

University of Nevada, Reno

**A Video Library Management Software Toolkit for the Nevada Climate
Change Portal**

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in
Computer Science

By

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August, 2012

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THE GRADUATE SCHOOL

We recommend that the thesis
prepared under our supervision by

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**A Video Library Management Software Toolkit for the Nevada Climate Change
Portal**

be accepted in partial fulfillment of the
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ABSTRACT

Web-based video libraries represent a recognized and useful method of gathering contributions in the form of videos to research information that is provided from various users. Video libraries can be more effective and innovative, as compared to other more usual forms of video libraries, in terms of accessibility, flexibility, streaming, cost, and several other factors. These factors are essential for the development of commercial video library management toolkits and are being increasingly adopted in commercial web-based video libraries.

The Video Library Management Software Toolkit for the Nevada Climate Change Portal (in short, VLMST for NCCP) presented in the thesis is a web-based video management system designed to be integrated in the Nevada Climate Change Portal (NCCP) that is being developed at the University of Nevada, Reno as a part of the NSF EPSCoR funded project Nevada Infrastructure for Climate Change Science, Education and Outreach. One of the primary goals of this toolkit is to ensure that the users of the Nevada Climate Change Data Portal have equal access to participate in, contribute to, and benefit from all the functionalities provided by this specialized video library. VLMST is a web-based video repository that uses the server-client technology, which allows management and sharing of videos for the purpose of enhancing research and education. The proposed solution incorporates the forthcoming HTML5 technology, including the accessible video capability, allowing users to utilize cross-browser compatible video control. The thesis presents the software specification, the design, and the prototype of the VLMST. It highlights VLMST's distinguishing characteristics, compares it with several related tools, and points to a number of directions of future work.

DEDICATION

To my parents and family

ACKNOWLEDGEMENTS

I would like to thank Dr. Frederick C. Harris, Jr. and Dr. Sergiu Dascalu for serving as my thesis co-advisors and committee members; and for their invaluable guidance and support throughout my master's program in the University of Nevada, Reno.

I would like to thank Dr. Yantao Shen for his great support and for serving as my thesis committee member. I am grateful to Dr. Sohei Okamoto for his great help and guidance throughout my thesis work.

I am grateful to the NSF Nevada EPSCoR and Nevada System of Higher Education for the financial support I received as a Graduate Research Assistant during my Master in Computer Science at University of Nevada, Reno. The work presented in this thesis was made possible through the support provided by NSF grant EPS-0919123.

I would like to thank my parents, Dr. K.T. Dhone and Surekha Dhone, without whose care and support this thesis would have never get completed; my brother Amarnath Dhone for never stopping to inspire me; and my wonderful sister-in-law Pratibha Dhone for her love and care. I would also like to thank all the people who inspired and loved me throughout my life.

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1 INTRODUCTION

Video libraries are widely adopted by various commercial companies to promote their projects or products amongst the users. Being one of the most significant medium for gathering and spreading information, video libraries facilitate users to understand services provided more easily. The Video Library Management Software Toolkit (VLMST) presented in this thesis is a part of the Nevada Infrastructure for Climate Change Science, Education and Outreach project operated within NSF Nevada EPSCoR [26]. This video library has been designed and further developed as a subsystem of the Nevada Climate Change Portal (NCCP). The information is aggregated and displayed by the users of the NCCP in the form of videos and added to this library. This solution is an end-product to meet the need for the users within the NCCP [23].

VLMST provides various features, including some advanced ones, which make this video library management system unique and innovative. The most prominent features of VLMST are searching videos by various criteria and playing them seamlessly. Flexibility and ease of use were considered as the primary goals in our interface design. Fulfillment of the flexibility requirements can be achieved by introducing various video search criteria including keywords, genres, categories, tag clouds, controlled tags, and other. On the other hand, it is also important not to overwhelm the users with unnecessary search criteria [19]. Being light weight (no extra plug-in is needed to be installed) and having the farthest potential reach, HTML5 video control has been used to present videos. The tool also allows users to upload, remove, and download videos from the repository. The users who create an account on the data portal are provided with these advanced features. All information is stored in the database with the use of Microsoft SQL Server 2008 [7], [9].

There are also additional advanced features that have been incorporated in the VLMST system, in order to enhance the user experience. For example, the system facilitates communication regarding videos through various social networking websites, as well as via integrated commenting and feedback features. This allows other users to evaluate the popularity and the quality of the videos as well. Apart from writing public comments, writing private comments to a video uploader is a feature that has been also incorporated, which we believe is a substantial feature of the proposed toolkit. This facilitates the direct communication between video uploaders and other users, where these comments will be visible only to them. The system also allows users to manage a playlist by adding videos to or deleting from a playlist, and also to share it on social networking websites. Downloading a video segment is considered one of the innovative features of the system. Users can specify the start or end time of a video, and play only the specified segment. Alternatively, users can download such segment instead of a whole video, which saves storage space and downloading time.

The main intention of the proposed VLMST system is to encourage users of all levels, especially educators, researchers, and students for research and education purpose. The key usability goal of this project has been to make the tool's interface easy, flexible, and convenient for users, thus enhancing the user experience. With all the features described above, and with an intuitive and user friendly interface, VLMST can be considered novel and innovative. In addition, the Microsoft technology has been used in developing the proposed solution, which also facilitates a smooth integration with the NCCP data portal (also developed using Microsoft tools).

This thesis presents the software requirements and the design of VLMST in detail, as well as its background and motivation. In addition, the thesis describes the toolkit in action with

step-by-step illustrations of various functionalities. Comparison with related work and a set of possible directions of future work are also provided.

The remaining chapters of this thesis are organized as follows: Chapter 2 provides a background study of existing climate change related video libraries, as well as other existing video library tools; Chapter 3 explains the motivations behind this thesis work; Chapter 4 describes the requirements specification in detail, outlining the software requirements, use case modeling, and requirements traceability matrix; Chapter 5 provides details of the VLMST design, and illustrates the toolkit's functionalities and behaviors using various system diagrams; Chapter 6 presents the developed prototype and its functionalities through a set of software interface screenshots; Chapter 7 provides a brief comparison between VLMST and some existing video library management solutions; Chapter 8 presents an outline of several potential directions for future work; and, finally, Chapter 9 concludes this thesis.

2 BACKGROUND

A survey has been performed as part of our research aimed at enhancing collaboration and learning among users of the NCCP. The survey was focused on existing online repositories related to climate change and online video library management systems, which are described in the following subsections.

2.1 Online Video Repositories Related to Climate Change

This subsection gives an overview of features provided by climate change related video repositories.

2.1.1 CUAHSI

CUAHSI [5], which stands for the Consortium of Universities for the Advancement of Hydrologic Science, Inc., provides a data portal dedicated to deliver abundant resources for research and education in hydrologic science. In addition to various documents and datasets, the CUAHSI website also provides a collection of cyber-seminars for education and the general public. These seminars mainly consist of recorded presentations on climate related topics, contributed by speakers from various institutions, which are viewable online through the Adobe Connect interface or the WebEx plugin. In addition, CUAHSI provides several short films intended for scientists to utilize within their projects, which can be viewed in a Flash video player, or downloaded in MPEG formats for better results.

2.1.2 NASA

NASA [21], which stands for the National Aeronautics and Space Administration, provides a well-established science-related website that also includes videos related to climate change. The video library tool allows users to search videos using different search criteria such as related videos, recent upload, most popular videos, and top-rated videos. Users can search videos by a keyword, or using provided video topics. Videos can be viewed in a Flash video player, and users can write comments for videos as well. Users can easily download videos, share videos through various social networking websites, send video links via email, or place videos on other websites using embedding code.

2.1.3 NOAA Climate Services Portal

Climate Services Portal [25], operated under the National Oceanic and Atmospheric Administration (NOAA), is a climate change related website that also provides a video library. Videos from repository can be searched by a keyword, by an author name, by date uploaded, by recently uploaded videos category or by using a tag cloud. Videos can be viewed in a Flash video player. Feedback for videos can be found by checking the number of votes or ratings.

2.1.4 National Weather Service Alaska Region Headquarters

National Weather Service's Alaska Region Headquarters [22], which is also operated under the NOAA, provides a web portal designed to deliver climate change related resources for Alaska region, which includes a video library related to the region. The library contains videos regarding various topics, such as climate, forecasting, marine weather, winter weather, and other, which are available for downloading, mostly in mpg and wmv formats.

2.2 Online Video Library Management Systems

It is a common practice to upload videos to an existing online video library, and use the embedding code to place videos within a website (for example [24]). In addition, these online video library management systems provide advanced features to enhance the usability. In this section, the survey has been conducted to review online video library management systems ([3], [6], [17], [29], [32], and [33]). Brief descriptions of the main features of these libraries are provided below.

2.2.1 YouTube

YouTube [33] is one of the leading video sharing website based on both Adobe Flash video and HTML5 technology to display videos [18]. Non-registered users of YouTube can view videos, whereas registered users can upload an unlimited number of videos, and get benefits from various features (described in this subsection) provided by the system. The supported file formats for uploading video are webm, mpeg4, 3gpp, mov, avi, mpegps (supporting mpeg2 video codec and mp2 audio), wmv, and flv [28]. The highlighting features of YouTube are presented in [34], and summarized below:

Registered users are able to *like* videos, add comments for videos, and provide feedback for the video comments by clicking the “Vote Up” or “Vote Down” buttons. When a user watches any video, YouTube suggests related videos to the user. Users can virtually *rent* fully featured films directly from YouTube. Various search criteria and filter option are provided to make the video search easier. Users are also able to subscribe to channels of other people to learn all their activities, which will be delivered to the user’s home page. With the “Tag Cloud” service, users can get the most popular video keywords searched currently, organized with

different font sizes reflecting their popularities. YouTube registered users can share videos with friends via social networking websites, blogs, or email directly from a video page, or place videos within any other website or blog by embedding the video player code.

YouTube provides customization features for registered users to personalize their channels by selecting background color, or using other formatting options. Users can add videos to their favorites, albums to watch later, or to various playlists that can also be shared with friends. When uploading a video, users can add description and annotations, and set the sharing option to be public, private, or specific to selected YouTube friends. In addition, users can combine video clips, trim the video length, add music using AudioSwap feature, or add transitions between video clips. YouTube also supports uploading High Definition (HD) videos as well as 3 Dimensional (3D) videos.

2.2.2 Yahoo! Screen

Yahoo! Screen [32], formerly known as Yahoo! Video, is also a popular video sharing website. The tool provides various search criteria to view videos in various categories, where videos can be viewed in a Flash video player. Users were able to upload videos of file formats MPEG, MOV, WMV, AVI, ASF, and 3GP. However, the uploading feature has been removed, and the website now provides a number of Yahoo-hosted videos only. Yahoo! Screen website also provides licensed videos from established video content providers [31].

2.2.3 Vimeo

Vimeo [29], a video-sharing website, allows users to search videos by using different video categories or to browse videos from video catalog. Videos are played in a Flash player by

default, but users can choose an option to switch to a HTML5 based video player. Users can join channels of other users, or create a group of their friends to keep track of their activities, discuss about each other's videos. Users are able to manage their profiles, change video privacy settings, and read or send private messages to other users. Users can *like* videos, and also keep track of videos they *liked*, or they can create various video albums, to watch them in the future. The video formats supported for uploading are mpeg, mov, wmv, avi, mkv, mod, asf, ogg, and 3gp. Basic (free) Vimeo users can upload videos up to 500MB per week, whereas Plus Vimeo users (subscribed to Vimeo by paying \$59.95 per year or \$9.95 per month) can upload videos up to 5GB per week. Vimeo provides a module called Vimeo Videos School, where various helpful and friendly tutorial videos are presented to sharpen the users' skills to make better videos.

