Interim Report

SoftVCR for Windows

Providing a Software Solution to Consumer Video Recording

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1 Introduction

The way media is delivered to us is current undergoing a rapid transformation. Traditional methods of delivery such as newspapers, radio and television are now competing with the Internet and broadband digital channels. As of January 2000, there were an estimated 70 million hosts connected to the Internet, an increase of 50% over the previous 12 month period[1]. This growing resource is beginning to be recognised as an important medium by many traditional media companies, a good example being Time Warner and their recent merger with the Internet provider AOL.

One of the key features of this revolution is the blurring of distinction between traditional media appliances such as televisions and radios, and IT appliances such as computers. As personal computing power has increased, it has now become possible to play high quality video and audio on your desktop while checking your email via your television. This trend is set to continue as broadcast networks such as cable, satellite and terrestrial are upgraded to increasingly integrated digital platforms.

This project concentrates on the area of consumer video recording. This has traditionally been dominated by the use of VHS videotape for delivering pre-recorded media and recording facilities in the home. Digital Versatile Discs (DVDs) have already penetrated the pre-recorded market with great effect, but video recording has yet to find a suitable solution outside of the analogue world.

The aims of this project are to examine the current technologies available for delivering digital video recording to the consumer and then provide an implementation of a possible software solution. In particular, we will examine the possibility of integrating external sources of information to provide a fully intuitive product. Also, we will examine how the presence of permanent network connections can be utilised to create distributed access to the video recorder.

Current video capturing packages suffer from a lack of intuitiveness. This project will concentrate on the task of using your computer as you would your home VCR. This would mean that the technical aspects of video capture should be hidden or masked from the user to provide a simpler interface. Extra functionality could be provided to make the recording experience more productive such as programme guides and storage options. The specification will expand on the areas of investigation.

[1] Source: Netsizer report on the growth of the Internet. http://www.netsizer.com/daily/table.html

2 Specification

The solution will involve the following elements:

1. A SOFTWARE VIDEO RECORDER capable of capturing and playing back clips from a TV tuner or video source.
2. A VIDEO LIBRARY capable of viewing and managing the clips recorded with the video recorder. This will include functions for disk space management and possibly categorisation.
3. AN ELECTRONIC PROGRAMME GUIDE (EPG) with the ability to acquire its information from a variety of sources.
4. A RECORDING TIMER capable of taking input from the EPG or from direct user parameters.
5. REMOTE ACCESS to the above features via a suitable mechanism. Basic features should allow setting of timer and management of files in library. Ability to stream video to remote location should be provided.

Overview

The platform for the practical deliverable will be Windows NT 4.0 (as installed in the CSG lab) with additional support for Windows 98. The remote access elements of the product shall be developed with the assumption that a permanent Internet connection is present.

The interface to any of the below features should be designed with a novice user in mind. Interface designs should be tested on a range of users. More on HCI will be mentioned in the Evaluation Plan below.

2.1 Software Video Recorder

The video recorder must perform the basic functions of a standard VCR such as Play, Fast Forward, Rewind, Channel Selection, Record, Pause.

The video recorder must support the Hauppauge WinTV PCI video capture card as provided by CSG. Channel setup should support the tuning and channel selection capabilities of the TV tuner. Support should also be offered for any external tuners such as satellite boxes connected to any video input on the capture board. Preview and playback of video clips and live material should be provided at the capture resolution in a window, or full screen.

Real time compression should be used to keep disk space consumption to a reasonable level. Investigation into what a reasonable level is will be required. Offline compression should be applied to recorded material to reduce file sizes further.

The user should not have to specify exact parameters for video capture quality. Parameters such as frame size, frame rate, codec used, codec quality settings should be grouped into presets based on output quality and space required. The user will then need to select the desired quality. The analogy of Standard Play and Long Play could be applied to aid the mental model.

2.2 Recording Timer

The video recorder must include a function for setting a number of timers for recording specific programs. The timer should be set by either directly selecting start and end times and the channel or by selecting a program from the EPG (described below).

The timer must check if the user has enough disk space to record the selected items using the settings provided and make a suggestion to the user to try a lower setting or delete some other files.

