Multimedia Production for eLearning with Linux and OpenSource

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1 Introduction

Mutual-interaction between students and teacher is factor that is missing in electronic based distance learning or e-Learning. In an e-Learning system, capability that enable student to self-learn is a mandatory. Although reading materials, such as lecture-notes, course presentations and sample-test, are available on most of e-Learning systems, there are circumstances which can not be fulfiled only by reading them. The ability of students to absorb reading materials might vary from one to another. Here, live-scene demonstration are necessary, by which students can directly read, watch, and hear communicated learning subjects.

Multimedia is combined materials in text, graphic art, sound, video, and animation which are delivered via digital computer or other electronic means. A good eLearning platform should include multimedia as one of its content. The objective is that it can help students to learn better and effective, as well as to avoid wrong interpretation of the subject.

Based on the type of user's interaction, multimedia content can be devided into two main categories [2]:

1. Non-Interactive Multimedia
   Presenting one element at a time (linear) and prepared sequencially.

2. Interactive Multimedia
   It is a non-linear content by means of giving users control over what elements to present and when.

There are stages in having multimedia production in eLearn platform :

1. Designing multimedia content.
   There are several tasks in this stage : analyzing requirements, presenting the idea, and drawing storyboard. The storyboard will be used as a basis for developing multimedia contents.
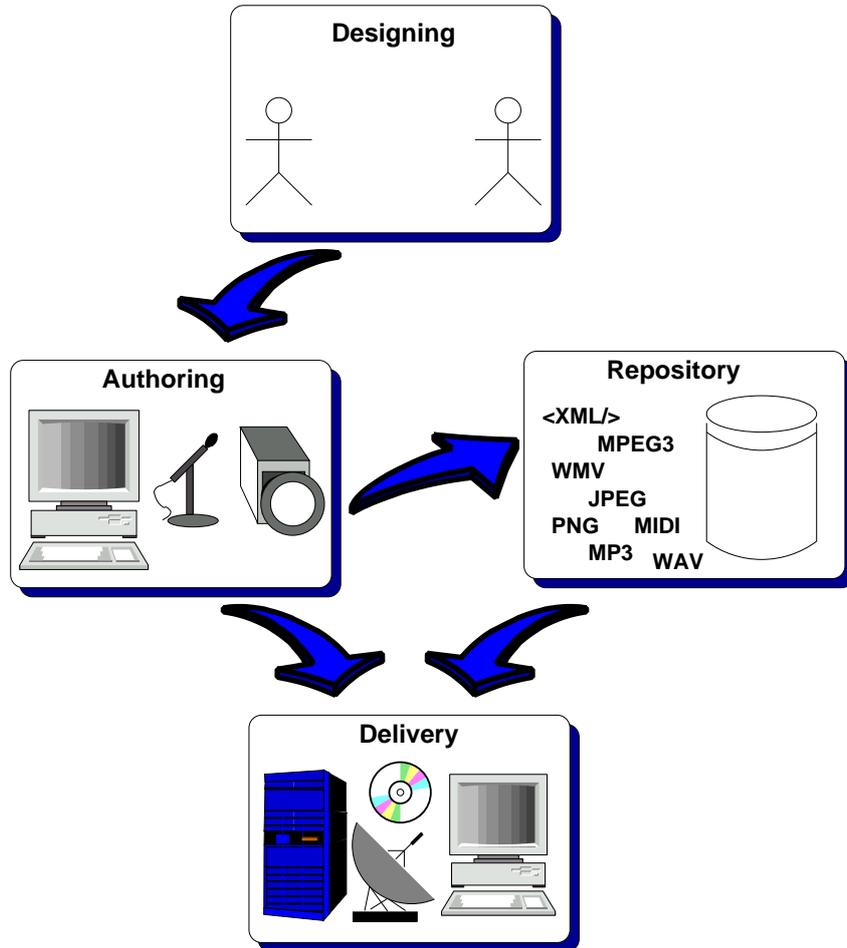
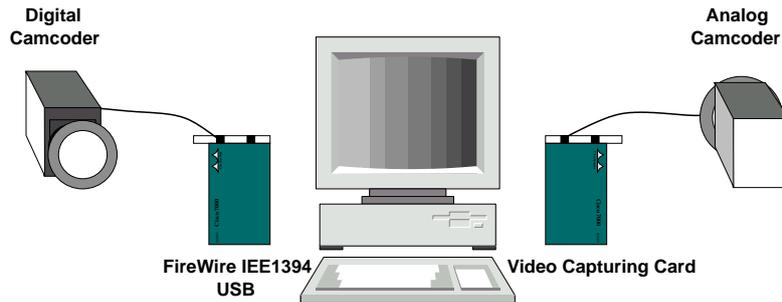Figure 1: Stages in Multimedia Production