2.2.4 Blip

Blip [3] is a platform of web video series, sharing a wide variety of dramas, comedies, arts, sports, and other shows. Users can easily browse various categories of videos using Blip catalog of web series. Only producers of web series are allowed to upload the web series, and are required to release new episodes on a regular basis. Videos can be viewed in a flash video player or HTML5 based video player. Videos with different file formats such as mpeg, mov, wmv, avi, mod, asf, ogg, and 3gp are supported for uploading.

2.2.5 DailyMotion

DailyMotion [6] is one of the leading video sharing websites. Registered users can upload videos up to 60 minutes in length and about 2 GB in size. In order to avoid browser support issues, videos with unlimited size are not allowed to upload. The video files in 3gp, avi, divx,

m4v, mkv, mov, mp4, mpeg, mpg, ogg, and wmv formats can be uploaded to the repository. Users can search video using different categories or use the browse option to search videos viewed by other users on the same day. User can manage their profiles by creating, editing, or deleting them. User can follow different groups, or create their own groups including their friends, and follow them to view their activities. Videos uploaded by others can be added to the favorite-list to keep track, and view them in future. Users can also create various playlists with a number of videos, and organize them in any order as they would like. DailyMotion displays videos in a flash player, but user can choose the option to play videos in a HTML5 based video player. One of the most interesting features provided by this website is the video-wall, in which users can choose videos (up to 81), generate a code, and use the code in other websites to display a group of videos with a slick interface.

2.2.6 Metacafe

Metacafe [19] is another video sharing website that provides short-form entertainment videos in the categories of movies, video games, sports, music, TV, and other. Users can manage channel settings to feature their own videos on their Metacafe favorites, to manually add videos from the various tabs (such as tabs containing videos produced or submitted by the user, and videos added to the favorite-list) to their profile, or to allow others to view their activities. Videos up to 2 GB size and of input file formats such as mpeg, mpg, mpe, avi, wmv, wmf, asf, m1v, divx, mov, mp4, flv, 3gp, rm, rmvb, rv, ram, or mkv can be uploaded to the video library.

As described above, this background chapter provides a survey of selected online video repositories and commercially developed online video library management systems. Note that

features described in each tool are not exhaustive but rather representative, to the best of our knowledge, highlighting their main characteristics.

Also to note is that the survey was not performed in a comprehensive manner, and we have selected popular tools for the reviews, as our main purposes have been in understanding the technologies currently being used in providing large video libraries, as well as finding the current-state-of-art technologies in this field.

3 WORK MOTIVATION

This chapter summarizes the work motivation for our VLMST research approach. There are several video library tools available in the market these days. Video library represents one of the most flexible tools for collecting information from people including commercial website users, society members, researchers, and other. The concept of a video library allows a user to gather information in the form of videos and upload it on a video library to be viewed by other interested users.

The work presented in this thesis is a part of the NSF-funded project “Nevada Infrastructure of Climate Change Science, Education, and Outreach” (2008-2013) [26]. Climate Modeling, Ecological Change, Water Resources, Policy, Decision Making, and Outreach are the main components this project is based up on. The project mainly focuses on developing an interdisciplinary program on climate change and supports NCCP that detects, analyzes, aggregates, and displays the results of climate change research to the concerned users [26]. The major motivation behind developing the VLMST solution is to be integrated with the NCCP [23], where the common users of this portal are researchers, scientists, lecturers, and students. The video library provides various videos to these users of NCCP, and to enhance communication between them. The VLMST tool has been developed to meet the requirements of NCCP, in which, to the best of our knowledge, current available video library tools are not effective to fulfill their needs. The system facilitates users to search videos by providing various search criteria, such as by keywords, genres, categories, tag clouds, and built-in controlled tags. The solution is designed to be open and shared so that registered users can easily download videos and video segments uploaded by other users. Writing public and private comments for videos have also been enabled to facilitate viewers to evaluate and uploaders to improve the

quality of their videos. HTML5 based video player has been chosen to play videos considering the fact that most modern web browsers support it, and it has the full future proof [11].

Due to large usefulness and wide acceptance of various video library tools by people, one of the most important motivations behind VLMST's development was also to develop an innovative solution by adding new features that are useful but not found in similar work. Along with that, adding other commonly used advanced features was also essential to our work as it is important for a system to compare positively with currently available and mostly used video library tools in the market. Therefore, many features of VLMST have been inspired or evolved from other existing video hosting websites, such as YouTube [33], Yahoo! Screen [32], Vimeo [29], DailyMotion [6], Blip [3], and Metacafe [17].

Flexibility and extensibility are the most useful traits of a video library that have been considered in designing and developing the VLMST solution. Flexibility in the system allows developers to make important, effective, and efficient further changes to a video library tool, e.g. to ensure precise system functionality. Also, any kind of essential and innovative changes made in accordance with system requirements or future extension of a solution should be allowed without affecting the current functionality of a system, as this will allow users to take advantage of new capabilities of a video library.

4 SOFTWARE REQUIREMENTS SPECIFICATION

VLMST for NCCP is a video management system that facilitates a video library with specific goals to be integrated into the Nevada Climate Change Data Portal. The nature of the system is to allow performing different types of functions and to share videos among our stakeholders. Functional and non-functional requirements of the proposed solution are described in the following sections. Functional requirements describe intended behavior of the software, where non-functional requirements describe required system behavior for development purpose, complementing functional requirements. In addition, the use case diagram and descriptions of each use case are provided to describe user interactions, and the traceability matrix is included to map the relationships between functional requirements and use cases. The following specifications outline the primary functionalities of the VLMST.

4.1 Functional Requirements

The functional requirements are concerned with functionalities or specific execution capabilities that the system provides [2]. We have categorized into three levels based on their significance to the system.

- Level 1: Most significant and mandatory for prototype implementation
(Shown in Table 4.1)
- Level 2: Less significant but necessary for prototype implementation
(Shown in Table 4.2)
- Level 3: Less significant but not strictly necessary for prototype implementation
(Shown in Table 4.3)

Level 2 and Level 3 requirements will be considered for implementation in the extension phase of the software development. The functional requirements 1.11, 1.14, and 1.16 (marked with a start in Table 4.1) are deemed to fulfill the most innovative functionality of VLMST.

Table 4.1: Level 1 Functional Requirements

FR1.1	The system shall allow users to search videos by a keyword
FR1.2	The system shall allow users to play (or view) a video
FR1.3	The system shall allow registered users to upload videos to the library
FR1.4	The system shall allow registered users to modify uploaded videos
FR1.5	The system shall allow registered users to delete uploaded videos from the library
FR1.6	The system shall allow registered users to download videos
FR1.7	The system shall allow users to search videos by their genre
FR1.8	The system shall allow users to view recently added videos in the library
FR1.9	The system shall allow users to view most popular videos in the library
FR1.10	The system shall allow users to search videos by tag clouds
FR1.11*	The system shall allow users to search videos by controlled tags
FR1.12	The system shall allow registered users to give feedback for a video by hitting the Like button
FR1.13	The system shall allow registered users to write public comments for a video in the library which would be visible to all the users
FR1.14*	The system shall allow registered users to write private comments for a video in the library which should be visible to the users who commented and the user uploaded the video
FR1.15	The system shall allow registered users to play a video segment by entering the start or end time of a video
FR1.16*	The system shall allow registered users to download a video segment
FR1.17	The system shall allow registered users to share videos on different social networking websites, such as Facebook, Twitter, and other.
FR1.18	The system shall allow users to create a playlist of their favorite videos
FR1.19	The system shall allow users to delete a video from a playlist
FR1.20	The system shall allow users to share a playlist of their favorite videos on different social networking websites, such as Facebook, Twitter, and other.
FR1.21	The system shall display the number of people who viewed each video
FR1.22	The system shall display the number of people who liked each video

Table 4.2: Level 2 Functional Requirements

FR2.1	The system shall allow the video uploader to select a video thumbnail when uploading a video
FR2.2	The system shall allow users to create multiple playlists
FR2.3	The system shall allow users to customize privacy settings
FR2.4	The system shall allow users to report to administrator when video seems controversial

Table 4.3: Level 3 Functional Requirements

FR3.1	The system shall allow registered users to create their own profile on the website
FR3.2	The system shall allow users to search videos by uploader's name or profile
FR3.3	The system shall allow users to select a user category such as scientists, researchers, professors, or students
FR3.4	The system shall allow users to search videos by the uploader's user category e.g. scientists, researchers, professors, students, and other
FR3.5	The system shall allow users to search videos by the video length, e.g., short, medium, and long

4.2 Non-Functional Requirements

Non-functional requirements are concerned with emergent properties of the system [2]. They represent constraints on the system and typically apply on it as a whole. Table 4.4 defines system requirements in brief for the prototype implementation, where all of them are defined on Level 1 as described in the previous section.

Table 4.4: Non-Functional Requirements

NFR1	The system shall be implemented in ASP.net 4.0
NFR2	The system shall be written in C#
NFR3	The system shall store data using MS SQL Server
NFR4	The system shall integrate with the Nevada Climate Change Data Portal
NFR5	The system shall include only interfaces in valid HTML
NFR6	The system shall include only interfaces in valid CSS styles
NFR7	The system shall be cross-browser compatible
NFR7.1	The system shall support Firefox 3.5 and up
NFR7.2	The system shall support Chrome 3.0 and up
NFR7.3	The system shall support MS IE 9 and up
NFR7.4	The system shall support Opera 10.5 and up
NFR7.5	The system shall support Safari 3 and up
NFR8	The system shall use ffmpeg for the video conversion
NFR9	The system shall be intuitive
NFR10	The system shall be extensible

4.3 Use Case Diagram

A use case diagram depicts the interactions between the system and users. An *actor* is a user interacting with the system, whereas a *use case* describes how an actor interacts with the system [2]. A use case diagram with primary use cases and two actors (registered and non-registered), are presented in Figure 4.1 to briefly describe the main functionalities of the VLMST.