With the program running in background on the users desktop, the timer should start the recording process based on selected or default recording preferences automatically. No user intervention should be required. If source for recording is an external set top box, then an option should be provided for reminding the user to set the channel on the box.

2.3 Video Clip Library

The library should provide a complete summary of the clips that have been recorded by the video recorder. Details to display include title, source channel, original broadcast time and duration.

Provision for disk space management should be provided. Space left on hard drive should be represented as recording time remaining based on the quality presets selected. Clips should be able to be deleted from the library. Facilities for recompressing a file with a different codec or quality setting should be provided for archiving clip.

2.4 Electronic Programme Guide

The EPG should provide listings for selected channels so that the user can select what program to watch or record from the guide. The source for listings should include TV listing web sites.

Each programme is defined by a start time, title, channel, description. Any other details should be made available via web links to the listing source website.

Listings should be cached on the users machine for as long in advance as the source can provide them. This should nominally be one week. This is to minimise the time needed for a user to remain on line if he/she does not have a permanent connection. Other features may rely on the presence of a permanent connection though.

Issues of content copyright must be addressed. Providing links to the listings source website and including logos may be necessary.

2.5 Remote Access

Assuming that the users computer has a permanent network connection, provision should be made to access functions of the application over the network on a remote terminal.

Ideally, this includes access to the timer functions, EPG and library along with the ability to view recorded clips using a suitable streaming media format. Optionally, the ability to watch the live source channel should be provided.

Access should be restricted to the user himself, no public access should be allowed to avoid issues of broadcast copyright. The program should therefore require the user to log in to the application.

The user should require the minimum of specialist software on the remote computer to access the material. Ideally, an up to date web browser should suffice.

3 Background

With the area of Digital Video in a state of rapid transformation, it has become clear from an early stage that new products and technologies are appearing constantly. There are currently a range of hardware and software solutions that are aimed at differing types of users. Many of these products are based on a common set of technology standards, such as the MPEG compression standard. A number of these products and technologies will now be discussed. The technologies that have been proposed in the specification will also be described.

3.1 Video Capture Cards

The project specification states that it will be based around the popular Hauppauge Win/TV video capture cards. These boards incorporate on-board TV Tuners and video capture hardware into an affordable package. The reason for its selection is due to its availability within the Department of Computing, however it should be noted that other cards are becoming available. We begin by looking in detail at the Hauppauge card.

3.1.1 Hauppauge Win/TV

Hauppauge manufacture a range of multimedia cards based around the Brooktree BT848 PCI Video Capture device[1][2]. Their cards, in general, integrate a region specific TV tuner, with a high quality video capture device. This allows the user to view live television and video on a standard desktop computer. The cards contain a number of useful features:

- Teletext: All the boards feature the ability to decode Teletext information for use in any application.
- PCI Bus Master: The board operates as a PCI Bus Master, therefore providing the ability to perform basic capture and video display without the need for CPU resources. The data is simply transferred directly across the PCI bus to the relevant device.
- Full frame capture: The device can capture video at up to full PAL resolution (758x576) at 25 frames per second. Full performance is dependant on the speed of the host computer but frame size can be scaled in hardware.

- Colour Format: A number of colour formats can be provided directly by the hardware including a extensive selection of RGB and YUV formats.
- DirectX and VFW: Drivers operate through fully compliant DirectX and Video For Windows (VFW) interfaces, allowing integration into any external application. Control of the tuner can be achieved through the Hauppauge SDK.
- Audio: Audio is available via dedicated outputs on the board. These can be connected to the host computers sound card for inclusion with the captured video.

Hauppauge estimate that they have an installed user base of 1 million users [1], making it the most popular retail TV card range currently available.

The software provided with the cards allows provides video capture capabilities, but does not support any type of compression. The result is that captured files can be extremely large and unsuitable for a consumer video application.

For external developers, Hauppauge provide a Software Development Kit (SDK) to access features not available through Video For Windows or DirectShow. In particular, features such as Tuner Control and Image Capture can be added any applications made in C++, Visual Basic or even HTML.

