of VPN gateways that allow both protected and unprotected traffic.
- Limitation of link encryptors.
- Configuration of VPN gateways to constrain their sources and destinations.

With the educational objectives being defined, the scenario developer will then design the game with the required supporting elements to achieve the objectives set forth. Likewise the in-game question function could be used to achieve the objectives in the event when an objective is not obvious or not achievable in the scenario play. This function allows the developer to create a pop-up dialogue box to seek input from the player in a form of multiple-choice questions. It is also configurable such that the dialogue will be looped continuously till the correct answer is chosen. The selection of the result can also be captured in the log file for further assessment in the later stage.

Therefore, with all the objectives and check-points being built into the game scenario, the instructors will be able to design the lab training session effectively and synchronizing it with the materials taught during lessons. Likewise, when a student is stuck at a certain phase, the instructor is able to correlate the issues depending on the stage they are at. Similarly, the instructors can also look at the answers to the quiz

questions and understand what the common wrong choices that students made. Other than using the Campaign Analyzer to look at all the student's progress as mentioned, a summary report capturing all the essential information would allow the instructors who are not familiar with the Campaign Analyzer to make similar assessment. The next section will cover the requirements of what a comprehensive summary report should have.

B.   SUMMARY REPORT ENHANCEMENT

As mentioned in the previous chapter, CyberCIEGE has been used by educators at hundreds of educational institutions. Among these, educators fall into two broad categories; advanced users and basic users. The advanced users are those who know every component of the game engine ranging from the game scenarios to the assessment modules. These users are able to identify the specific scenarios and use them to enhance the conduct of network security lessons or lab sessions. Upon completion of the training sessions by the students, these educators will be able to assess and track student achievement through use of the Campaign Analyzer and Event Log Analyzer.

The second class of educators is the basic user. These users know the basic scenario set-up and are able to design and conduct lessons or lab sessions with the available scenarios. However, these users are not necessarily familiar with the assessment module and they are dependent on a CyberCIEGE administrator to generate the required reports or they merely use it with alternate methods of assessment or analysis of the student's performance. Therefore, in order to cater to the needs of various users, a smoother way of generating the summary report and a extending the report to include information necessary for assessment are required.

In order to create a seamless report generation process, the report generating function should be integrated into the Campaign Analyzer Module. This would allow the instructor to have his initial assessment using the Campaign Analyzer and in the event that a summary report is required, the report could be generated via clicking of button in the Campaign Analyzer. The function should allow the user to select the result from the

relevant scenarios and extract the necessary information. It should also have the flexibility to filter the selected students' log files for the class.

The next step is to look at the requirements for a good summary report. As shown in Chapter II, the current summary report only contains the basic information of status and time spent on that particular lab. The information only helps instructor know who has attempted and completed the assigned lab. Therefore, a second level of report that encompasses more details should also be generated to allow a more effective assessment.

For the first level summary report, a proper listing of the status could be implemented as compared to the currently the report which only shows the "Won" status. When a player lost or quit the game, only the total time spent is shown in the status area. Likewise, the total time spent shown in the status might not be enough to assess the student's achievement; therefore, additional information like the number of times played could be included, as shown in Figure 5.

Student Name	Lab 1	Lab 2	Lab 3	Lab 4
Student001	WON(10/2)	WON(17/3)	NOT PLAYED	WON(16/2)
Student002	LOST(20/2)	WON(14/2)	LOST(725/8)	NOT PLAYED
Student003	WON(23/3)	WON(9/1)	WON(76/5)	WON(18/2)
Student004	WON(22/2)	WON(18/2)	WON(16/3)	NOT PLAYED
Student005	WON(14/1)	WON(23/2)	WON(20/2)	WON(10/1)
Student006	WON(54/4)	WON(18/2)	WON(21/1)	WON(33/3)
Student007	LOST(17/2)	LOST(50/5)	WON(82/6)	NOT PLAYED
Student008	WON(15/1)	WON(72/6)	LOST(23/2)	WON(19/3)
Student009	WON(27/3)	WON(22/2)	WON(10/1)	NOT PLAYED
Student010	WON(36/5)	WON(43/5)	WON(33/3)	WON(27/2)

Figure 5.   Improved Level 1 Summary Report.

As for the second level of report, it could present a framework similar to the Campaign Analyzer. The details can also be further broken down into the attempts for each student in a student view table (Figure 6) or a summary of the lab attempts in a lab view table (Figure 7) with all the student attempt information. This will allow the instructor to have a good view of both the class performance and individual achievement for the scenario just from the summary report.

STUDENT001

LAB 1

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST
1	01-Jul-11	3	LOST	Phase 1
2	03-Jul-11	7	WON	----

LAB 2

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST
1	22-Jul-11	2	QUIT	----
2	22-Jul-11	5	LOST	Phase 2
3	22-Jul-11	10	WON	----

LAB 3

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST

LAB 4

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST
1	01-Aug-11	10	WON	----
2	01-Aug-11	6	WON	----

Figure 6.   Student View Summary Table

LAB 1

STUDENT001

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST
1	01-Jul-11	3	LOST	Phase 1
2	03-Jul-11	7	WON	----

STUDENT002

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST
1	02-Jul-11	12	LOST	Phase 2
2	02-Jul-11	8	LOST	Phase 2

STUDENT003

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST
1	01-Jul-11	7	LOST	Phase 2
2	01-Jul-11	10	WON	----
3	02-Jul-11	6	WON	----

STUDENT004

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST
1	01-Jul-11	13	WON	----
2	01-Jul-11	9	WON	----

STUDENT005

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST
1	01-Jul-11	14	WON	----

Figure 7.   Lab View Summary Table

Analytical graphs and charts could also be implemented in the summary report to enhance the assessment. A few variants of the charts that could be implemented are as follows:

- Time Spent Analysis Chart (Figure 8)—Time spent on each scenario could be used as a proxy to identify which student has attempted the lab.