Figure 2: Capturing Video Data

2. Producing / Authoring.
   This is the stage where multimedia content is produced. The works are distin-
   guished as follows: text producing, video taking, sound / music recording-and-
   sequencing, as well as developing animation and interactive program.

3. Storing / Repository.
   Multimedia content can be stored as various format and on various medium. Some-
   times, eLearn platform should provide combinations of formats-medium due to
   various platform that students are using and the availability of infrastructure.

4. Delivering / Distribution
   The latest stage of production is distribution of contents produced. Here, some
   criteria must be taken into account. For example, content transport channel (CD,
   DVD, LAN, Internet-based), and the platform that will be used to deliver and
   display contents (Linux based server, Windows based server, Mac, etc).

This document provides short description in producing multimedia content using Open-
Source software. The design issues are beyond the scope of this document. As a com-
panion to this document, a presentation is available separately.

2 Production (authoring)

2.1 Video (non linear editing)

Video Capturing

There are two types of video camera recoder (camcoder) : analog camcoder and digital
camcoder. Basic idea is, before video data can be digitally edited and sequenced, they
must be transformed into digital format. Analog video signal stored in video cassette
must be transformed / digitized / captured using a video capture device. This device is
ussually a PCI card that has analog video-audio input RCA jack or SVHS (Super VHS).
However, using this scheme, video has to be captured in normal timeplay which takes a
long time to finish.

Digital camcoder records video data in digital format. The advantage is that it can be transferred directly to the normal computer. Normally, a digital camcoder has digital video output interface that uses USB (Universal Serial Bus) or FireWire (IEEE 1934). Most of the high-end computers have those two interfaces integrated on the motherboard. If this interface is not available, than FireWire card or USB card is necessary. Time needed for transferring video data is vary and depends on the speed of interface. A USB 2.0 interface can perform data-transfer up to 120 MBps, and latest FireWire interface can perform data-transfer up to 60 MBps.

Note that, before deciding to use an interface, it is better to check hardware compability with the operating system. For example, due to license problem, some chipsets might not be supported by Linux.

Video Editing / Composing

After video data is available in digital format, production moves to video editing stage. Contrary to analog video editing, digital video editing can be performed non-linearly. That means the software can select any state of the video without having to rewind or forward the video sequentially. Open Source community has produced several video editing softwares. Each has advantages and weakness[1]. Some of them are:

- **Cinelerra**
  Cinelerra is an advanced compositing and editing system for native Linux. Native Linux means that no emulation of proprietary operating systems and no additional commercial software are required to run this software. The developer says that Cinelerra is intended to be used by professional by means it does not provide ease of use, simplicity, and convenience, like other home used video editing application. It requires high end computer such dual high end processor with 1 Gigabyte of memory and huge capacity of harddisk. Cinelerra can be found at *http://heroinewarrior.com/cinelerra.php3*.

- **Broadcast 2000**
  Broadcast 2000 is a successor from Cinelerra created by same group of developer. However, it can be used in simple mode that eases end-user to operate the system. Broadcast 2000 is available in several Linux distribution including SuSE and Debian.