3.1.2 ATI All-In-Wonder [3]

The ATI All-In-Wonder video card is one of the first generation of a fully integrated desktop video solution. It combines the traditional functions of a VGA card with advanced TV tuner and video capture functions. Of particular interest is the ability to capture and record real-time MPEG2 video, thus making a substantial saving on capture file size whilst maintaining a decent level of quality. Here is a summary of its capabilities:

- 128 bit 2D/3D graphics
- Video input
- Video output
- TV-Tuner
- Hardware DVD Playback
- Video Editing
- Real-time MPEG Video Encoding

3.1.3 Matrox Marvel G400 TV [4]

This is another recent entrant into the fully integrated multimedia card market. As with the ATI card, it combines a VGA card with a TV Tuner and video capture hardware. It also provides hardware video compression in the form of Motion-JPEG. This provides a high quality source of video, but at a higher bitrate than MPEG2. The package is supplied with a software only MPEG2 transcoder for converting its own files to MPEG2, but this is provided at the expense of speed.

3.1.4 Pinnacle Systems Studio Family [5]

Pinnacle Systems manufacture a range of dedicated video capture cards aimed at differing segments of the market:

- Studio DC10 Plus: PCI MJPEG capture device with composite and S-video inputs. Maximum resolution of 640x480.
- Studio 400: Parallel port low resolution Intel Indeo capture (160x120).
- Studio MP10: Parallel port MPEG 1 codec and video capture. Maximum resolution of 352x240.

These devices are primarily aimed at capturing short clips for creating presentations and sending emails.

3.2 Current Software VCR Applications

Many of the above hardware devices are provided with their own video capture application. These range from complete video editing programs to VCR programs that utilise the specific hardware available to them. There are, however, an increasing number of stand alone applications becoming available which offer digital VCR facilities.

3.2.1 Cinax WinVCR [6]

Released in August 1999, this product is an MPEG based software VCR. The MPEG codec is licensed from Ligos Technologies [7] and implements the MPEG 1 CPB standard allowing 30 frames per second recordings at 352x288. It has the following features:

- Utilises latest MPEG technology from Ligos.
- Works in Windows 95 OSR2 and Windows 98 (not NT compatible).

Figure 3.1: Sceenshot from Cinax WinVCR

- Constructed on DirectX Media 6.0 .
- Supports a number of TV Tuner boards.
- Real Time MPEG encoding requires a 300MHz Pentium or faster.

This product does not include any library functions for organising recorded clips. Nor does it utilise any Electronic Programme Guide for setting the timer.

Cinax have recently licensed WinVCR to Hauppauge for bundling with their new range of TV Tuner boards. By not using the more processor intensive MPEG2 technology, WinVCR keeps the hardware requirements at a reasonable level so that a larger percentage of end users can utilise the product.

Personal testing of WinVCR on a Windows 98, Hauppauge WinTV machine revealed problems with the installation of the product. Installation corrupted the WinTV drivers resulting in the failure of Hauppauge software. The only remedy was a complete reinstallation of the WinTV drivers and removal of WinVCR. This problem was reported to Cinax technical support.

3.2.2 MGI Pure DIVA [8]

This product utilises Intel Pentium III SIMD technology to deliver an MPEG2 based video recorder. It was debuted at the E3 show in Los Angeles in May 1999 as a complete