However, it cannot be used as a good assessment tool for which student is better as some students might be exploring the other parts of the scenario.
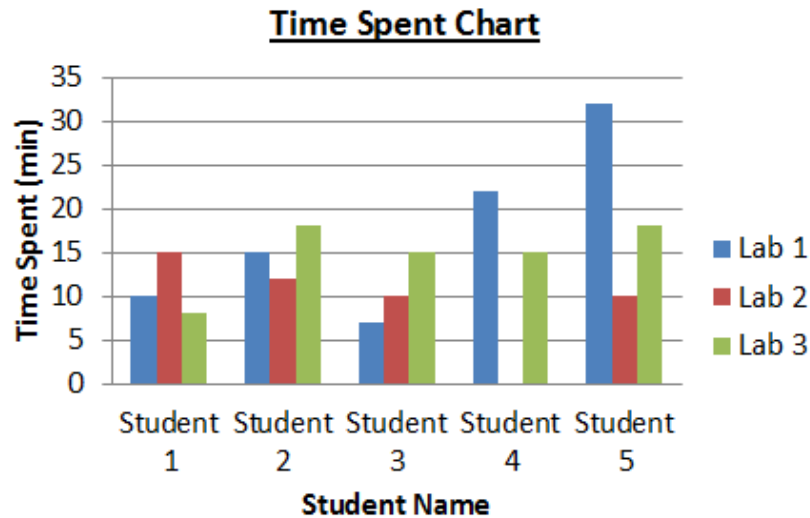
Figure 8.   Time Spent Analysis Chart

- Attempt Analysis Chart (Figure 9)—The attempt chart is a better analysis chart compared to the Time Spent Chart. This chart enables the instructor to assess who has attempted and on top of that he is also able to know which student has completed the lab successfully. Such a chart might aid conclusions like whether this is an easy lab or whether the students have enough knowledge to prior to attempting the lab. This would also allow the instructors to review his teaching materials so that the students are able to handle the problem set in the game scenario.

Figure 9.   Attempt Analysis Chart

- Scenario Analysis Chart (Figure 10)—This chart would provide the instructor with information on which part of the game scenario is too difficult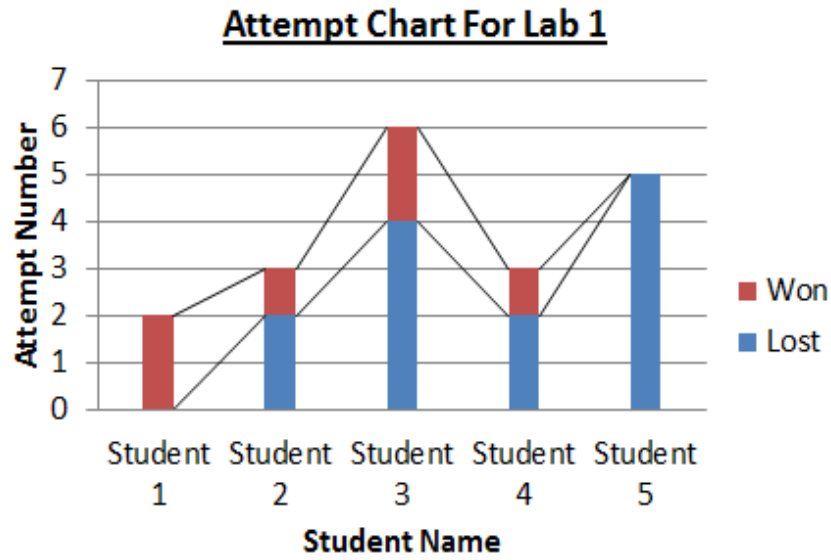 for the student to handle. From the analysis, the instructor would be able to decide whether to cover more material on that particular subject or provide more instructions for that particular scenario.
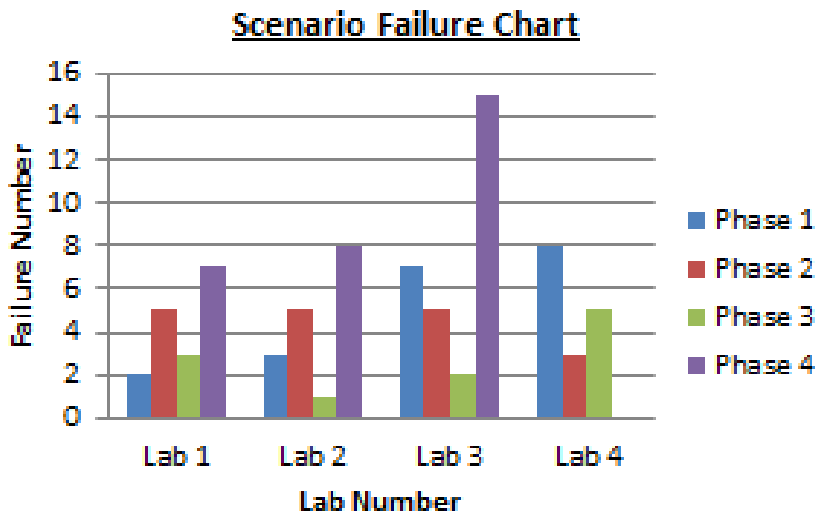

Figure 10.   Scenario Analysis Chart

Once the reports are generated, the next step is to deliver these reports to the respective instructors. Prior to this thesis work, the NPS approach was to deliver these summary reports via hardcopy or through e-mail. The next section will discuss how the summary report could be delivered to the instructors through a CLE.

C.   INTEGRATION WITH A CLE

Many educational organizations utilize CLE platforms to centralize course materials whereby the course notes, assignments and quizzes are conducted within the respective course site. This approach has made the management of courses much easier for the instructors. NPS is one of over 350 educational organizations that have adopted the Sakai CLE as a learning management system [15]. Sakai CLE is a platform that allows academic and research collaboration and it is built on open pedagogy and open standard [16].