- **MJPEG Tools**
  "The mjpeg is a set of tools that helps to record videos as well as playback, simple cut-and-paste editing and the MPEG compression of audio and video under Linux" this sentence is taken from MJPEG Tools homepage at *http://mjpeg.sourceforge.net*.

- **Main Actor**
  MainActor is the most easy-to-use video sequencer written for Linux as well as

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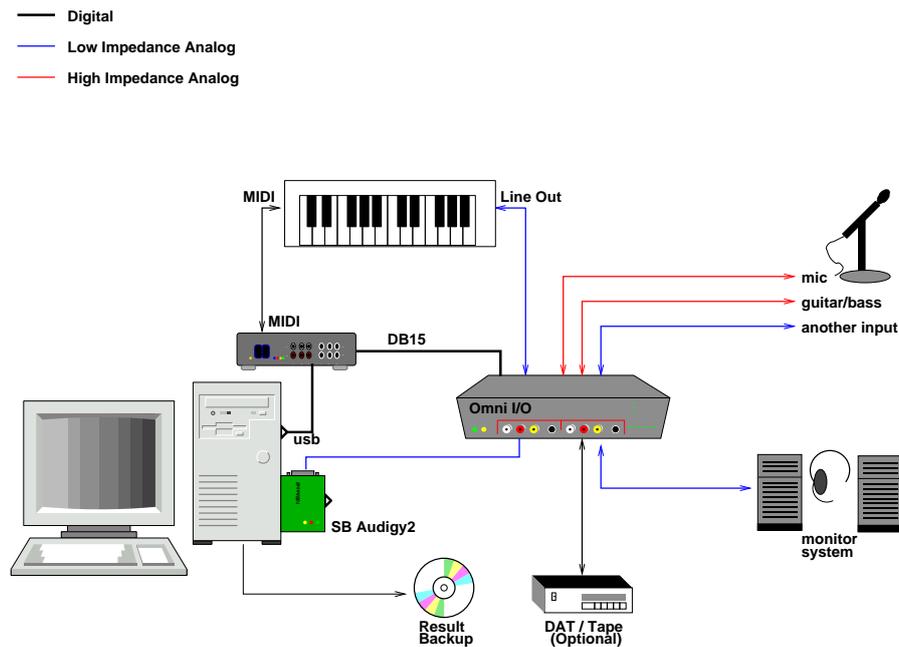[1]Please refer to discussions in several available mailing lists

Figure 3: Example of Computer Based Studio

Windows. However, MainActor is not OpenSource. User must pay and obtain license key before using it in full version.

2.2 Audio

Audio processing is performed for editing conversation, producing sound effects, or integraring music in eLearn multimedia material. There are types of data which will be used in audio editing / composing:

1. Digital audio data which is enveloped in PCM (Pulse Code Modulation). Raw PCM data is stored as WAV file format and compressed PCM can be stored in MP3 or OGG file format.

2. MIDI (Musical Instrument Digital Interface) data. On the contrary to normal digital audio, this file does not contain any sound data, but rather music data. It contains sequence of note information that assemble the music along with attributes and sequence of device-related command. These data are arranged according to time-events.

Multi Track (direct to disk)

In the old days, recording is done by a multitrack studio system. Analog sound signal from microphones and musical instruments are recorded on separated track so-called multitrack tape. After recording is finished, recorded sounds are played and mixed

down by a device called "mixer" to obtain a master record. The problems are that these equipments are expensive and need a professional sound engineer to setup and to operate.

Nowdays, a high end PC can be utilized to perform most of digital multitrack recording system. This system requires a PC with sound card and already-installed digital recording or multitrack software. Analog sound signals are digitized / sampled using one or more sound card and digital sound data (sampling) are stored in harddisk (direct to disk). The mixing process is done also by the software. Sound preprocessor such as soundeffect can also be done using the software.