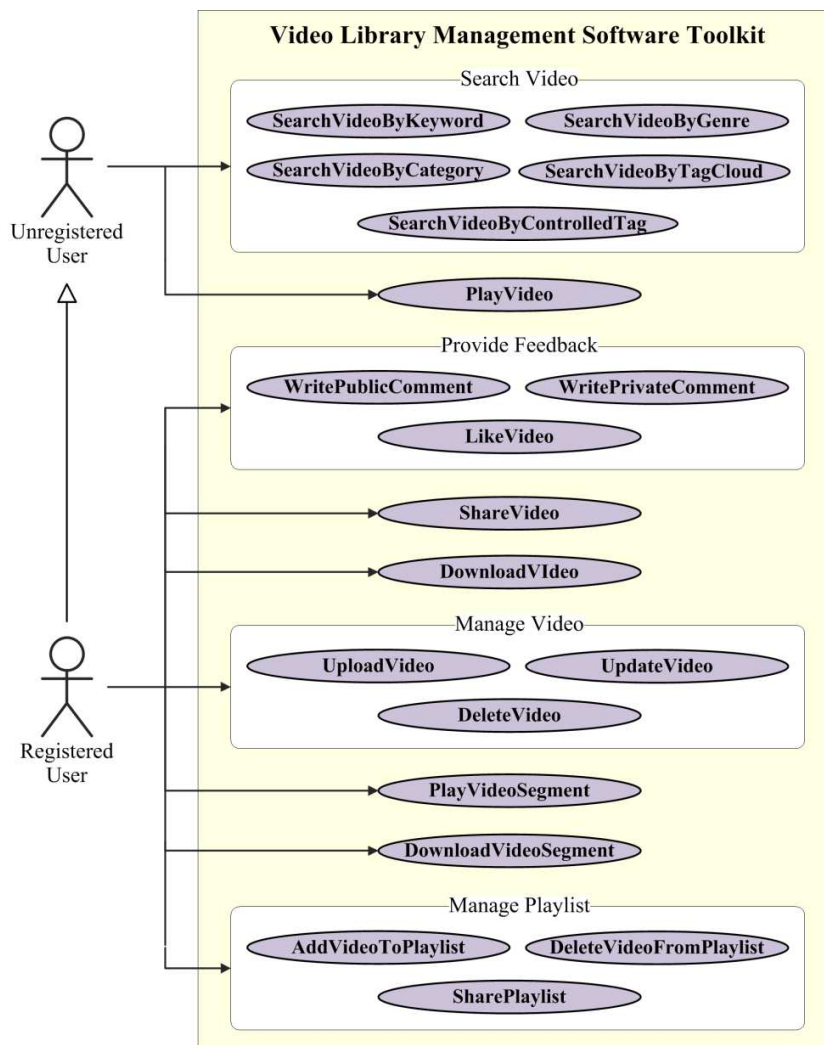


Figure 4.1: VLMST Use Case Diagram

4.4 Use Case Descriptions and Requirements Traceability Matrix

Table 4.5 provides descriptions of use cases shown in Figure 4.1, to better understand each of them. The requirement traceability matrix shown in Figure 4.2 specifies how each functional requirement maps to each use case, and vice versa, to make sure that the specification is consistent.

Table 4.5: Use Case Descriptions

UC1: Search Video by Keyword	The user searches videos by entering keywords in the search field provided
UC2: Search Video by Genre	The user searches videos by selecting a video genre
UC3: Search Video by Category	The user searches videos by selecting respective video category, such as most popular videos, most viewed videos, or recently added videos
UC4: Search Video by Tag cloud	The user searches videos with the help of tag clouds created automatically by the system
UC5: Search Video by Controlled Tag	The user searches videos with the help of controlled tags provided by the system
UC6: Play Video	The user plays a video
UC7: Write Public Comment	The user writes a public comment for a video
UC8: Write Private Comment	The user writes a private comment for a video
UC9: Like video	The user gives feedback for a video by liking it
UC10: Share Video	The user shares a video on different social networking websites such as Facebook and Twitter
UC11: Download video	The user downloads a video
UC12: Upload Video	The user uploads a video to the repository with detailed information, such as title, description, genre, tags, and controlled tag category
UC13: UpdateVideo	The user updates/edits the details of an existing video
UC14: Delete Video	The user removes an existing video from the repository permanently and other associated data
UC15: Play Video Segment	The user plays a video segment by entering the start and/or the end time for a video
UC16: Download Video Segment	The user downloads a video segment specified by start or end time for a video
UC17: Add Video to Playlist	The user adds a video to a playlist
UC18: Delete Video from Playlist	The user deletes a video from a playlist
UC19: Share Playlist	The user shares a playlist of videos on different social networking websites such as Facebook and Twitter

		Use Case (UC)																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Functional Requirement (FR)	1.1	✓																		
	1.2						✓													
	1.3												✓							
	1.4													✓						
	1.5														✓					
	1.6											✓								
	1.7		✓																	
	1.8						✓													
	1.9						✓													
	1.10				✓															
	1.11					✓														
	1.12									✓										
	1.13							✓												
	1.14								✓											
	1.15															✓				
	1.16																✓			
	1.17										✓									
	1.18																	✓		
	1.19																		✓	
	1.20																			✓
	1.21						✓													
	1.22									✓										
	2.1												✓							
	2.2																	✓		
	2.3												✓							
	2.4							✓	✓											
	3.1	✓																		
	3.2	✓																		
	3.3	✓																		
	3.4	✓		✓																
	3.5	✓																		

Figure 4.2: VLMST Requirements Traceability Matrix

5 SOFTWARE MODEL

VLMST has been designed in accordance with the requirements specification described in the previous chapter. Its design incorporates most of the basic features that are included in currently available video library tools on the market, as well as several advanced features to enhance its usability. The following section goes over the design of the VLMST solution in several subsections, and provides details of VLMST together with diagrams depicting the system's architecture and functionalities.

5.1 High-level Design

Figure 5.1 depicts the sitemap of VLMST. The sitemap was chosen to describe the high-level design, as the VLMST solution can be most easily broken down into high-level structural elements by providing the overview of its views (or pages) and how the pages are associated with each other. As seen in the diagram, VLMST Home links to various pages/views such as recently added videos, most popular videos, videos search by keyword, videos search by genre, videos search by tag cloud, videos search by controlled tag, playlist page, and video upload page. The View results page can be accessed from all search pages. The Video play page is accessible from any page that displays the information of a video or videos.

As shown in Figure 5.1, a video upload page *uses* The Video update page, as both of them use exactly the same input fields, either to insert or update a video. Most popular videos and playlists are displayed using a slider. The Play video page includes comments template which can be categorized into public comments and private comments. Public comments and

private comments can be multiple. Note that the Update page, slider, and comments are components that are reused or inserted within a page or in multiple pages.

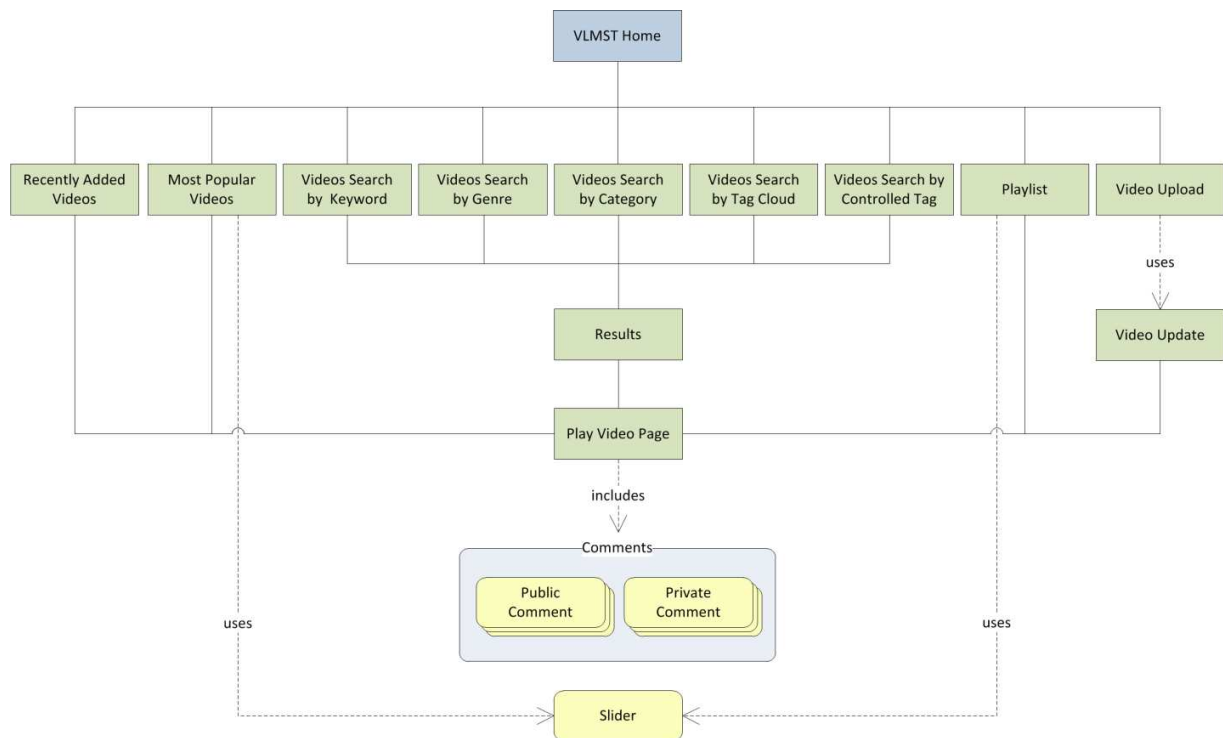


Figure 5.1: VLMST Sitemap

Figure 5.2 shows a user activity diagram for a video searching action. As shown in the figure, when a user opens the VLMST Home Page, the user goes to the Search video page. After specifying the search criteria, such as video search by a keyword, genre, category, tag cloud, or controlled tag, videos are searched to match the criteria. For that, a query is built by the system, which is then executed to search videos with matching criteria. When videos are found, the user sees the generated video list; otherwise the system goes back to the Search video page with different criteria. After viewing a video list, the user can either select an option to search video again or exit. Some actions, such as open the VLMST Home page, go to search page, specify criteria, and search video, shown in purple color are actions performed by a user, while other

actions, such as build query, execute query, and display video list, shown in blue color are actions performed by the system.

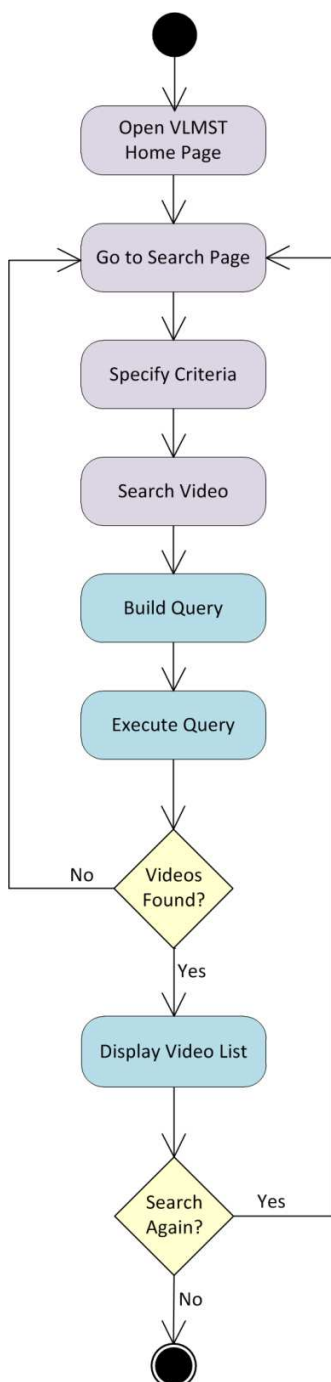


Figure 5.2: VLMST User Activity Diagram to Search Video

Figure 5.3 presents the overview of the three-tier architectural pattern that VLMST is built upon. The user interface layer consists of valid HTML/CSS/JavaScript pages that will be accessible to the clients, the application layer consists of an ASP.NET framework coded in C# language that performs system logic, and the data storage layer consists of the MS SQL Server [7], [9] that manages system data storage.