In those situations where the course instructor is not the one who is gathering the logs and creating the reports, it would be useful to provide those instructors with report output within the Sakai environment. To more fully integrate CyberCIEGE into Sakai, we would need to look at how CyberCIEGE can adopt the Sharable Content Object Reference Model (SCROM) standards [17]. SCROM is a set of technical standards, (for which Sakai claims compliance), that specify three key areas; how content should be packaged and described, how content should be launched and how students can navigate between parts of the course. The tools that manage CyberCIEGE scenario packaging and student access to scenarios could be adapted to operate within a SCROM-compliant context, however that is beyond the scope of this thesis, but it will be addressed further in Chapter VI for possible future work.

For the purpose of this thesis, we will only explore how to integrate the summary report generated by CyberCIEGE into the Sakai CLE. The details of that implementation will be covered in the next chapter.

IV.   DEVELOPMENT STRATEGIES AND CONCEPTS

This chapter describes the development strategy and concepts in developing the solution to provide a more efficient CyberCIEGE student assessment environment. The development strategy is to divide the work in three key phases that will be discussed in the next three sections. Each of these phases will explain the selected requirement listed in Chapter III and how these requirements were implemented. The first phase will look at how the Event Log Analyzer can be improved to facilitate the assessment for instructors who are using the module. The next phase will discuss what information should be captured for the different level of summary reports and how the framework of the report should be like. The last phase will look at how the summary report can be integrated into Sakai CLE.

A.   IMPROVEMENT TO THE CURRENT EVENT LOG ANALYZER

As described in Chapter II, the Event Log Analyzer window will be activated when the user selects the log file of a particular student and clicks on the view log button on the Campaign Analyzer window as shown in Figure 11. The top panel of the resulting window shows the event list of the student's game log sorted by actual date and time. The middle panel shows the details of the event whenever an event is selected on the top panel. The bottom panel allows the user to filter the required event and the number of games to be shown on the top panel.
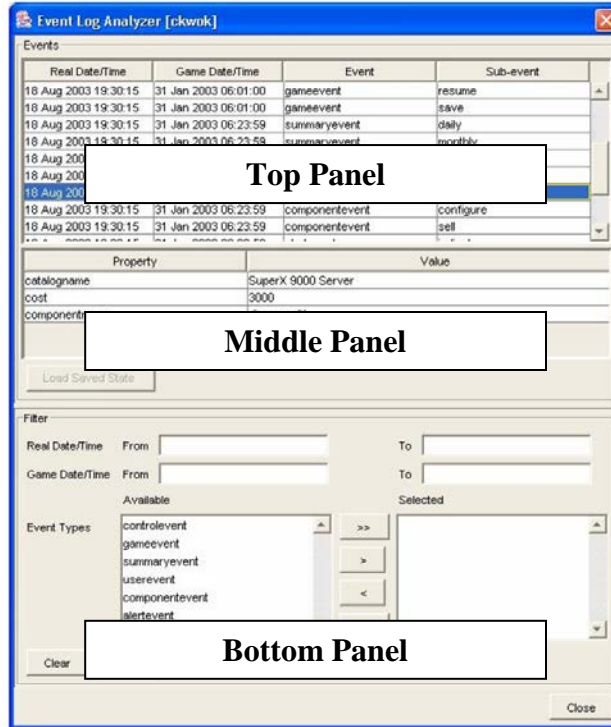
Figure 11.   Event Log Analyzer description.

There are two limitations with the current Log Analyzer. The first is that it is not able to show only a single game session except the last one. This is because the design of the module only allows the user to display the number of last log files to be presented. For example, if a student plays a particular scenario four times, and if the instructor would like to look at the second game that the student played, the module will only allow the instructor to load the last three games such that the instructor has to ignore the other two games at the end of the event list. The other issue identified is that both the Campaign Analyzer and the Event Log Analyzer do not provide a summary of all the attempts by the respective student in that scenario. This makes the assessment difficult as the instructor has to scan through the full event list for every student in order to know how the student did for each of the attempt.

Therefore, this thesis implemented the following improvements to the Event Log Analyzer.

- Include a summary table that shows all the student's attempts on the scenario.

- Display only the selected game attempt by the user.

To design the summary table, it was required to first identify the information that is essential for the instructor. This information should provide the instructor with sufficient details so that he can decide whether to look further into that particular game attempt. The identified information is as follows:

- The attempt number by the student.

- The status for that attempt (Won, Lost or Quit).

- The amount of currency at the end of that attempt.

- The real time that attempt started.

- The real time that attempt ended.

- The number of minutes played for that attempt.