There are some opensource multitrack program available on the internet :

- **Ardour** (*http://ardour.sourceforge.net*)
- **Audacity** (*http://audacity.sourceforge.net*)
- **SLab** (*http://www.slabexchange.org*)
- **ECASound** (*http://www.wakkanet.fi/˜kaiv/ecasound*)

First, digital sounds data are stored in raw PCM format. After mixing down the master record, it can be converted in other compressed-format such as MP3 or Ogg. Note that when the data is needed for further processing then it is better to keep the format in a raw PCM format. The reason is that compressing would produce loss of quality.

In a sound card, an ADC (Analog to Digital Converter) is responsible for converting analog audio signal into digital data. The quality of this sampling process is defined by two measures: sampling rate and how big a sample is performed. Sampling rate is measure in *herz* which means how many samples / snapshots per second the ADC has to convert analog audio signal into digital audio data. The rule is the sampling rate must be twice the maximum frequency signal to be reproduced. For example, the sampling rate used for compact discs is 44.1 kHz. Every samples contains an information of amplitude which measures as a "*bit*". More bits of amplitude is sampled than more broad the sound will be produced. As this document is written down, lates sound card is capable for doing high quality DVD sampling : 24 bit, 96 Khz.

Sequencer

MIDI (Musical Instrument Digital Interface) is more-or-less framework / standard / protocol, by which digital music instrument, such as electric keyboard, synthetizer, digital electric guitar, can be connected together and communicate each other exchanging notes information and its attributes. That is, in a MIDI system, information being exchanged are notes and device-related commands. But not the analog sound signal nor digital sound data.

A sequencer is a device, which can be a computer with a sequencer program, that records these information, and put them in a sequence of MIDI events. These MIDI events can be placed in different track representing different instrument and different MIDI device. In a sequencer, MIDI events can be easily edited and manipulated.

Some opensource MIDI sequencer available :

- **JAZZ** (*http://www.jazzware.com*)
- **Rosegarden** (*http://www.all-day-breakfast.com/rosegarden*)
- **MUSE** (*http://muse.seh.de*)

More on sound system in Linux can be found in : *http://sound.condorow.net*

Syncronization

When pieces of video, audio, and MIDI equipment are gathered, there is a needs for having these equipment work together, means that they can play in time with each other. This process is called Syncronization or "*Sync*". Every sequence of digital video, audio, and MIDI data carries a time information or SMPTE/EBU timecode (SMTPE stands for *Society of Motion Picture and Television Engineers*). With this timecode and single sequencer program, video, audio, and MIDI can be syncronized and mixed down together to obtain the final result.

2.3 Animation

In particular condition, eLearning system should include animation as one of its content. Perhaps as a main demonstration or a accompaniment for video lecturing. In producing animation there are two components which are needed. The first is the modelling tools (2D or 3D) and the second is rendering engine. Modelling tool provides a graphical interface or scripting interface for building animated components and for sequencing the components within the animation. The 3D model created is called Wire-Frame in which different angle of camera, lighting, and textures can be included as well as sounds and graphic. After wireframe is finished, rendering process has to be performed to get final result as a movie or interactive application, etc. There are set of open source softwares for making animation :

- **BLENDER** : Modelling Tools (*http://www.blender.org*)
  Blender is one of powerfull 3D animation modelling tools available from Open-Source. It has many enhanced feature to make professional 3D animation content.
- **POVRAY** : Rendering Engine (*http://www.povray.org*)
  Render process of high quality 3D animation needs a powerfull computing system. Povray provides rendering system on top of cluster system.

2.4 Interactive program

Multimedia content such as video, sound, and animation, can be integrated with interactive program in order to help student in their learning process. Most of the eLearn platform uses Web as its interface, therefore, interactive program should be capable to be embeded in Web enviroment:

- **Java**
  Java is choosen because almost all browser in any operating system has Java Runtime Environment to run Java Script or Java Applet, thus interoperability is not significant issue in using Java. Moreover, Java has many libraries to deal with multimedia content, hence it is easy to develop interactive application in Web.