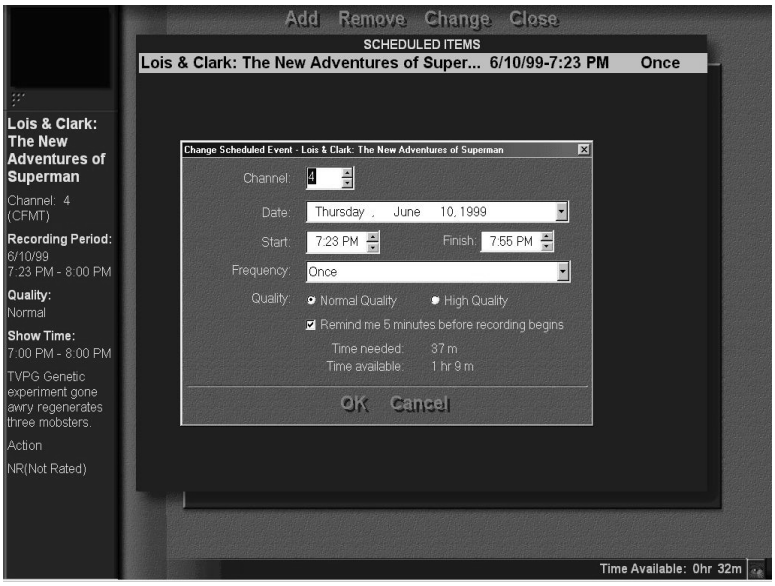

Figure 3.2: Programming the scheduler in MGI Pure DIVA

entertainment product featuring:

- TV Viewing
  - Time Shift technology allows a live program to be paused, rewound and replayed.
  - Pan and Zoom functions while watching a live program
- Video Recording
  - Video can be programmed via Internet updateable Electronic Program Guide
  - Bookmarks can be placed anywhere in video
  - Library functions for organising and deleting recorded clips
- DVD Mode
  - Allows playback of DVD videos
- CD Mode
  - Allows playback of normal audio CDs

Such features require a very powerful desktop computer and the minimum specification is a 500MHz Pentium III. This product is only available through OEM licensing so the

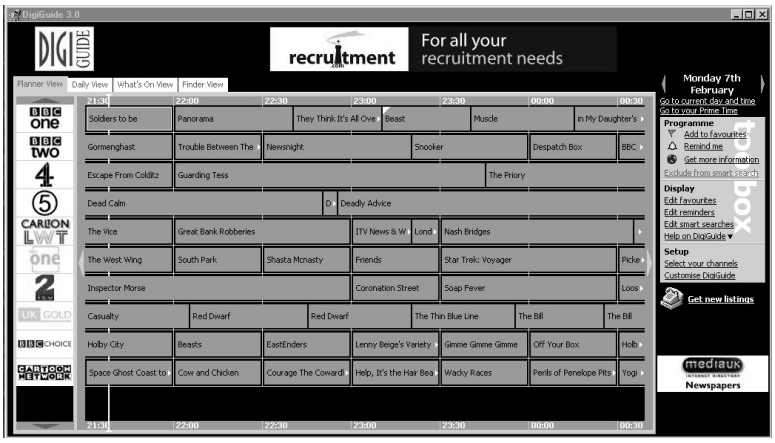

Figure 3.3: Planner View in DigiGuide

only way to obtain a copy is to buy a new computer that is bundled with the software. There are no demonstration versions available for evaluation.

The Electronic Program Guide(EPG) is updated via the Pure DIVA website. The default recording resolution is 352x480 at 6 Mbps with 176KBps audio. This is used for both time shifting and recording. If the user wishes to record only, then a resolution of 720x480 can be achieved.

For future versions, MGI are looking into providing access to different EPGs. They also plan to add editing functions and support for other multimedia formats such as MP3.

3.3 TV Listing Sources

3.3.1 DigiGuide [9]

DigiGuide is a TV listings application that provides access to most UK terrestrial and satellite channels. It works by downloading proprietary data at regular intervals (once a week) on the channels you select. The data is displayed as a list for each channel showing the time, name and description, or as a daily planner comparing all your channels across a horizontal timeline (see Fig. 3.3).

DigiGuide is free to download and use; their financial revenue is generated via adverts displayed in the application and merchandising links on the website and application.

The application includes a number of features for making listing navigation easier and more useful:

- Reminders can be set to provide visual warnings on when programmes are about to start.

- The user can elect favourites so that users can see at a glance when a programme is on.
- Smart searches allow complex queries to be entered based on channel, category of programme and a search string.
- Clicking on "Get More Information" spawns a web browser to open a page in their www.tvlibrary.co.uk website providing more information about the programme as well as site and merchandising links.