In order to display the selected event, the best option is to allow the user to select the game straight from the summary table. This approach allows the instructor to select the game attempt directly from the information on the summary table. Therefore, the summary table should be positioned at the top panel of the Event Log Analyzer so that the user can first look at the game attempts and then, upon selection of the particular attempt, the sequence of events appear on the second panel as shown in Figure 12.
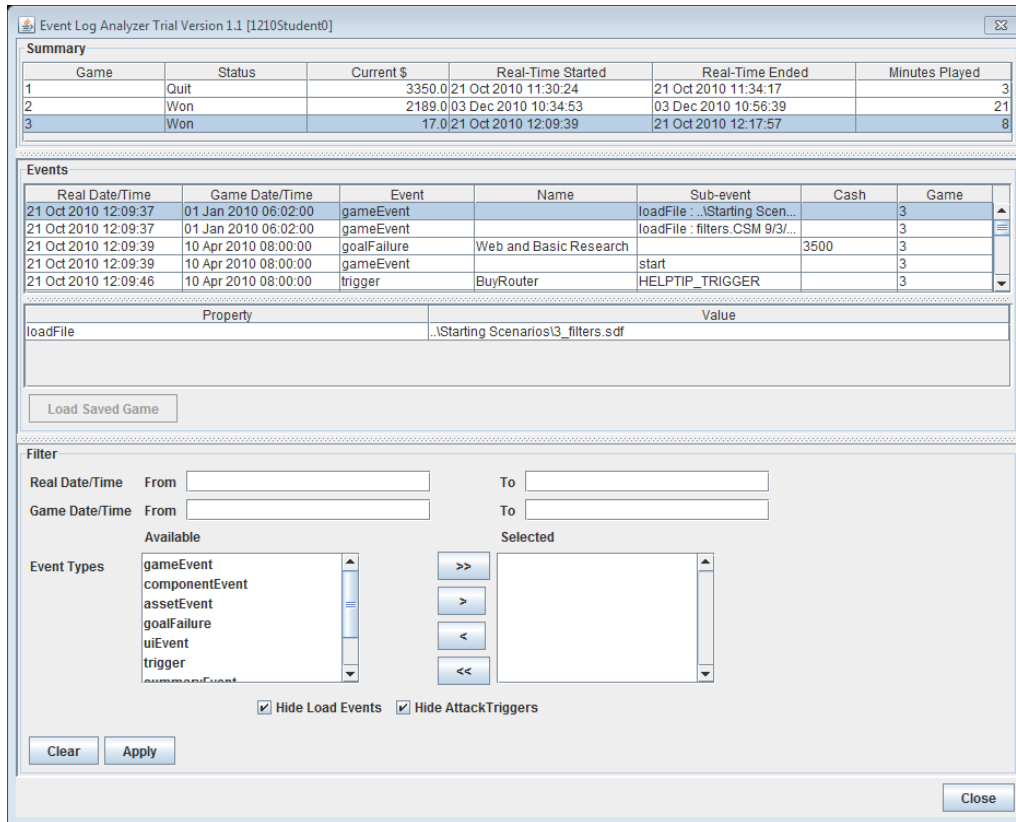
Figure 12.   Improved Event Log Analyzer.

B.   SUMMARY REPORT

The summary report is important for those instructors who are not personally collecting and processing the logs files. The key concept for the summary report is to keep it clear and concise while providing sufficient information for student assessments to be made. With that in mind, if the summary report was broken down into two levels. The first level provides the basic achievement of each individual student. If deemed required, the instructor would then click on the student name to go into the second level of detail for further assessment.

The information set identified for level 1 is as listed.

- Student name
- Lab Status to show the state of progress for each student. (Won, Lost or Quit)

24

- Total time spent
- Number of attempts for each lab

In order to ensure clarity in the report, necessary terms *e.g.*, mins, game, *etc.* are included in the summary table. The report also utilizes color shading to highlight those who are yet to start the lab and also those who have lost or quit the game to enhance the identification of possible problem areas, as shown in Figure 13.

SUMMARY REPORT (quarter fall-2010 taurus)

STUDENT NAME	LAB 1	LAB 2	LAB 3	LAB 4
Student01	Won (7 mins/1 game)	Won (32 mins/3 game)	Won (8 mins/3 game)	Quit:GoPhaseOne--1 (11 mins/1 game)
Student02	Not started	Won (10 mins/1 game)	Won (13 mins/3 game)	Not started
Student03	Not started	Won (19 mins/2 game)	Won (16 mins/4 game)	Not started
Student04	Not started	Won (27 mins/7 game)	Quit (21 mins/4 game)	Not started
Student05	Not started	Won (27 mins/1 game)	Won (21 mins/1 game)	Not started
Student06	Not started	Won (83 mins/5 game)	Won (28 mins/5 game)	Not started
Student07	Not started	Quit:goPhase3--2 (26 mins/2 game)	Won (18 mins/2 game)	Not started
Student08	Not started	Won (17 mins/1 game)	Won (12 mins/4 game)	Not started

Figure 13.   Level 1 Summary Report.

The level 2 summary report should be linked seamlessly from the level 1 report. A link function was built to hyperlink to the level 2 report when the user clicks on the "Student Name." The level 2 report shows all the lab sessions and details of the achievement in each attempt within that particular lab session. For example if the instructor would like to look at student Student07 game sessions, he will click on Cooper's name and it would lead him to the level 2 report, as shown in Figure 14.

Student07's Lab Summary

LAB 1

ATTEMP NOS	STATUS	CASH	TIME STARTED	TIME ENDED	MINUTES PLAYED
1	Not Played	----	----	----	----

LAB 2

ATTEMP NOS	STATUS	CASH	TIME STARTED	TIME ENDED	MINUTES PLAYED
1	Lost:goPhase2--0	-7569.0	06 Dec 2010 23:08:26	06 Dec 2010 23:22:12	13
2	Quit:goPhase3--0	966.0	06 Dec 2010 23:22:38	06 Dec 2010 23:36:18	13

LAB 3

ATTEMP NOS	STATUS	CASH	TIME STARTED	TIME ENDED	MINUTES PLAYED
1	Won	3657.0	20 Oct 2010 21:46:23	20 Oct 2010 22:03:31	17
2	Lost	-1996060.0	20 Oct 2010 22:04:10	20 Oct 2010 22:05:15	1

LAB 4

ATTEMP NOS	STATUS	CASH	TIME STARTED	TIME ENDED	MINUTES PLAYED
1	Not Played	----	----	----	----

BACK TO TOP

Figure 14.   Level 2 Summary Report.

From the report, the instructor is able to deduce the following:

- The student has yet to start his lab 1 and lab 4 sessions (this conclusion can also be made from level 1 summary).

- The student has attempted lab 2 twice, and the student lost the game on the first attempt. The student quit on the second attempt of phase 3.

- The student has attempted lab 3 twice. He has successfully achieved the game objectives on the first attempt. The student attempted the lab again and could be trying out a different configurations or choices for his own learning purposes.