- **Macromedia**
  Macromedia Inc. offers its product so-called macromedia flash animator. It has set of powerfull multimedia producing, delivery, and player which can be said to be widely used multimedia application in Internet. The weakness is, that the data has propietary format, by which only macromedia player can play content produced. This proprietary format should be avoided to gain compability with other applications.

3 Repository

3.1 File format & Type of Compression

In order to restore multimedia data, there are some standard formats which are supported globally or only as a propietary format. This format (read : encoding algorithm) is usually combined / associated with the compression, because having multimedia content needs exhausted storage and bandwidth expecially video data.

There are three main encoding algorithm which are used widely : MPEG format for audio (MP3) and video, Windows Multimedia Format, and RealPlayer Multimedia format. Almost all player and encoder are capable to encode/decode MPEG format, hence it can be considered as a good choice for multimedia content. Since windows 2000, Microsoft has announced their Windows Multimedia Format family : ASF (Advanced Streaming Format), ASX (Advanced Stream Redirector), WMA (Windows Media Audio), and WMV (Windows Media Video). These formats offer high compression capability. The last is format for RealPlayer, this format is intended to be used in streaming application.

OpenSource application support all of these formats, MPEG format can be played by any movie / sound applications, and Windows Multimedia Format can be played by opensource application called MPlayer. For playing stream video / audio in RealPlayer format, one can use RealPlayer or MPlayer, they both support this format.

There are some considerations to be taken into account before one can decide which format should be used for storing multimedia format. Due to the deprivation of information (quality) in various encoding-compression algorithm, it should be clear the goal for storing multimedia content, whether it will be used for further processing, or whether it will be used for delivery. Further processing requires high quality data, hence, usually data is stored in original format such as WAV or RAW Video data. Compression in MPEG can be done but the compression ratio must meet the quality requirement.

For final delivery there are some requirements : Player Availability, Quality, and Compression ability. These requirements depend on which purposes of applicance will be.

Appliance	Main Requirements	Format of Choice
Share through CDs	Quality, Player Availability	MP3, MPEG
Share through internet	Quality, Compression	MP3, MP3PRO, MPEG, WMA, WMV
Portable players	Compression, Quality	MP3PRO, MPEG
Broadcasting through internet	Player Availability, Compression	MPEG, WMA, RA-G2

Table 1: Best choices of algorithm per appliance [1]

Table 1 provides suggested choices of algorithm per appliance.

3.2 Cataloging

After contents are ready to be delivered, a cataloging system is needed in order to accompany users to seek for the content they need. This cataloging system includes indexing and categorizing functions and providing searching, directory, thumbails, and preview model for the users. Searching and directory browsing in multimedia catalogue system is a little bit different from those in text based / database system. There must be some kind of contextual representation in text for each multimedia content by which user can associate them.

4 Delivery

4.1 Off line media

Multimedia content is usually delivered in CD based media because it requires big space and fast access, moreover, most of multimedia data is sequencial. Sounds can be delivered in audio CD and mid-quality video is in VCD format. High quality video requires more space, therefore DVD will be more proper media, however, DVD media, writers, and players are still expensive for end user.

Interactive multimedia applications require combined format in a CD by means of data-video-audio, but sometimes they don't. Sounds and videos are stored as normal file encoded with MP3 or MPEG, and simply load them with widely available decoder.

Opensource community has been releasing several tools for creating these format. **K3B** (*http://k3b.sourceforge.net*) is an easy front-end application for creating CD and DVD. It uses many tools such as *cdda2wav, cdrdao, cdrecord, lame*, and other video/audio encoder.