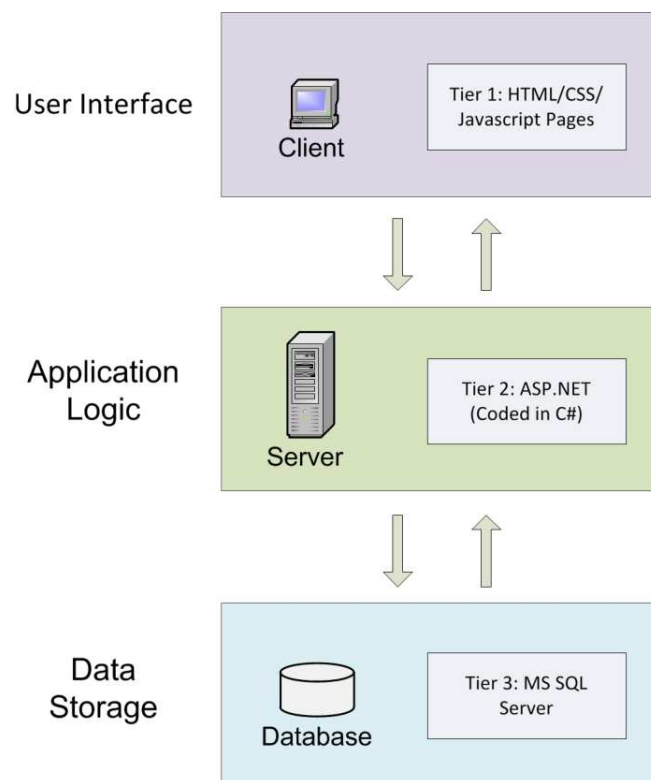


Figure 5.3: VLMST Three-Tier Architectural Pattern

Being a web-based application, VLMST is based upon the client-server architectural pattern. Figure 5.4 depicts VLMST's architectural pattern presenting the possibility of synchronous interaction of the VLMST users' actions with the system. As it is seen in the diagram, different users can send http requests to the server for example, as shown in Figure 5.4, client 1, client 2, and client n are sending HTTP requests to server for searching and viewing videos whereas client A is sending an HTTP request for managing videos (by uploading, updating, or editing a video). A server captures and processes all the requests, and updates a video repository if necessary.

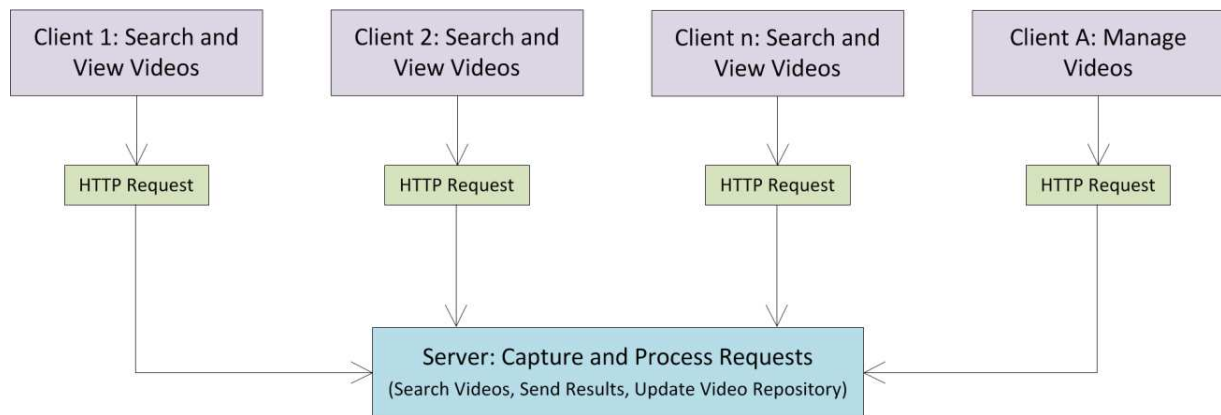


Figure 5.4: VLMST Client-Server Architectural Pattern

5.2 State Machine Diagrams

This section presents two state machine diagrams describing user action within the VLMST solution. In particular, state charts show possible transactions between states as well as actions that trigger the transitions. Figure 5.5 covers the basic functions that are performed by the non-logged-in users of VLMST such as searching videos using various search criteria, viewing the results, viewing a video, viewing playlist of other registered users, and other. One thing to note in this diagram is that the users have different transitions and options to play a video.

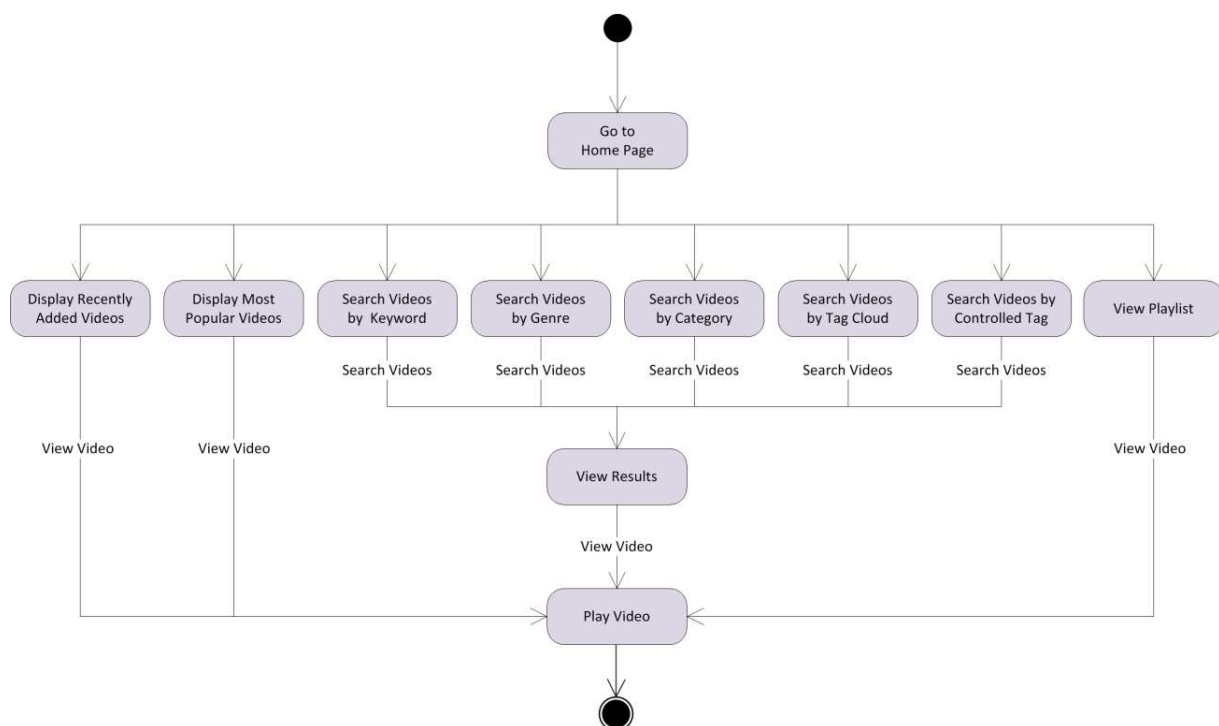


Figure 5.5: VLMST Non-Logged-In Users' State Machine Diagram

Figure 5.6 presents the user actions of logged-in users of VLMST. Apart from the actions that can be performed by non-logged-in users, logged-in users have the advantage of performing additional actions. Logged-in users can manage videos by uploading, updating, and deleting videos, as well as they are allowed to download existing videos in the repository. In addition, any logged-in user can download any videos in the library; give feedback for a video by liking and writing public or private comments to a video; and share videos on various social networking websites, such as Facebook, Twitter, and other; as well as play and download a video segment. Note that only a video uploader of a video has the privilege to update or delete videos from the repository, which is indicated by blue color in Figure 5.6. In addition, the playlist owner is allowed to add or delete videos in the playlist, or share the playlist (shown in blue color as well in Figure 5.6).

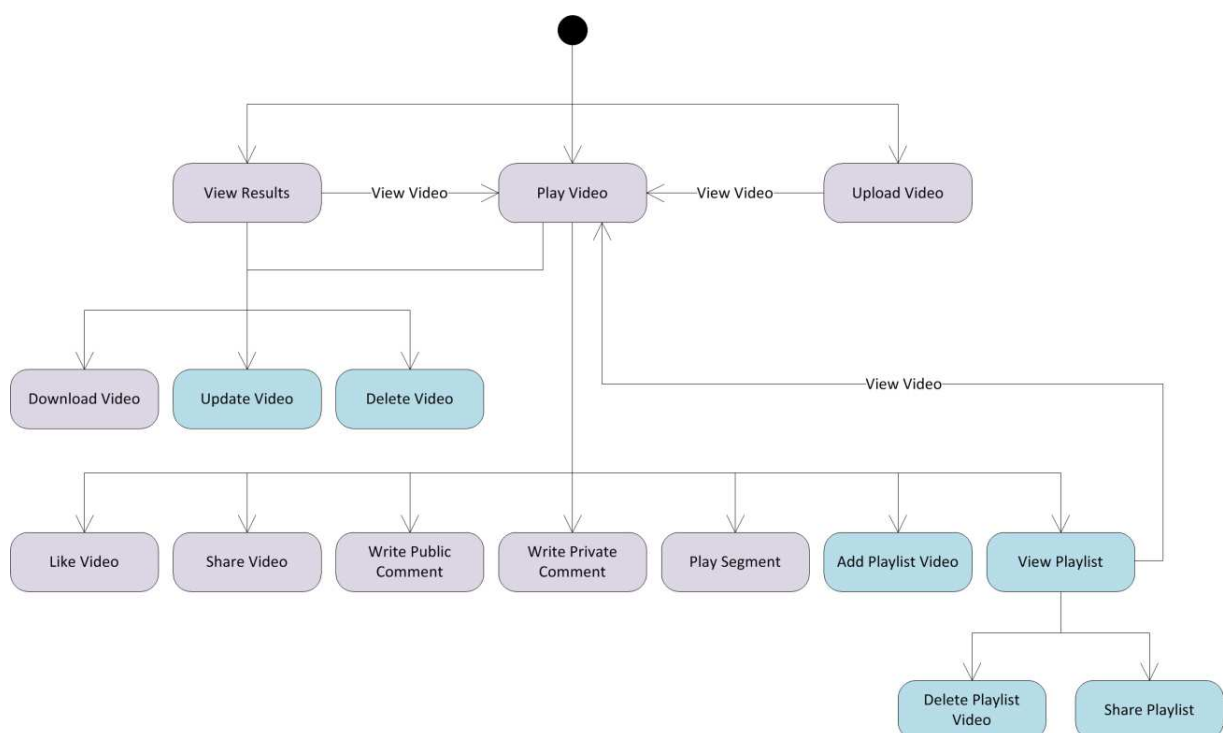


Figure 5.6: VLMST Logged-In Users' State Machine Diagram

5.3 Data Design

Figure 5.7 depicts the database design diagram for VLMST. The diagram presents the database tables used in the VLMST design, and the relationships between those tables. In particular, lines between tables indicate the connections between the tables with the linking keys, indicating one-to-many relationships. Worth noting, some tables such as Tags and Playlist realize many-to-many relationship with the Videos table, by utilizing intermediate linking tables such as VideoTag and PlaylistVideo, respectively.