Now that both the level 1 and 2 summary reports have been described, we will look at how the summary report is generated and what type of file format the reports should be in. The report generation function was built into the Campaign Analyzer module, as shown in Figure 14, to allow the user to generate the summary reports at a click of the button.
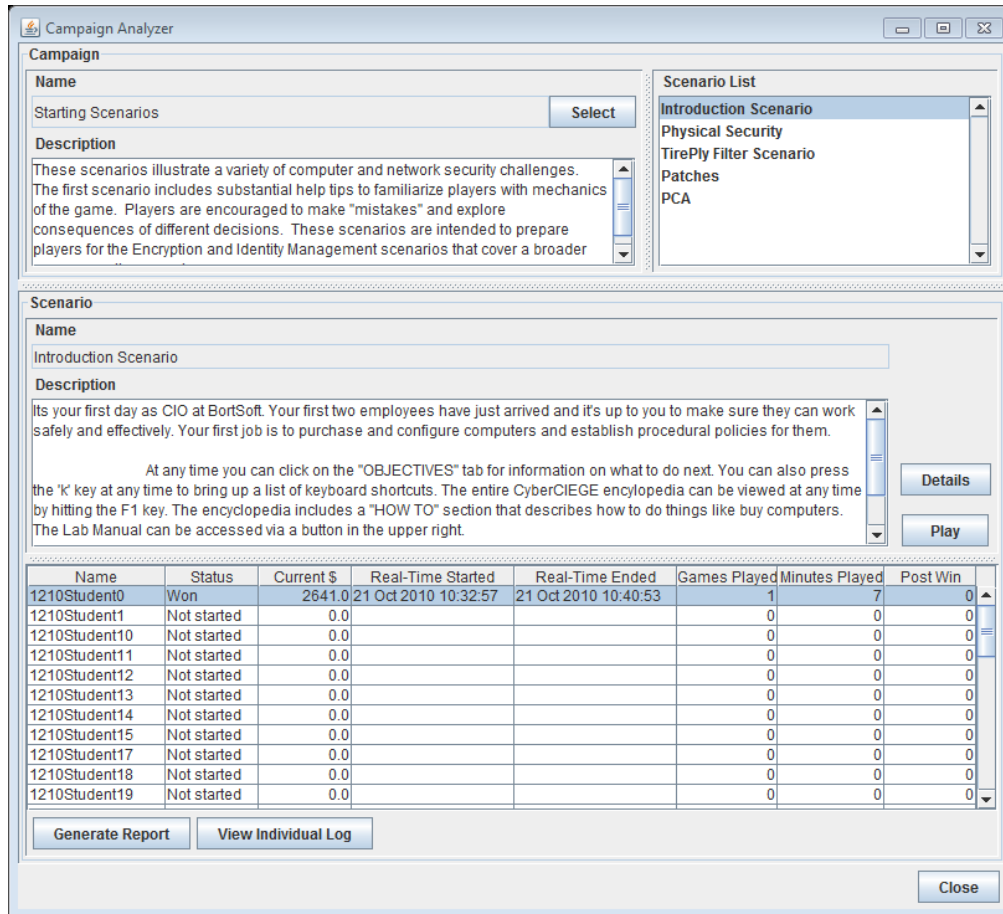
Figure 15.   Campaign Analyzer with Generate Report Function

Upon clicking the "Generate Report" button, another interface appears to let the user select the required input and output files, as shown in Figure 16.
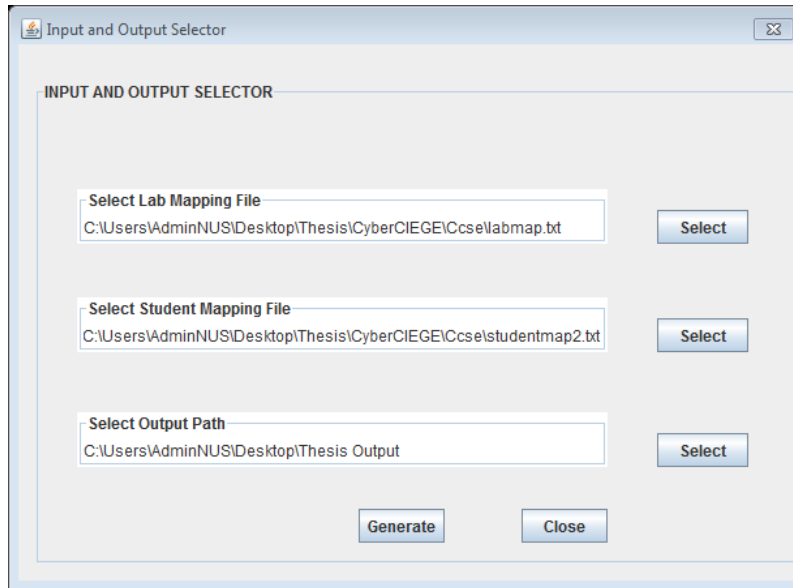
Figure 16.   Input and Output Selector Dialog Window

This dialog selects two input mapping files and one output path. The first file identifies how the scenario and lab session are mapped together. The information from that file directs the system to pull information from the corresponding scenarios and package them into the respective lab sessions. The second input file is comprised of the class description and the name of students who belong to that class. The system will use the class description for both the title of the summary report and the output file name for easy identification of the report. The name of the students will allow the system to identify the correct student log files to be pulled out for the summary report. This step is required because the person administering the logs might be doing so for more than one class.

The key considerations for the output file format is that it should be able to hold both level 1 and level 2 summary report in one single file. This is necessary so to prevent overloading the instructors with too many files. Having that in mind, two options were explored, the excel file format and the html file format. The excel format is able to store the various reports using the "tab" function. It also provides a good platform for the instructors to conduct further analysis with graphs and charts provided in the excel program. However, for this format to be usable, the instructor would need to have Excel

program installed in his system. This pre-requisite could be limiting as not all educational institutions have the Excel program. Therefore, the html format was chosen as the report file format and this format also provides easier integration to Sakai CLE.