4.2 On line media

As internet became widely available and cost per bandwidth became cheaper, hunger space and bandwidth applications like multimedia are considerly feasible to be transfered
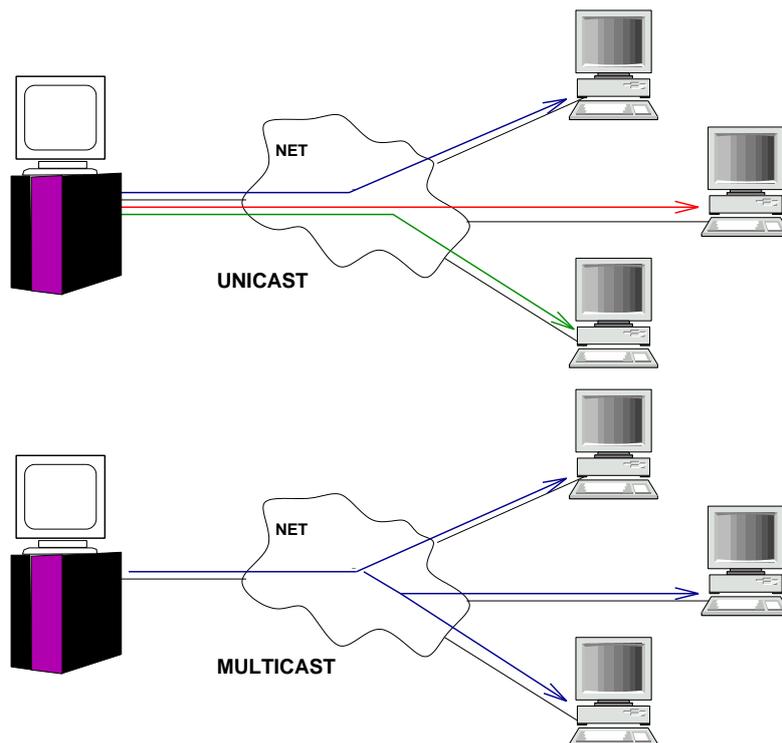
Figure 4: Unicast vs Multicast

via the Net. The contents can be transfered in easy way by means of transferring file on top of HTTP or FTP protocol, which then can be played with appropriate player program. Or, the content can be transfered in sequence and directly played with streaming supported player.

4.3 Streaming

Streaming multimedia content are transmited in two modes:

- Unicast
  Unicasting is one way link data transmission established between two nodes within a network. This kind of link is tipically can be found in client-server model by means of server will transfer stream of multimedia content to the client based on client's request. One can say that this kind of method is one-to-one link. Server and clients with normal TCP/IP connection can perform unicast multimedia delivery system.

- Multicast
  Contrary to unicast, multicast is one to many, that is, one server transmits its contents once, and can be received and played by several clients. This saves a lot of network bandwidth when it is applied with the correct type of multime-
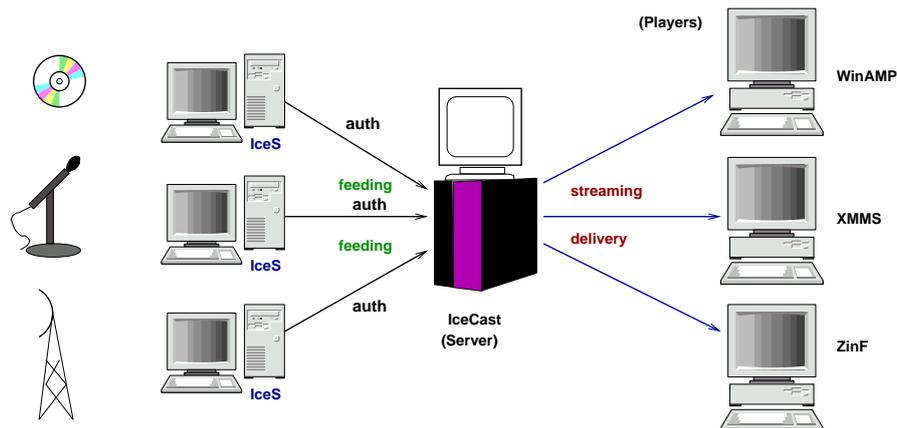
Figure 5: IceCast architecture