3.3.2 Website Listings

A popular source of TV listings information is the World Wide Web itself. Many websites exist that provide comprehensive listings and information on a multitude of terrestrial, satellite and cable channels and all their regional variations. Many of these sites are run by traditional listings sources such as:

- Radio Times: http://www.radiotimes.beeb.com
- Cable Guide: http://www.cableguide.co.uk
- Teletext: http://www.teletext.co.uk

Structure

The common factor between these listings sites is the HTML language that they are written in. HTML is a tag based hierarchical language and describes how a page should be displayed in terms of headings, bodies, tables, frames, etc. Listings in all of the above websites are displayed using tables. As tables are split into cells, this makes it relatively easy to isolate different types of information depending on the cell being looked at. For example, the following is an edited example of a line from the radio Times website:

```
<TR>
    <TD><IMG SRC="film.gif"></TD>
    <TD><FONT><SPAN>23:45</SPAN></FONT></TD>
    <TD><FONT><SPAN><B><A HREF="programme details"><IMG SRC="arrow.gif">
    Every Home Should Have One </A></B></SPAN></FONT></TD>
    <TD></TD>
    <TD></TD>
</TR>
```

Here, the second cell contains the start time of the programme. The third cell contains the name of the programme and also a link to display more information on the programme. The other mentioned websites are simple variations on this structure and also supply the descriptions for the programs in the listings instead of having to get another page.

The benefit of this structure is that it would be straightforward to write a routine for extracting the programme information based on navigation of the table structure.

Getting The Right Information

These websites use server side programming to extract information from a database. A side product of this method is that the URL for each page contains the exact parameters to construct the necessary query. For example:

```
http://www.cableguide.co.uk/bread/go?
date=17/01/2000&time=03%A00&theme=&alias=8&type=list
```

This is the Cable Guide URL to get the listing for the next six hours from 3AM on BBC2 (alias 8) on 17th January 2000.

3.4 Programming Technologies

The specification states that this project will be based on a Microsoft Windows 98/NT4 platform. Display and Audio technology has come a long way from the monochrome CGA graphics and PC Speaker of early home PCs. To begin with, application developers would write code themselves to support different makes of multimedia devices. As the number of devices grew, it became clear that it was unfeasible for application developers to support them all and maintain their code. To that end Windows removed that hardware dependence by creating a uniform programming interface to hardware. For graphics programming, this abstraction was known as the Graphics Device Interface (GDI). Hardware manufacturers would then write device drivers to provide the hardware layer programming.

Different layers of abstraction now exist for the different services required by modern computers. Many of these are captured by the DirectX family of APIs [10]including the one of most relevance to this project, DirectShow.

3.4.1 Quicktime for Windows

Before discussing DirectShow, it is relevant to mention an alternative architecture, Quicktime for Window (QTW). Quicktime is the video environment developed by Apple for their Macintosh platform. It was initially ported over to Windows to enable playback

only of QTW videos. As of version 3.0, the ability to edit and capture Quicktime videos under Windows had been added. Quicktime is favoured by many over Video for Windows (discussed below) as it has better overall performance and better synchronisation methods than VFW.

A notable feature of early QTW is that it provides its own device level drivers, bypassing the GDI and therefore improving performance. Newer versions now use DirectDraw (discussed below) to achieve similar performance.

3.4.2 DirectX and DirectShow

DirectX was developed by Microsoft to provide device independent access to a number of services. These are split into two layers, known as DirectX Foundation and DirectX Media. DirectX Foundation provides the low level access to devices:

- DirectDraw: API for accessing graphics devices
- Direct3D: API for accessing 3D graphics devices
- DirectInput: API for accessing input devices such as Joysticks
- DirectSound: API for accessing audio devices
- DirectPlay: API for providing network gaming functionality
- DirectMusic: API for providing Musical services such as MIDI

DirectX Media Adds the following services:

- DirectAnimation: API for supporting different media types such as vector graphics, sprites and images.
- DirectX Transform: API for creating transforms to applying space and time effects to 3D objects.
- DirectShow: API for capturing and playing back multimedia streams (such as Video and Audio) from local files and the Internet

At the time of writing, Microsoft have announced that DirectX Media will no longer be developed as a separate product to DirectX Foundation and will be integrated into the upcoming DirectX 8.0. The last version of DirectX Media (and the one used for this project) is version 6.0.

DirectShow has its roots in Video For Windows (VFW). Video For Windows provided Windows with the ability to capture and edit video. It catered for different methods of compression and spurred the development of codecs such as Intel Indeo and Cinepak.