C.   INTEGRATION WITH SAKAI CLE

The integration was made easy by the sharing features of the Sakai CLE, which employs the Web-based Distributed Authoring and Versioning (WebDAV) protocol that facilitates collaboration in Hypertext Transfer Protocol (HTTP). However, during the testing of the WebDAV interface of the NPS CLE, a WebDAV client command line failed to connect to the CLE. Similarly, a popular WebDAV drag-and-drop client called WinSCP was unable to connect to the CLE. Therefore, an alternative connection strategy using Window 7 drive mapping was chosen.

As Window 7 has a built-in WebDAV client, the user can use the Windows network drive mapping function to map a drive using the unique URL created for each course site on the CLE. During the mapping of the drive, WebDAV will authenticate the user using the CLE authentication function, which at NPS is configured to use the NPS domain authentication services.

Access to Sakai resources by authenticated users is controlled by a Sakai application policy which is based on the rights assigned by the instructor. The instructor would selects the access permission *e.g.,* create, read or delete contents, for each of the folders he created, as shown in Figure 17.
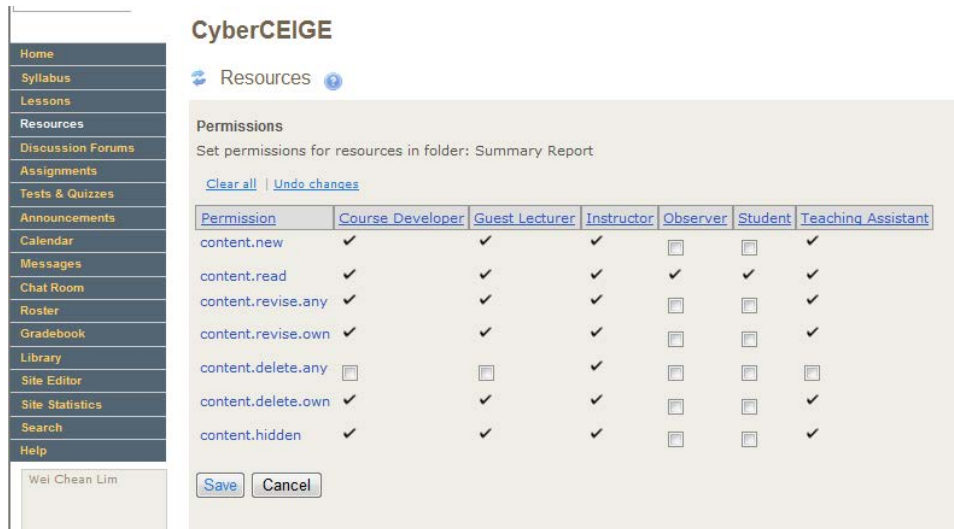
Figure 17.   Permission Assignment in CLE.

This thesis employed the following steps to upload the report to the instructor:

- The instructor managing the CLE course site adds the CyberCIEGE administrator as a member of the course.

- The administrator logs into the course site and obtains the URL link from the resource page as shown in Figure 18.
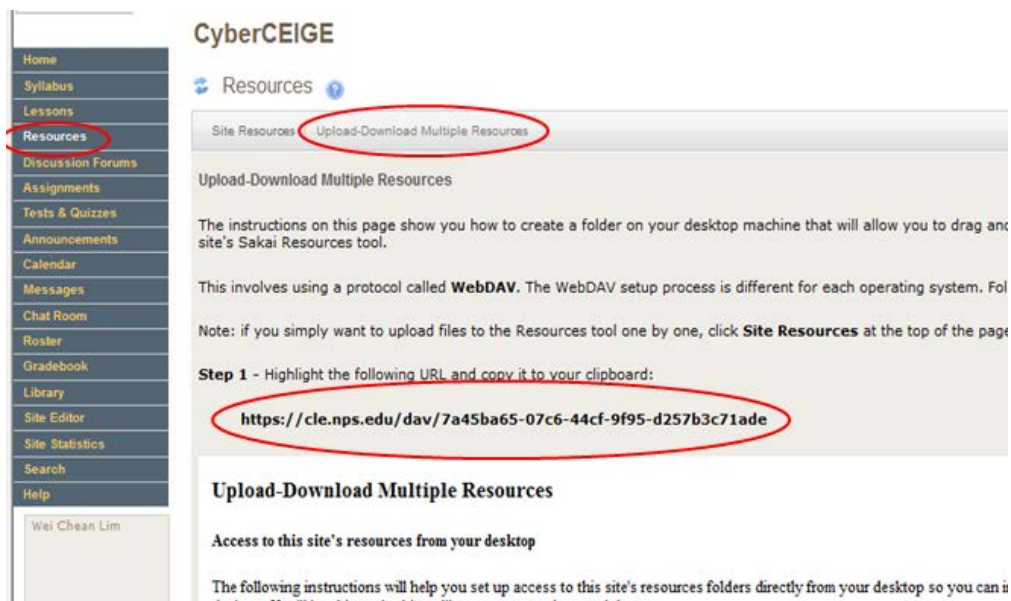
Figure 18.   CyberCIEGE Resource Page

- The administrator will then map the URL to a particular drive on his system.
- Once the drive is mapped, the administrator uploads the generated summary report by indicating the path on the Input and Output Selector.

In the event the instructor is not comfortable giving the administrator rights to insert materials into the course site, an alternative is for the CyberCIEGE administrator to manage a "CyberCIEGE" course site himself. In the course site, the administrator will published all the summary reports for the various classes onto the resource. Once that is done, the instructor can either go into the CyberCIEGE course site to pull out the summary report or he can create a link in his course site for easy reference. The steps for creating the link are as follows:

- The instructor selects "Edit Tools" option in the "Site Editor" of his CLE course site.
- Once in the "Edit Tools" window, the instructor selects "Web Content" which allows him to create a link that is mapped to the summary report as shown in Figure 19.

Figure 19. CLE Site Editor Feature.