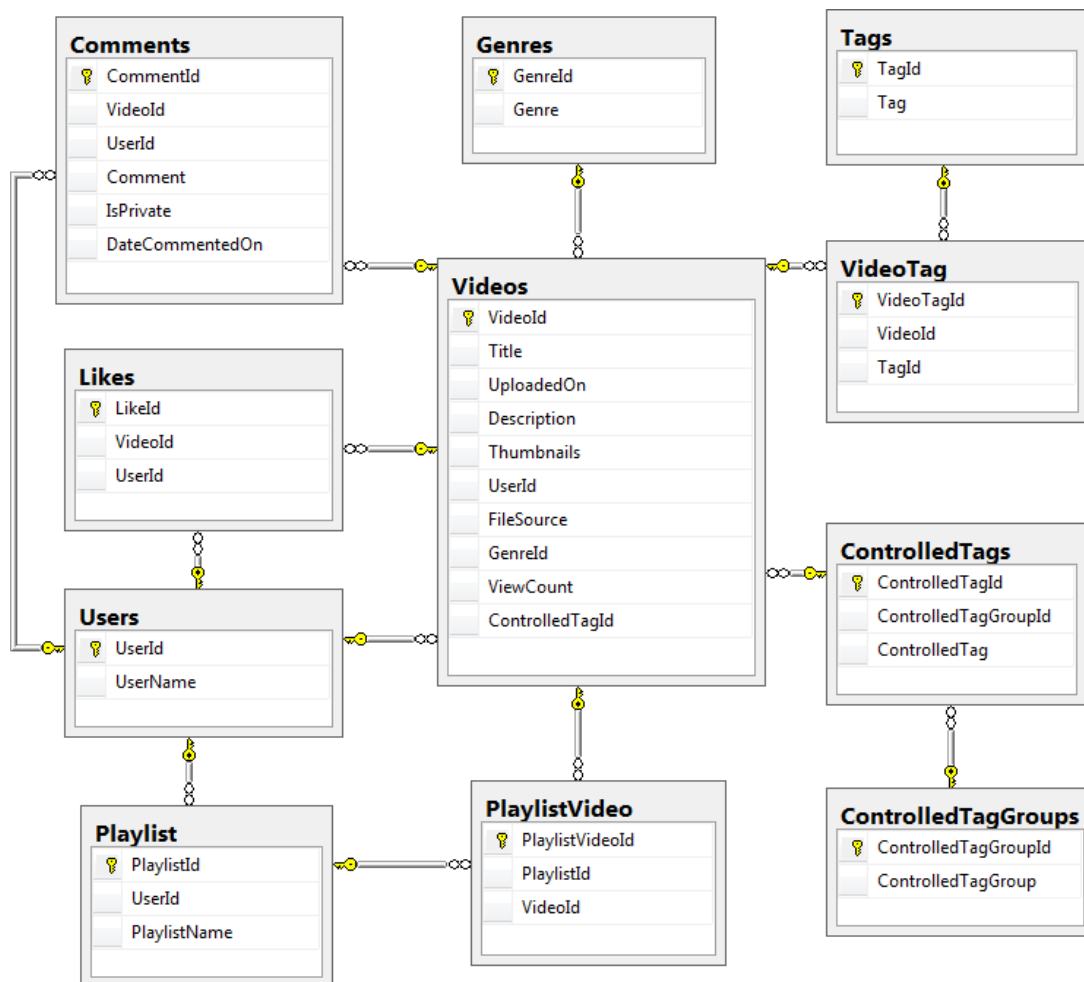


Figure 5.7: VLMST Database Diagram

6 VLMST PROTOTYPE DETAILS

This chapter presents an overview of the VLMST software prototype based on the design provided in the previous chapter. It provides a general introduction to VLMST's user interface by demonstrating the usage of the most significant features of the toolkit. The actions performed by any non-logged-in users, and any logged-in users are described, followed by examples for video management.

6.1 VLMST in Action for Non-Logged-In Users

Figure 6.1 presents a screenshot showing the VLMST application's home page that is visible to any non-logged-in user. As shown in the figure, a non-logged-in user of VLMST is able to search and view videos in the repository. Non-logged-in users can search videos using various search criteria such as search by keywords, genres, categories, tag clouds, and controlled tags.

Figure 6.2 and Figure 6.3 depict screenshots showing results for searching a video by a keyword. In the first example, a tag named *soil* is used to search related videos for which there are no videos found in the repository. In the second example, a tag named *framework* is used that displayed related videos on the page. These tags are inserted to the database while uploading videos, and are used (along with video title) to retrieve videos on search by a keyword [14].



Figure 6.1: VLMST Homepage for Non-logged-in User



Figure 6.2: VLMST Video Search Results for a Keyword - *soil*


Welcome To Video Manager [Log In]

Video Library Management Software Toolkit

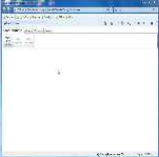

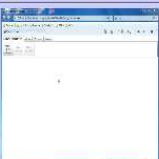
Home Genres Videos Tag Cloud Controlled Tags About

framework

Most Popular Videos



Search Results for framework

	Software Framework Demo Software Framework Demo description is here
	Demeter Framework IEMSS Demo Demeter Framework IEMSS Demo project description is here
	Software Framework Software Framework

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[Help](#)
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Figure 6.3: VLMST Video Search Results for a Keyword – *framework*

Figure 6.4, Figure 6.6, and Figure 6.11 provide screenshots of various tabs, that is, *Genres*, *Videos*, and *Controlled Tags*, respectively. Along with other tabs such as *Home*, *Tag Cloud*, and *About*, users can easily navigate to the specific pages.

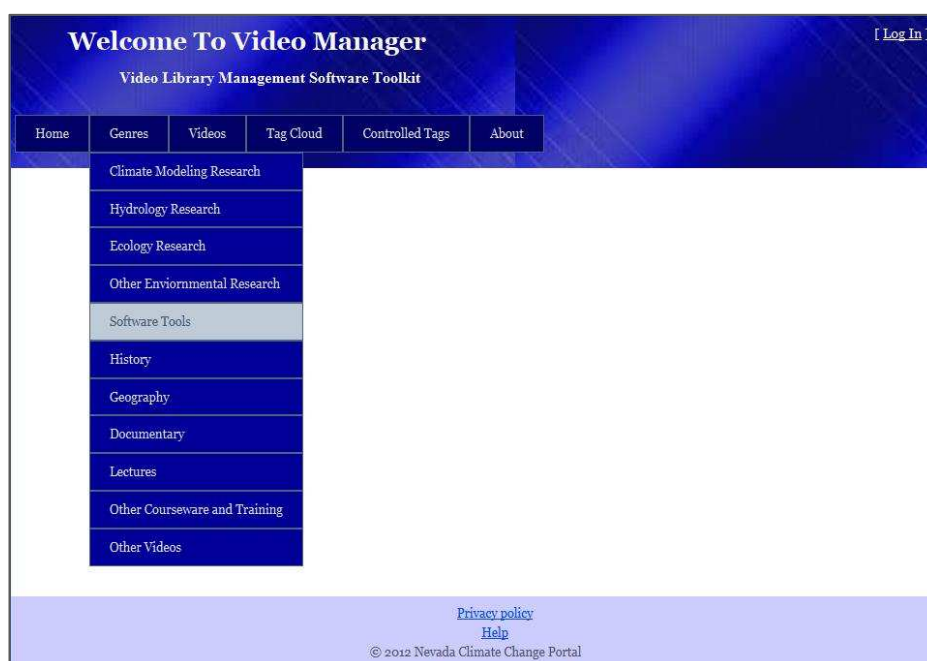


Figure 6.4: VLMST Tab Genres

Figure 6.5 shows a screenshot showing search results for genre *Software Tools*. A user can select a video genre from the *Genres* tab to display a list of related videos [4]. Similarly, as shown in Figure 6.7 and Figure 6.8, a user can select video categories such as most popular videos and recently added videos from the “categories” sub-tab (provided under the *Videos* tab) to display the list of videos corresponding to the search criteria.

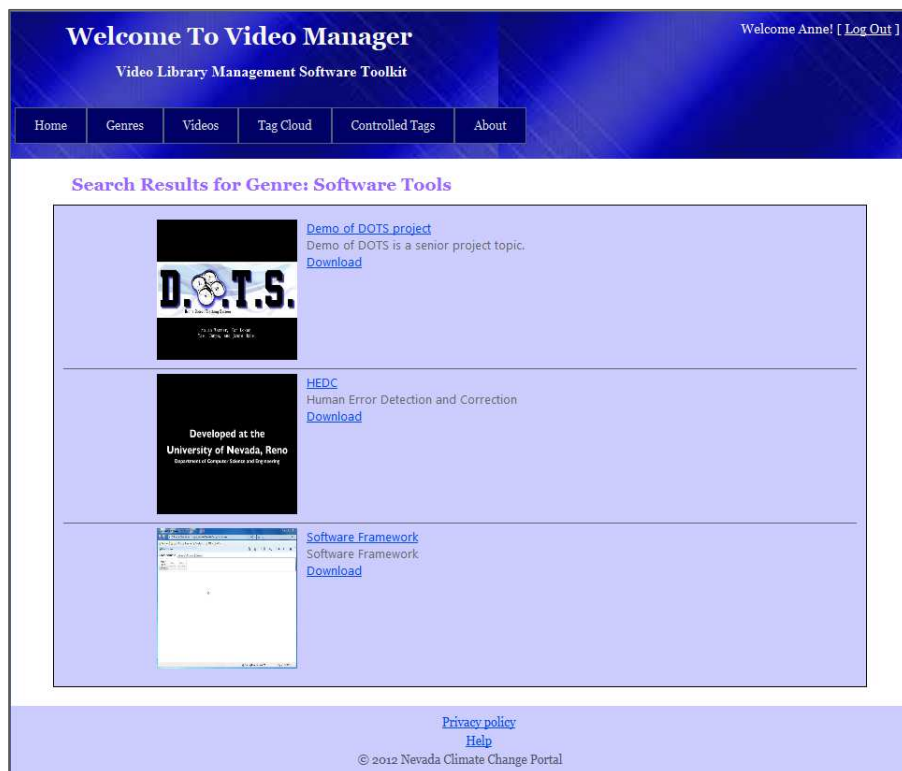


Figure 6.5: VLMST Search Results for Genre – *Software Tools*



Figure 6.6: VLMST Tab Videos

Welcome To Video Manager

Video Library Management Software Toolkit

[Home](#) [Genres](#) [Videos](#) [Tag Cloud](#) [Controlled Tags](#) [About](#)

[\[Log In\]](#)

Most Popular Videos



[Map View](#)
Map_View is one of the NCCP tutorial videos.



[GE Mobile Dashboard](#)
GE Mobile Dashboard project description is here



[Project video](#)
Project video



[Text View](#)
Text_View video description.



[Atmosphere Search](#)
Atmosphere_Search video description is here

Figure 6.7: VLMST Most Popular Videos

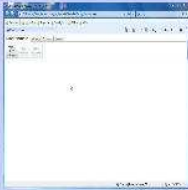
Welcome To Video Manager

Video Library Management Software Toolkit

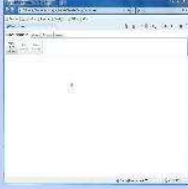
[[Log In](#)]

[Home](#) [Genres](#) [Videos](#) [Tag Cloud](#) [Controlled Tags](#) [About](#)

Recently Added Videos



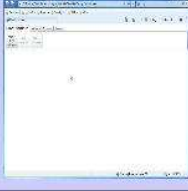
[test2](#)
test



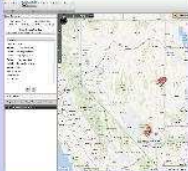
[Software Framework](#)
Software Framework



[Project video](#)
Project video



[Project video](#)
Project video



[Map View](#)
Map_View is one of the NCCP tutorial videos.

Figure 6.8: VLMST Recently Added Videos

Figure 6.9 shows a search results for selecting the *Tag Cloud* tab. A tag cloud is created by using an algorithm, in which the tags used frequently while uploading a video have been displayed with a larger font size, whereas the tags used less have smaller font size [27]. There are four font sizes defined in the CSS style sheet and are used in the algorithm to create a tag cloud. As shown in the figure, if a user doesn't select any tag from the *Tag Cloud*, there are no videos displayed on the page. After selecting the tag *NCCP* from the tag cloud, as shown in Figure 6.10, related videos are displayed on the page.