The initial release was flawed by inadequate audio and video synchronisation and poor overall graphics performance. Next came ActiveMovie, which addressed the synchronisation problems and added support for the MPEG standard. Finally, ActiveMovie was superseded by DirectShow, which is integrated with the DirectX SDK and supports new media sources such as the Internet.

DirectShow is implemented as a collection of standard Component Object Model (COM) interfaces which can be implemented or called by any compatible application.

3.5 Compression Technologies

As mentioned above, Video for Windows spurred the creation of several codecs by third parties. The most popular of which are Intel's Indeo software (now at version 5.1) and Radius Cinepak[13].

3.5.1 Intel Indeo Software [12]

Indeo was originally developed to provide constant bitrate video compression for delivery via CD-ROM. It is optimised to take advantage of features only found in Intel's range of processors and is only found on Windows computers.

The latest version of Indeo (Version 5.1), is specifically designed to take advantage of MMX and Pentium II technology. Indeo 5.1 features a wavelet compression algorithm, which is intended to improve video quality over previous versions. It also support Progressive Download, a feature of DirectShow which is intended to provide scaleable video at real time over networks.

Indeo provides two versions of its codec; the first is called a Quick Compressor. As the name suggests, it provides a means to compress a video stream quickly, mainly for prototyping and capturing. In tests, a Pentium II 350MHz can capture SIF (352x240) at 25fps in real time without problems using the Quick Compressor. The second is the standard codec. It produces higher quality, lower bitrate video but at the expense of processing speed.

3.5.2 MPEG [14]

MPEG stands for Motion Pictures Experts Group. MPEG has become increasingly popular and is now the platform for video and audio compression in Digital Video Broadcasting (DVB) worldwide. MPEG1 was used in the original Video CD format and MPEG1 Audio Layer 3 has become synonymous under its other name, MP3. MPEG2 is the standard that was created for DVB and provides a number of profiles and levels to cater for different delivery methods. Digital Versatile Disc (DVD) Videos use a subset of MPEG2.

Although MPEG1 can theoretically be applied to video streams at 4095x4095 and over 100Mbps, the most common implementation is 352x240 at 30fps (known as SIF (Source Input Format), also restricted to bitrates of 1.86Mbps or less. This combination is commonly know as Constrained Parameters Bitstreams.

MPEG2 expands on this to provide various levels for different application. For example, the most common are:

- SIF at 352x240 30fps. Known as Low Level (LL)
- CCIR 601 or 720pixels per line, 480 lines (NTSC) x 30fps. Known as Main Level (ML)

MPEG decoders are freely available with Windows for use in DVD playback applications and network video applications. MPEG coders are available, but normally incur higher costs due to their complexity. Until recently, MPEG encoding was restricted to dedicated hardware (such as the Pinnacle Studio MV10, above), but processor speeds and features are now allowing software coders to emerge such as the Ligos GoMotion codec [7] used in WinVCR [6] and Pure DIVA [8].

3.5.3 Streaming Media

The Internet is playing an increasingly important role in audio and video delivery. Real Networks and Microsoft both produce technologies for providing real time streaming media over a network.

RealMedia[15]: The first RealPlayer was released in 1995 and was only able to play audio. RealPlayer is now at version 7.0 and is able to support a range of audio, video and animation codecs.

Windows Media[16]: Microsoft responded to Real Networks by extending their Media Player product to support their own streaming media technology, now called Windows Media. The video utilises a proprietary MPEG4 codec. The current version is 4.1.

3.6 Stand-Alone Hard Disk Video Recorders

It is not only personal computers who are benefiting from the digital video technology. In the United States, two stand alone consumer products have been released that implement many of the features mentioned in this report. TiVo[18] and ReplayTV[17] were both brought to market in March 1999. They are described as the first examples of Personal Television devices. Both devices take the form of a VCR size box that sits on top of your

existing television. They both connect to the phone line to get an up to date program guide via a toll free number. They use MPEG2 compression to record programs straight onto large hard drives. They also implement Time-Shifting features so that live programs can be paused and navigated at will.