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V.   IMPLEMENTATION AND TESTING
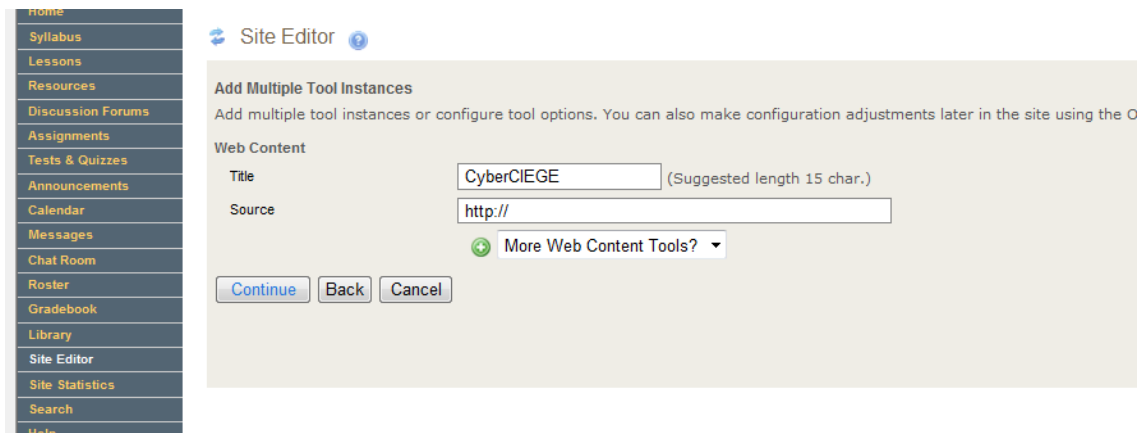
This chapter contains two sections. The first section describes the implementation of the functions highlighted in Chapter IV. The second section covers the test strategy employed for the verification of the developed functions.

A.   IMPLEMENTATION

Chapter IV discussed the development strategies for four key improvements to the analysis module, summary table for event log analyzer, summary report generation function, various levels of summary report and integration with CLE. The implementation of these improvements utilized the current CyberCIEGE code, written in Java, and classes as much as possible. The developments were done using the NetBeans Integrated Development Environment (IDE) 7.0, which is a free and open source IDE.

Some of these developments could be implemented using the GUI design features of NetBeans. However, it was not done so because the existing Campaign Analyzer code base uses manual construction of window components. An exception is the new class that was created to allow the user to select the input files and output directory through a dialog window. Also, the existing directory structures are not consistent with NetBeans project management assumptions and thus compilation was performed outside of the IDE using manual scripts.

1.   Implementation of Improved Event Log Analyzer

The "EventLogGUI" class was modified to include the additional features for event log display. Two key supporting methods were created for the inclusion of the new features. The first method that was created is "makeSummaryPanel". This method defines the layout of the new summary panel and it initiates retrieval of the selected game details from the log file. The second method created was "onSummaryTableValueChanged". This method an active listener that waits for the user's selection on the summary table and loads the selected event details on the middle

panel. A "summaryData" method was created in the "PlayerStatus" class to collect the required information from the selected game's log file. The method uses the game number to parse the logs to retrieve the summary for that particular game session. Summary of the modifications is as listed:

- Included a summary pane on the top of the event log analyzer window.
- Function to pull in the required data.
- Display events based on the selection from the summary pane.
- Highlight and display the event log for the last game by default.
- Removed the display game feature.

2. Implementation of Summary Report

"CampaignAnalyzerGUI.java" was modified to create the summary report feature. A new class "SumInputGUI" was also created to generate an input window for the user to define the paths for the required files. Once the user defines the respective paths, the two new methods "readLabFile" and "readStudentFile" will parse the files to get the lab mapping and student information respectively. All the required information is then retrieved from the logs and stored in a multidimensional array and eventually passed to "outhtml" for printing out the HTML summary report. The HTML is embedded in the code. Chapter VI identifies future work to make the HTML output configurable by the user. The modifications are as listed:

- Created the generate report button.
- Included the function to read the input files.
- Included the function to populate data for the summary report.
- Included a function to generate the summary report.

B. TEST STRATEGY

In order to validate the developed tools worked as intended, a two-stage distributed testing procedure was used. At the end of each development phases, the product will be first tested locally with the sample log files provided by the CyberCIEGE

project engineer. The second stage was to implement the developed tools in the actual system and test it with actual log files in the database by the engineer.

1.   Testing of Improved Event Log Analyzer

Verification tests were conducted to test whether the summary table displays the correct information, including the number of games played by the student. Each of the games displayed on the summary table was also selected individually to test whether correct information was displayed on the Event panel. The student's log with the follow number of games was selected:

No. of Games to be Displayed	Result of Test
1 game	Successful
3 games	Successful
5 games	Successful
7 games	Successful
9 games	Successful

Table 2.   Event Log Analyzer Test Cases and Result

The summary table was able to display the correct information and the correct number of games as stated in each of the selected logs. All the selected games were also able to display the correct event log.

2.   Testing of Summary Report

The following test cases were created to verify the summary report function could pull the required information based on the input given by the user. The tests were set to verify the following:

- The function is able to read the information from the input files correctly.
- The function is able to locate the correct game logs from the various game folders.
- The function is able to collect the required information from the log files.

- The function is able to generate the summary report in the correct format.
- The function is able to output the summary report at the defined location.

In order to verify the function is able to perform the abovementioned features, the function was tested with the following input:

No. of Lab to be Displayed	Number of Student	Result of Test
1 lab	10 students	Successful
2 labs	20 students	Successful
3 labs	30 students	Successful
4 labs	40 students	Successful

Table 3.   Summary Report Test Cases and Results

The function is able to generate the summary reports capturing all the required information.