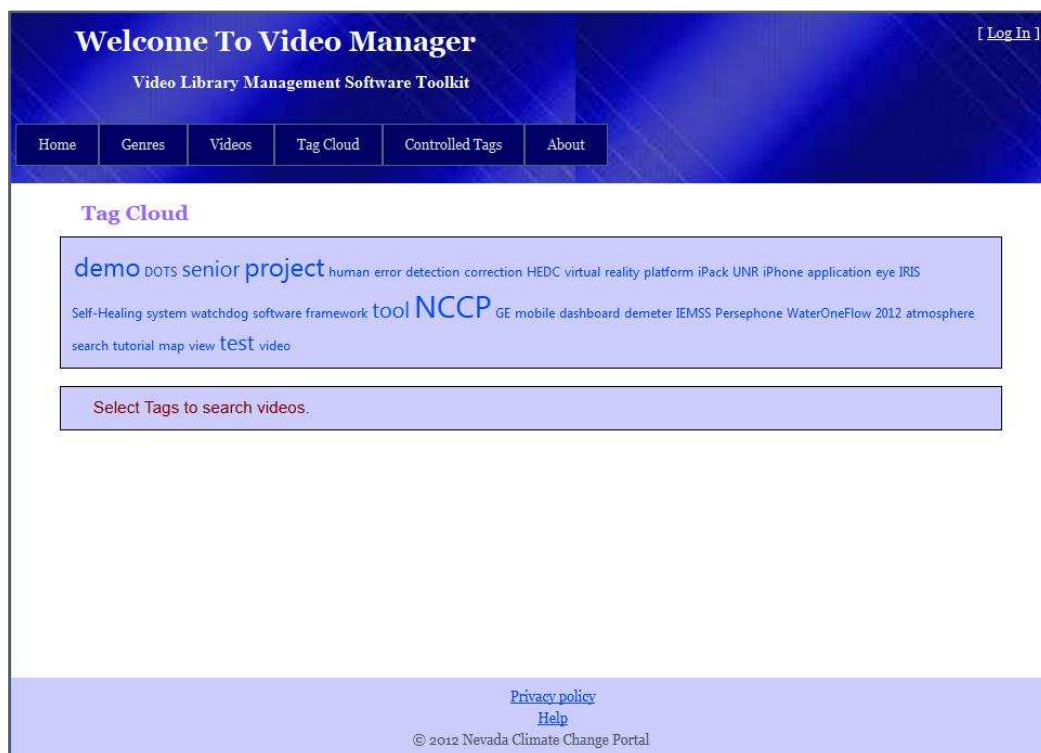


Figure 6.9: VLMST Tag Cloud

Welcome To Video Manager
[Log In]
Video Library Management Software Toolkit

Home
Genres
Videos
Tag Cloud
Controlled Tags
About

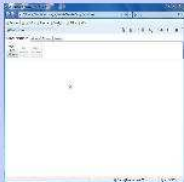


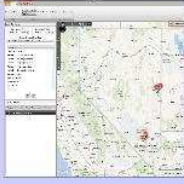
Tag Cloud

demo DOTS senior project human error detection correction HEDC virtual reality platform iPack UNR iPhone application eye IRIS

Self-Healing system watchdog software framework tool **NCCP** GE mobile dashboard demeter IEMSS Persephone WaterOneFlow 2012 atmosphere

search tutorial map view test video

Search Results for Tag: NCCP

	Software Framework Demo Software Framework Demo description is here
	Atmosphere Search Atmosphere_Search video description is here
	Text View Text_View video description.
	Map View Map_View is one of the NCCP tutorial videos.

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[Help](#)
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Figure 6.10: VLMST Tag Cloud Video Search Results for Tag - *NCCP*

The screenshot displays the 'Video Manager' web application. At the top, a dark blue header contains the title 'Welcome To Video Manager' and the subtitle 'Video Library Management Software Toolkit'. A '[Log In]' link is positioned in the top right corner. Below the header is a navigation menu with tabs: 'Home', 'Genres', 'Videos', 'Tag Cloud', 'Controlled Tags', and 'About'. The 'Controlled Tags' tab is currently selected, revealing a hierarchical tree structure of tags. The tree starts with 'Earth' at the top, which branches into 'Water' and 'Ecology'. 'Ecology' further branches into 'Ecosystem', 'Soil', and 'Climate'. 'Climate' is highlighted with a light blue background. Below 'Climate', there are three more tags: 'Water', 'Living Organism', and 'Energy'. At the bottom of the page, a light blue footer contains links for 'Privacy policy' and 'Help', along with the copyright notice '© 2012 Nevada Climate Change Portal'.

Welcome To Video Manager

Video Library Management Software Toolkit

[Log In]

Home Genres Videos Tag Cloud **Controlled Tags** About

Earth

Water

Ecology Ecosystem

Tools Soil

Others Climate

Water

Living Organism

Energy

[Privacy policy](#)
[Help](#)

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Figure 6.11: VLMST Tab Controlled Tags

When a user selects a controlled tag from the tab *Controlled Tags*, the related videos will be displayed. Figure 6.12 depicts the search results for the controlled tag *Climate* that is included in the controlled tag group *Ecology*. In particular, controlled tag groups and tags in VLMST are predefined to facilitate the users of the NCCP [23] to search videos more easily.



Figure 6.12: VLMST Search Results for Controlled Tag – *Climate*

Figure 6.13 depicts a screenshot showing a view video page for a non-logged-in user. When a user selects any video to play from a list of videos, the video is played in a HTML5 based video player. The page also contains a slider for recently added videos. The fields are displayed showing the name of the video uploader, as well as the total likes and views of the video. A comment field shows public comments on the video.

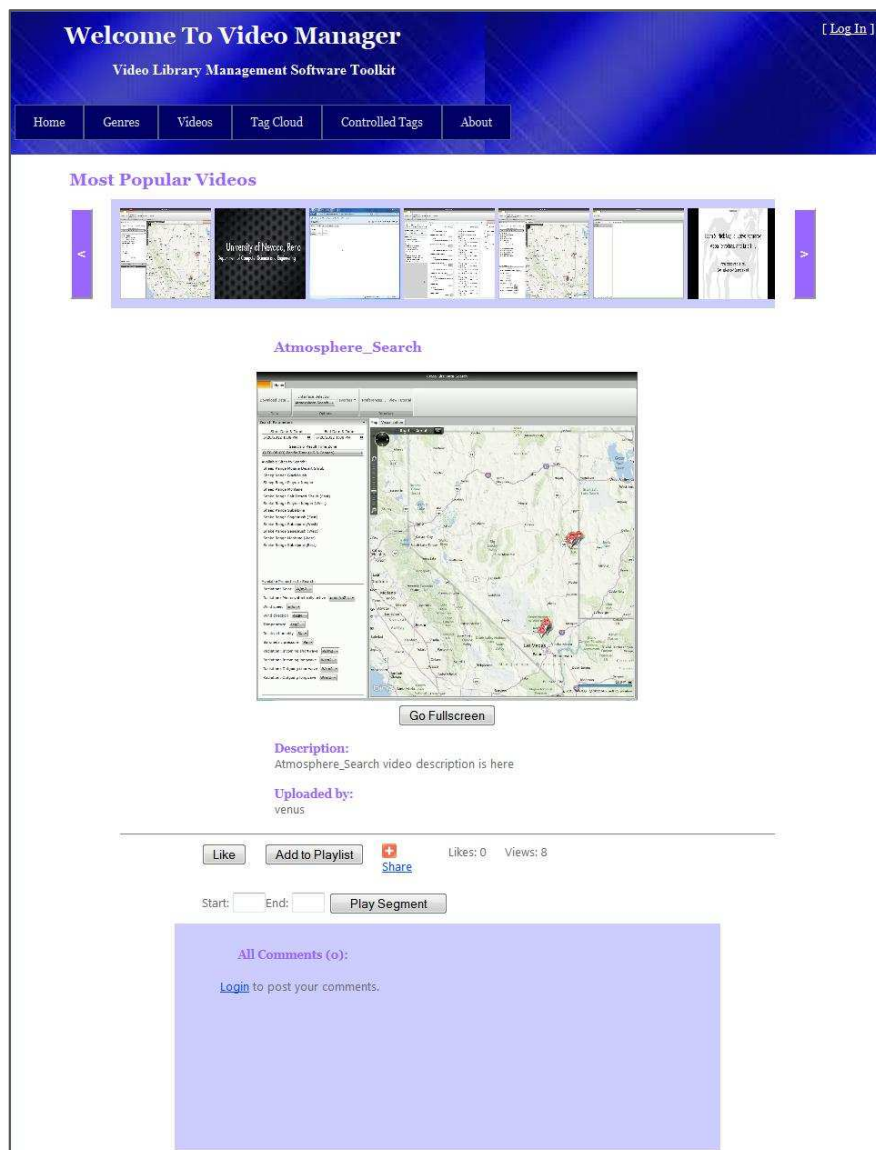


Figure 6.13: VLMST View Video Page for Non-Logged-In User

6.2 VLMST in Action for Logged-In Users

Figure 6.14 and Figure 6.15 depict an overview of a user registration to the VLMST system. As shown in Figure 6.14, a user details such as username, email, and password can be submitted by a user to get an account on the VLMST website. Figure 6.15 shows the errors that can occur during the user registration process and their associated messages, so that a user can correct the information provided. Figure 6.16 shows a screenshot of user Login process. Once a user completes the VLMST user registration, he or she can simply login to the system anytime with the user name and password that he or she provided during the registration.

Welcome To Video Manager [\[Log In \]](#)

Video Library Management Software Toolkit

Home Genres Videos Tag Cloud Controlled Tags About

Create a New Account

Use the form below to create a new account.

Passwords are required to be a minimum of 6 characters in length.

Account Information

User Name:

E-mail:

Password:

Confirm Password:

[Privacy policy](#)
[Help](#)
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Figure 6.14: VLMST User Registration

Welcome To Video Manager [Log In]

Video Library Management Software Toolkit

Home Genres Videos Tag Cloud Controlled Tags About

Create a New Account

Use the form below to create a new account.

Passwords are required to be a minimum of 6 characters in length.

- E-mail is required.
- Password is required.
- Confirm Password is required.

Account Information

User Name:
Anne

E-mail:

Password:

Confirm Password:

Create User

[Privacy policy](#)
[Help](#)

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Figure 6.15: VLMST User Registration Error

Welcome To Video Manager [Log In]

Video Library Management Software Toolkit

Home Genres Videos Tag Cloud Controlled Tags About

Log In

Please enter your username and password. [Register](#) if you don't have an account.

Account Information

Username:
Anne

Password:
••••••

☐ Keep me logged in

Log In

[Privacy policy](#)
[Help](#)

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Figure 6.16: VLMST User Login Page

Figure 6.17 shows a screenshot of the VLMST application's home page that is visible to logged-in users. Apart from the features accessible to non-logged-in users, logged-in users can also benefit from various other features from the VLMST homepage, such as downloading a video, uploading or deleting a video (if the user has uploaded the video to the repository). As shown in Figure 6.17, a logged-in user, *Anne*, has access to download links for the videos uploaded by other users. If she would have uploaded some of the videos, she could have an update and delete link for each of the videos she uploaded previously.