TiVo: TiVo was founded in 1997 by Michael Ramsey, an ex vice president of Silicon Graphics. Their business partners include Philips, Sony, DirectTV, AOL and Blockbuster. Their current device incorporates two 13.6Gb hard drives capable of storing 30 hours of VHS quality video at around 2Mbps. High quality video for movies and sport reduces the capacity to 9.3 hours.

ReplayTV: ReplayTV was also founded in 1997. Their business partners include Panasonic, Matsushita and Sharp. Their current device features a 20Gb hard drive capable of storing 20 hours of VHS quality video. This reduces to 6.7 hours for high quality video.

A more complete comparison of their features can be found on Eric Lund's ReplayTV vs TiVo comparison webpage[19].

4 Project Plan

This project can be broken down into a number of milestones consisting of differing levels of functionality. At each stage, the added functionality can be fully tested before progressing. Functionality is also added in order of priority to the project. In case of failure, later sections of the specification may be re-evaluated or removed to allow for more important sections to be completed.

4.1 The Electronic Program Guide

Complete the prototype BBC Radio Times website parser

Here, the parser will be able to connect and read a selected page from the Radio Times website. This page should then be processed and the programme data converted to a standard internal format.

Move parser code into seperate Dynamic Link Library (DLL) and standardise interface to parser

The parser should be isolated into its own library so that a collection of parsers can be created for different websites based on a common interface.

Create prototype programme guide

Take the data structure created by the parser and present it to the user in an intuitive fashion. Provision should be made for the functions required for it in later sections.

The Electronic Program Guide should be have an estimated completion date of 29th February 2000.

4.2 Video Recorder

Incorporate Amcap code into MFC program

Amcap is the sample application provided in the DirectX Media SDK for demonstrating video capture. However, it is not presented using the Microsoft Foundation Classes

(MFC) which provide access to easy to use graphical interface components. In this part of the project, the code from Amcap should be tailored and integrated into an MFC application, ideally into the prototype EPG described above.

Add Compression

Amcap does not currently support any compression codecs. Here, the ability to specify compression should be added to the application as mentioned in the specification.

Add Playback

Add the facility to playback videos directly within the application.

The video recorder should have an estimated completion date of 18th May 2000.

4.3 Timer and Library

Create timer facility

Add the ability to record a program without user intervention at a specified time. Add the facility to create timer events from EPG and from direct user input.

Create Clip Library

Add the facility to manage the clips that have been recorded by the VCR. This will include the space management features described in the specification.

The Timer and Library should have an estimated completion date of 5th June 2000.

4.4 Remote Access

Create Web Interface to Application

Add the ability to manage the timer and library via a web browser as described in the specification.

Add Support for Streaming Media

Provide support for viewing the recorded clips or the live source via a suitable streaming format.

Remote Access will have an estimated completion date of 19th June 2000.

5 Evaluation Plan

5.1 Testing Against Specification

Unit Testing shall occur at each of the implementation stages described above to make sure the recently added feature functions correctly.

Programme Guide Normal Operation: Verify that programme guide correctly reads in programme listings for a user specified time period.

Programme Guide Error Handling: Verify that programme guide correctly handles a incorrect date or unavailibility of data.

Video Recorder: Verify that VCR transport controls function correctly. Test the ability to record and playback clips at any quality level specified by the user.

Timer: Verify that a timer event is created and executed correctly when selected from the Programme Guide or from direct user input. Test combinations of channels and times, including conflicts.

Library: Verify that correct information is displayed and updated on the videos taht have been recorded. Verify that files can be safely deleted or recompressed in the library.

Remote Access: Verify that an authorised user only, is able to access the VCR from a remote location. A lab environment will suffice, but testing should be done over a variety of connections. Verify that video clips can be viewed through the interface via a streaming format.

5.2 Interface Testing

As this project is targeted as a non technical product, all interfaces should be tested on a variety of users with differing degrees of IT experience. This should be assessed through

observational sessions where a user is given a number of tasks to do with the system. The user will then be required to provide a commentary of any problems. Observations on behaviour should be made by the assessor. These results will then be directly used for improving the system as well as final evaluation.

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