3.   Testing of Integration to CLE

A CyberCIEGE account was created in NPS CLE. This account was used to test the uploading and downloading of the summary reports. The results of the tests are as follows:

Test Description	Result of Test
Mapping of drive using Window 7 system	Successful
Uploading of reports to the resource folder	Successful
Viewing of the reports by another user	Successful
Creating link on another course site	Successful
Viewing of report using the link	Successful
Uploading of report from Campaign Analyzer	Successful

Table 4.   CLE Test Cases and Results.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

CyberCIEGE is designed to be an educational instrument to enhance the delivering of network security knowledge. Therefore, it is important to create a learning management platform so that an instructor is able to assess whether the learning objectives are being met and to monitor the progress of his students.

To create the learning management platform, we first looked at how a scenario can be better designed such that the key information and lessons are delivered in the game play. This led to analysis of how key information can be captured and presented in the current event log analyzer, and in the form of summary reports for the instructors as described in Chapters III and IV. The thesis also developed a process whereby CyberCIEGE can be linked to the collaborative learning environment which allows a smoother transfer and management of the summary reports.

During the course of developing the products for this thesis, some other potential enhancements were also identified. However, due to the limited timeframe for this thesis, these enhancements were not implemented. These additional features will be explained in detail in the next section for possible future work on the learning management platform.

B. RECOMMENDATIONS

1. Capturing of In-Game Questions Results

The CyberCIEGE engine was modified to implement the in-game questioning during the game play. These in-game questions are in the form of multiple choice questions that can keep looping till the correct answer is selected. The improved summary report did not managed to capture and utilized these information for analysis. It is recommended that the sequence of the student's selection could be captured and

presented in the summary report. This information may help the instructor to assess the student's level of understanding. The information could be captured in the level 2 report as shown in Figure 19.

STUDENT001

LAB 1

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST	QUESTION (CORRECT 1ST TIME/NOS OF QNS)
1	01-Jul-11	3	LOST	Phase 1	(0/1)
2	03-Jul-11	7	WON	----	(2/3)

LAB 2

ATTEMPT NOS	DATE	TIME SPENT (MIN)	RESULT (WON/LOST/QUIT)	POINT OF LOST	QUESTION (CORRECT 1ST TIME/NOS OF QNS)
1	22-Jul-11	2	QUIT	----	(0/1)
2	22-Jul-11	5	LOST	Phase 2	(1/2)
3	22-Jul-11	10	WON	----	(2/2)

Figure 20.   Insertion of the question information in the level 2 summary table.

The suggested format is as shown in the last column of Figure 19. A summary of how many times the student got the correct answer on the first try and the total number of questions in the particular scenario. In the event when the instructor would like more information, he could select the respective cell and the next level of report would list all the questions for that scenario and the student's answer sequence.

2.   Use of Graphs and Charts for Summary

As highlighted in Chapter III, the attempt and scenario analysis charts and graphs could provide better analytical information for the instructor. Therefore, additional features to generate these charts could be created in the summary report or the charts could be pre-generated and included into the summary report.

3.   Usage of GUI Builder

The GUI builder function in the NetBeans IDE provides a much simpler way to create tables and windows similar to what the Campaign Analyzer and Event Log Analyzer currently implement. It would be useful if these displays were recreated with the GUI builder to enhance future expandability.

4.   Enhanced Integration with CLE

The ideal integration between CyberCIEGE and CLE is to allow the CyberCIEGE to run in CLE environment. This would allow the instructor to post the relevant lab in the course site in CLE, the students would just need to click on the link and proceed with the lab just like the current test and assessment features in CLE. At the end of the lab session, an auto generated summary report will be created in the CLE site for better management.

However, running CyberCIEGE within the CLE environment is not possible as the CyberCIEGE GUI utilizes the DirectX based 3D hardware acceleration that is not currently available in web browsers. Additionally, converting CyberCIEGE to use a new set of graphical interfaces would be a major undertaking. A more achievable integration of CyberCIEGE with the CLE might be to utilize SCROM functions to define campaigns and to guide students through these campaigns. For example, the CyberCIEGE Campaign Player could retrieve campaign information from the CLE rather than from local game storage.

5.   Configurable Summary Report Formats

Color-coding is used in the summary report to highlight student's progress *e.g.,* red color for a not attempted game, yellow color for an uncompleted game. This set of color-coding is embedded in the code and it would be difficult for user to change the color scheme. Therefore, a Cascading Style Sheet (CSS) could be implemented to provide more flexibility for the user to change the presentation scheme *e.g.,* color, fonts, without changing the code. Control to the report formatting *e.g.* colors, fonts.

6.   Extended Student Assessment

The improved summary report includes of two levels of detail for the instructor to analyze the student's progress in each of the scenarios. However, the implementation would still require the instructor to refer to the scenario definition or separate instructor

notes to understand exactly what problem the student is facing. Therefore, a third level of detail could be implemented to allow an automated generation of analysis based on proxies that are built in the game scenario.

The implementation of the third level of detail is more complicated as it would require the scenario designer to tag an analysis field for each question's answer, phases and objectives in the game scenario. The report generator would then pull this information depending on the progress of the student and generate the analysis of possible problems that a particular student faced. A simple illustration for this implementation is that when the scenario designer implements the questions in the game, he will tag an analysis note to each of the wrong answer that the student chose. Therefore, in the event when the student chose the wrong answer, the summary report engine will pull the analysis note out indicating that the student might not understand a certain concept. In the case where a student only progressed until the particular phase of the game, the summary report will also reflects the possible issues faced by the student as indicated in the analysis note created by the scenario designer.

Although the implementation would promote a certain level of in-game assessment of the student's capability, we would want to retain the initial idea of promoting the idea for student to explore the various options provided by the game. Thus, the analysis algorithm could adopt the logic that if a student returns to play the scenario after he has successfully completed the scenario, the wrong choices that he made subsequently would not be reflected in the summary.

Allow scenario designer or instructor to tag a specific game objectives and questions to specific learning objectives such that an instructor can obtain an automated indication of what is the problem faced by the student.

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