Figure 6.17: VLMST Home Page for Logged-in User

Figure 6.18 depicts a view video page for a logged-in user. A user is required to login to the system to perform advanced actions. The page contains some partial fields or templates such as a template below the video player that displays the name of the video uploader, as well as the total likes and views of the video. A comment field shows public comments and private comments (visible to an uploader or a commenter) on the video. The page also provides a feature to play and download a segment of a video by providing the required start and end time. A video segment can be replayed in the video player starting and ending at the times entered. If the start time is not provided then video will be played from the actual start time of the video, and similarly, if end time is not provided, the video will be paused at the actual end time of the video. For providing the start and end times, hours, minutes, and seconds are separated by a colon, e.g. 1:12:30. Users can also provide times in seconds only for a start or end time that is less than a minute, e.g. 30. The video segment can also be downloaded from the “download” link provided. A video segment is extracted from a video using FFmpeg [8]. Update and delete links are provided on the same page if a user is the uploader of a video that is being played at the time. At the bottom of the page, a slider showing a playlist of favorite videos (visible to logged-in users only) is displayed.

Welcome To Video Manager
Video Library Management Software Toolkit
Welcome Anne! [Log Out]

Home
Genres
Videos
Tag Cloud
Controlled Tags
About

Most Popular Videos

A

A

Atmosphere_Search

Go Fullscreen

Description:
Atmosphere_Search video description is here

Uploaded by:
venus

Like
Add to Playlist
Share
Download

Likes: 0
Views: 9

Start: End: Play Segment

All Comments (0):

☐ Post as a private comment. Post

Figure 6.18: VLMST View Video Page for Logged-in User

Figure 6.19 and Figure 6.20 present screenshots of comment fields showing, respectively, public comments, and all comments (including public and private comments) for a video. All the comments for a video will be seen only to the uploader and the commenters of the video, however all other users can see the public comments. A commenter should mark a check box provided while sending private comments.



The screenshot shows a comment section titled "All Comments (2):" in purple text. Below the title is a large white text input field with a small icon on the right. Underneath the input field is a checkbox labeled "Post as a private comment." followed by a "Post" button. Below this are two public comments: "good job!" by "venus" on "7/17/2012 9:49:56 PM" and "nice video" by "venus" on "7/17/2012 9:36:25 PM".

Figure 6.19: VLMST Public Comments for a Video



The screenshot shows a comment section titled "All Comments (3):" in purple text. Below the title is a large white text input field with a small icon on the right. Underneath the input field is a checkbox labeled "Post as a private comment." followed by a "Post" button. Below this are three comments: "good job!" by "venus" on "7/17/2012 9:49:56 PM", "what exactly is it about?" by "venus" on "7/17/2012 9:49:34 PM (This is a private comment)", and "nice video" by "venus" on "7/17/2012 9:36:25 PM".

Figure 6.20: VLMST All Comments for a Video

Figure 6.21 and Figure 6.22 present screenshots of the playlist slider. When a user doesn't choose a favorite video to add in a playlist, an empty playlist slider will be displayed, as shown in Figure 6.21, whereas if a user adds favorite videos to a playlist (by selecting "Add to Playlist" button on the page), a slider with all the selected videos will be displayed, as shown in Figure 6.22. A user can choose an option of hide or show playlist.

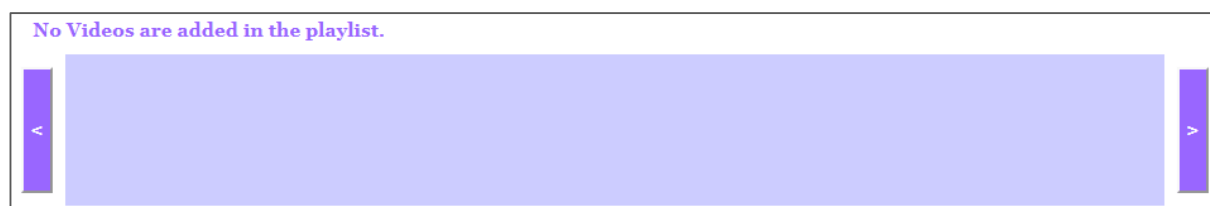


Figure 6.21: VLMST Empty Video Playlist



Figure 6.22: VLMST Video Playlist

When a user clicks on the link *Favorite videos*, the update playlist page will be displayed as shown in Figure 6.23, where a user can view a list of favorite videos, delete videos from a playlist, or share the playlist on various social networking websites such as Facebook, Twitter, and other. If a user chooses to delete a video from a playlist, a pop up window will be displayed to confirm the request, as shown in Figure 6.24. Figure 6.25 presents a screenshot showing a message when there are no videos in the playlist.



Figure 6.23: VLMST Update Playlist Page

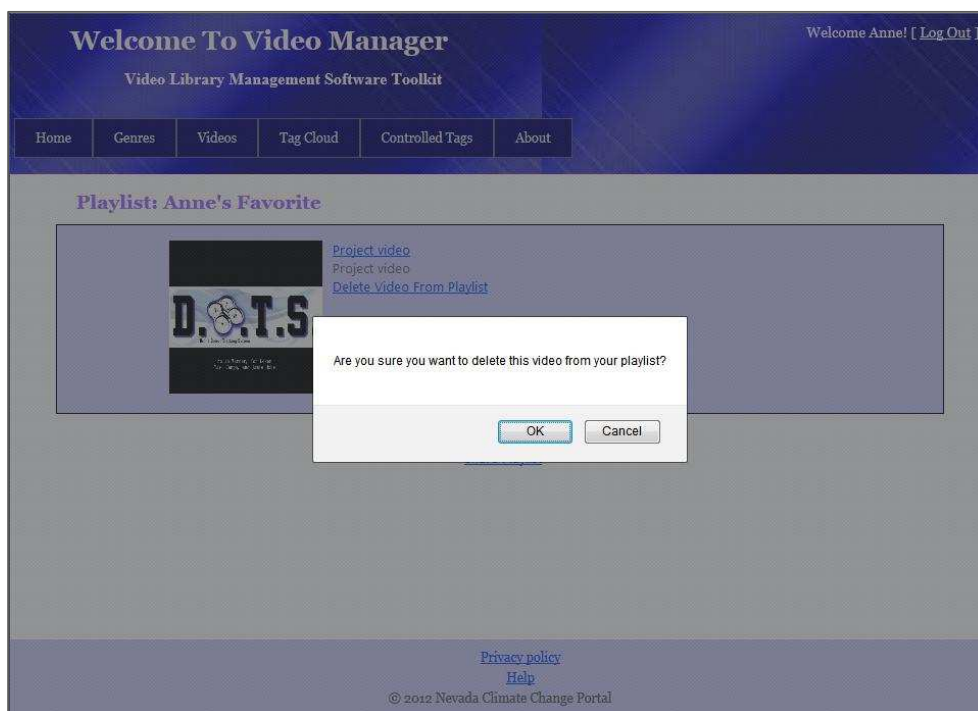


Figure 6.24: VLMST Video Delete Confirmation Dialog Box

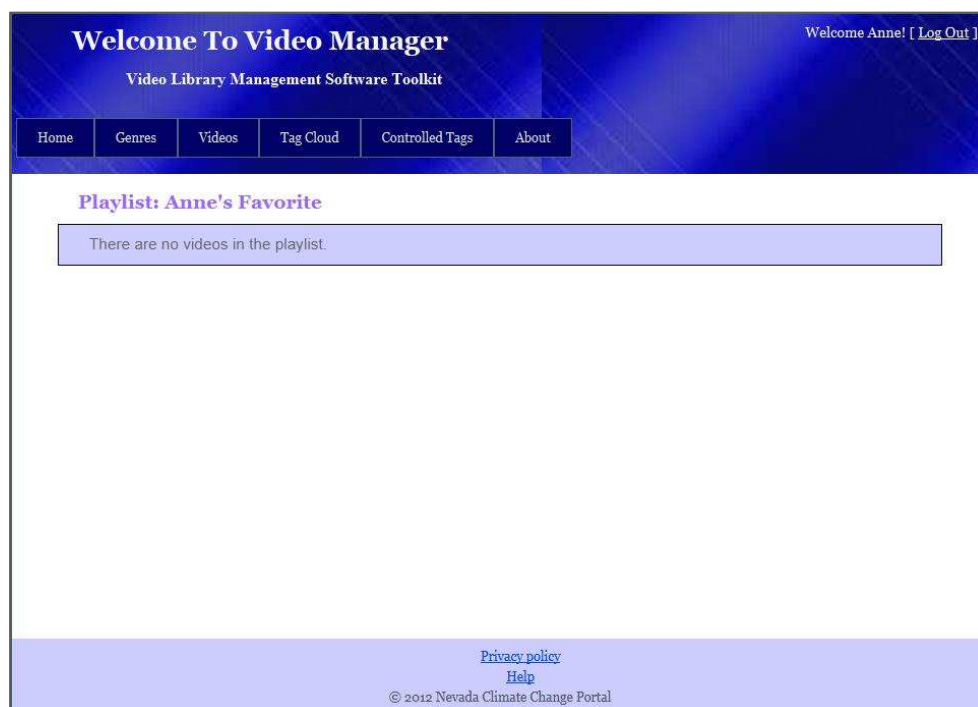


Figure 6.25: VLMST Video Delete Success Message

6.3 Video Management

If a non-logged-in user selects the option of “upload video” from the tabs provided, an error message will be displayed as shown in Figure 6.26, whereas a logged in user will be navigated to the upload video page as shown in Figure 6.27. After filling out all the details of a video, if a user selects a video with a file format other than flv, avi, mpeg, wmv, mp4, webm, mov, odd, 3gn, and asf, an error message will be displayed as shown in Figure 6.28.



Figure 6.26: VLMST Upload Video Non-Logged-In Error

As shown in Figure 6.27, while uploading a video a user should fill out all the details about the video, such as title, description, genre, controlled tag group, controlled tag, tags, and video file. When a video is uploaded successfully to the repository, a success message will be displayed as shown in Figure 6.29. FFmpeg [8] is used to convert supported input video formats to mp4 and webm formats, and to create thumbnails for the video. After video uploading a video, a user can choose the option to update or delete the video.

Welcome To Video Manager

Welcome Anne! [[Log Out](#)]

Video Library Management Software Toolkit

Home Genres Videos Tag Cloud Controlled Tags About

Video Details:

Title: Software Framework

Description: This is a demo video for software framework.

Genre: Software Tools

Controlled Tag:

Group: Tools

Tag: Software Framework

Tags: software, framework, demo, video

Video File: C:\Users\vector\Desktop [Browse...](#)

Upload

[Privacy policy](#)
[Help](#)
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Figure 6.27: VLMST Video Upload Page

The screenshot shows the 'Welcome To Video Manager' interface. The header includes the title 'Welcome To Video Manager' and 'Video Library Management Software Toolkit', along with a user greeting 'Welcome Anne! [Log Out]'. A navigation bar contains links for Home, Genres, Videos, Tag Cloud, Controlled Tags, and About. The main content area is titled 'Video Details:' and contains a form for uploading a video. The form fields are: Title (Software Framework), Description (This is a demo video for software framework.), Genre (Software Tools), Controlled Tag (Tools), Tag (Software Framework), Tags (software, framework, demo, video), and Video File (with a Browse... button). An Upload button is located below the form. A red error message box states: 'Please only upload files that end in types: flv, avi, mpeg, wmv, mp4, webm, mov, odd, 3gp, and asf. Please select a new file and try again.' The footer includes links for Privacy policy and Help, and a copyright notice for 2012 Nevada Climate Change Portal.

Figure 6.28: VLMST Upload Video Invalid File Format Error

The screenshot shows the 'Welcome To Video Manager' interface after a successful upload. The header and navigation bar are identical to the previous screenshot. The main content area displays a success message: 'File Uploaded Successfully' and 'SoftwareFrameworkDemo.flv has been converted to WebM and MP4'. A video player thumbnail is shown on the left, and the video title 'Software Framework' is displayed on the right, along with a description 'This is a demo video for software framework.' and links for 'Edit Video' and 'Delete Video'. The footer includes links for Privacy policy and Help, and a copyright notice for 2012 Nevada Climate Change Portal.

Figure 6.29: VLMST Upload Video Success Message

Figure 6.30 presents a screenshot showing the Video update page, where a video uploader can edit the video details and save it in VLMST repository. Figure 6.31 shows a success message displayed after updating a video. If a user (video uploader) chooses the delete option for a video, a confirmation pop-up window will be displayed as shown in Figure 6.32 and, after deleting the video, a delete success message will be displayed as shown in Figure 6.33.

Welcome To Video Manager
Video Library Management Software Toolkit

Welcome Anne! [[Log Out](#)]

[Home](#) [Genres](#) [Videos](#) [Tag Cloud](#) [Controlled Tags](#) [About](#)

Video Details:

Title:

Description:

Genre:

Controlled Tag:

Group:

Tag:

Tags:

Video File:

[Privacy policy](#)
[Help](#)
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Figure 6.30: VLMST Update Video Page

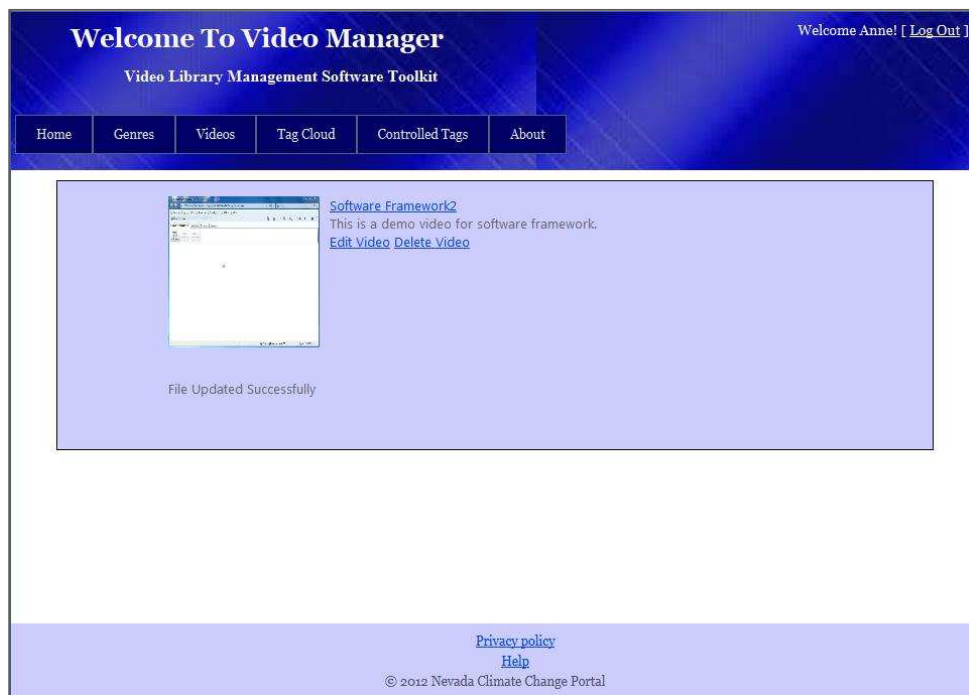


Figure 6.31: VLMST Update Video Success Message

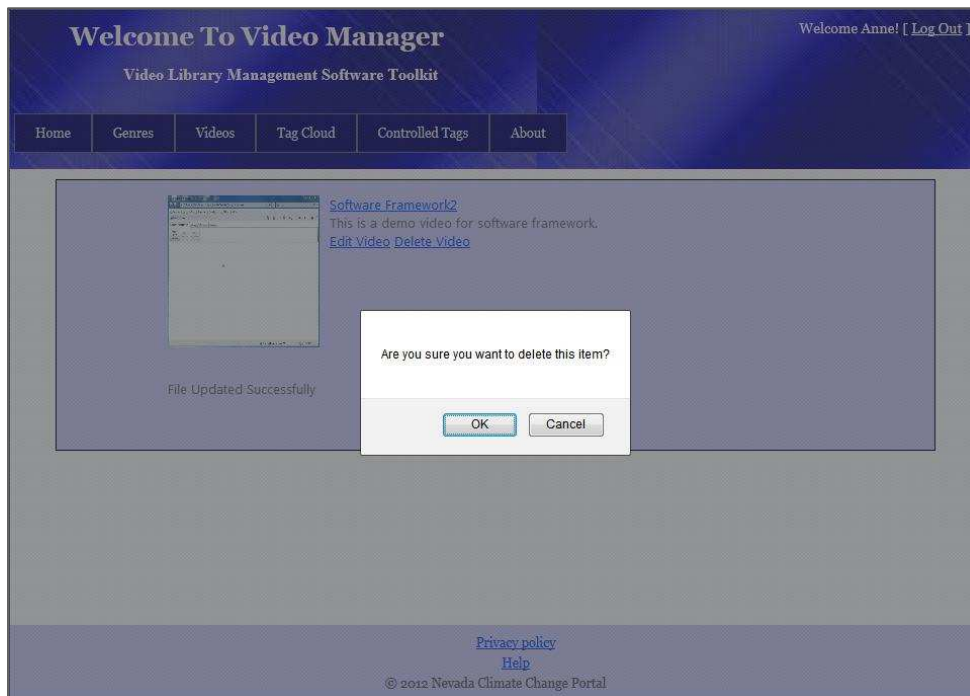


Figure 6.32: VLMST Delete Video Message



Figure 6.33: VLMST Video Delete Success Message

7 COMPARISON WITH RELATED WORK

This chapter gives an overview of the VLMST prototype as related to six other web-based video library management solutions, using a set of comparison metrics. The comparison is performed by indicating whether the VLMST and the given video-hosting environments possess the following set of features:

- | | |
|-----------------------------|------------------------------|
| 1. Video Search | 7. Public Video Comments |
| • Search by Keyword | 8. Private Video Comments |
| • Search by Genre | 9. User Feedback |
| • Search by Video Category | 10. Video Sharing |
| • Search by Tag Cloud | 11. Play Segment |
| • Search by Controlled Tags | 12. Download Segment |
| • Search by User Categories | 13. Create Playlist |
| • Search Using Filter | 14. Manage playlist |
| 2. Video Upload | 15. Share Playlist |
| 3. Video Update | 16. Privacy |
| 4. Easy Video Download | 17. Video Slider |
| 5. Video Delete | 18. HTML5-based Video Player |
| 6. User Accounts | |

Table 7.1 depicts an overview of the comparison using the features provided by VLMST and other video-hosting solutions, whereas Table 7.2 presents an overview of supported input video formats for VLMST and other video-hosting environments.

Table 7.1: Features Comparison

		Software Tools						
		VLMST	YouTube	Yahoo Screen	Vimeo	Blip	DailyMotion	Metacafe
Features	Video Search by Keyword	✓	✓	✓	✓	✓	✓	✓
	Video Search by Genre	✓	✓	✓	✓	✓	✓	✓
	Video Search by Video Category	✓	✓	✓	✓	✓	✓	✓
	Video Search by Tag Cloud	✓	✓					
	Video Search by Controlled Tags	✓						
	Video Search by User Category		✓		✓	✓	✓	✓
	Video Search Using Filter		✓	✓	✓	✓	✓	✓
	Video Upload	✓	✓		✓	✓	✓	✓
	Video Update	✓	✓		✓	✓	✓	✓
	Easy Video Download	✓						
	Video Delete	✓	✓		✓	✓	✓	✓
	User Accounts		✓	✓	✓	✓	✓	✓
	Public Video Comments	✓	✓	✓	✓	✓	✓	✓
	Private Video Comments	✓						
	User Feedback	✓	✓	✓	✓	✓	✓	✓
	Video Sharing	✓	✓	✓	✓	✓	✓	✓
	Play Segment	✓	✓					
	Easy Download Segment	✓						
	Create Playlist	✓	✓		✓		✓	✓
	Manage Playlist	✓	✓		✓	✓	✓	✓
	Share Playlist	✓	✓		✓	✓	✓	✓
	Privacy		✓	✓	✓	✓	✓	✓
	Video Slider	✓	✓					
	HTML5 based Video Player	✓	✓		✓	✓	✓	

Table 7.2: Supported Input Video Formats

		Software Tools						
		VLMST	YouTube	Yahoo Screen	Vimeo	Blip	DailyMotion	Metacafe
Supported Input File Formats	MPEG	✓	✓	✓	✓	✓	✓	✓
	MOV	✓	✓	✓	✓	✓	✓	✓
	WMV	✓	✓	✓	✓	✓	✓	✓
	AVI	✓	✓	✓	✓	✓	✓	✓
	MKV		✓		✓		✓	✓
	MP4	✓			✓		✓	✓
	MOD				✓	✓		
	ASF	✓		✓	✓	✓		✓
	Ogg	✓			✓	✓	✓	
	3GP	✓	✓	✓	✓	✓	✓	✓
	WebM	✓	✓					
	FLV	✓	✓		✓	✓	✓	✓
	Divx						✓	✓

As it can be seen, while there are still many enhancements needed for VLMST, both its sets of features and supported formats compare well with other related video library software tools. We note however that VLMST, developed as a university project by a single person, is only a proof-of-concept prototype that exposes some novel features but it doesn't have the strength and scope of other video library toolsets on which many software engineers have worked.

8 FUTURE WORK

This chapter outlines several directions for future work for VLMST, beyond the research and development done for this thesis. One of the possibilities for extending the functionality of the VLMST is to upgrade the major features that comprise the innovative aspects of this software toolset as well as the user interface for example by making use of JavaScript and AJAX.

Various commonly used features provided by other video library systems can also be added to the system, such as using a filter option to narrow the search results, allowing users to select a video thumbnail from multiple options while uploading a video, enabling users to create a number of playlists of videos, and allowing users to create user accounts and thus to search videos by a video uploader's name. Along with the extensibility, maintaining prohibition of controversial content in the videos will also be an important feature (and one of the main challenges) that can be considered as a part of future work.

The browser compatibility can be increased by allowing the system to support older versions of browsers. In addition to that, the most important work that will be achieved is to integrate and deploy VLMST solution on the NCCP. These challenges will be encountered during the enhancement phase of VLMST's development, which is in beyond the frame of this thesis work. The requirements of the NCCP will also be considered for the development of further VLMST features to mitigate the complexity those features might introduce in the system.

9 CONCLUSIONS

This chapter summarizes the research done and development efforts made for the VLMST solution designed and developed as part of this thesis work. Naturally, VLMST is not as strong or widespread as the solutions that it has been compared with and many other video library management toolkits, but VLMST provides basic applicability to manage a library of videos, along with providing some innovative features such as writing private comments for a video, easy video segment download, in-built controlled tags to search videos, and other. VLMST also provides several search criteria such as video search by keyword, genre, tag cloud, category, controlled tag (as mentioned before), as well as it provide a slider of most popular videos in the library. In this way, VLMST helps users to search videos easily and efficiently. Being an open and shared video library, VLMST provides an easy video download feature to any logged-in user, and videos and a video playlist can be shared through various social networking websites. There are many video library tools present on the market, (and we survey some of them), but VLMST has been designed and developed considering the specific requirements of the NCCP data portal, and will be integrated seamlessly with the portal to enhance the users' experience and communication within the Nevada's climate change data portal. Along with common features to manage a video library, VLMST also provides several innovative features that make it a novel video library management solution.

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