dia application such as broadcasting, teleconferencing, etc. Of course, multicast system must include : server - client which are multicast ready, and set of networking pheripheral (router, switch, protocol) which are capable to transmit multicast packet. In TCP/IP addressing, multicast has their own block of address starting from 244.0.0.0 until 255.255.255.254.

There are several streaming server available under Linux, some of them are opensource, some of them are freeware :

Icecast (http://www.icecast.org)

Icecast is a collection of programs and libraries for streaming audio over the Internet. Icecast project includes: *icecast*: a program that streams audio data to listeners, *libshout*: a library for communicating with Icecast servers, and *IceS*: a program that sends audio data to Icecast servers. That is, IceS encodes audio data and feeds them to icecast server with functions which are available from libshout library, these encoded streams are then transmited to the player on listener's side. Icecast transmits streams in Ogg Vorbis format.

Helix Server - Helix Producer (Video - RealNetworks)

Helix Server is standards-based digital media server that delivers choreographed multimedia presentations: RealAudio 8, RealVideo 9, Flash animation, images, slides, and streaming text over the Internet or corporate intranets. Made by RealNetworks, an old player in multimedia world. Helix server basic is server version which can be download freely with limited feature and limited bandwidth. Helix server is also available for Linux and BSD platform.
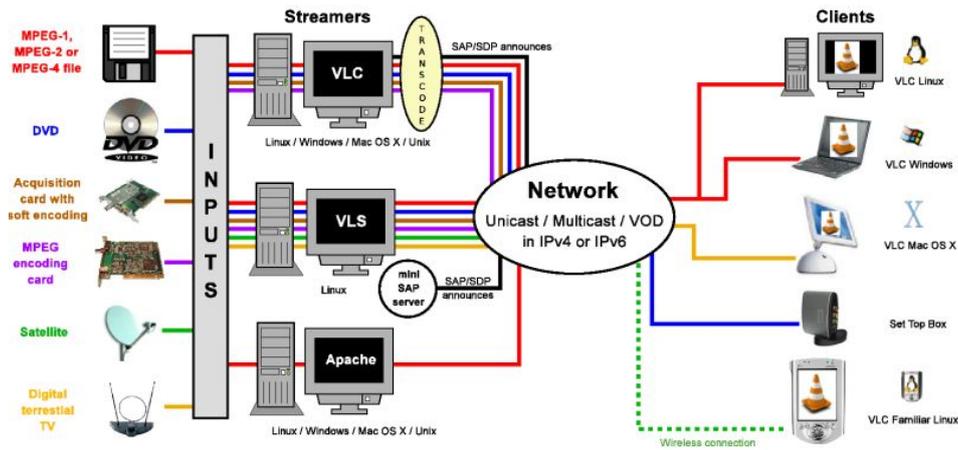
Figure 6: VideoLAN solution (taken from original site)

VideoLAN Server / Client (http://www.videolan.org)

VideoLAN project makes video streaming from any source in any platform became easy. It deliveres multimedia streaming of MPEG-1, MPEG-2, MPEG-4 and DivX files, DVDs, digital satellite channels, digital terrestial television channels, and live videos in many OS.

References

[1] Panos Stokas, "Which is the best low-bitrate audio compression algorithm ? OGG vs. MP3 vs. WMA vs. RA", *http://ekei.com/audio*

[2] Multimedia Design and Development, *http://www.cse.lehigh.edu/~glennb/mm/mm.htm*

[3] VideoLAN homepage, *http://www.videolan.org*

[4] Linux Audio Users Guide, *http://www.djcj.org/LAU/guide/index.php*

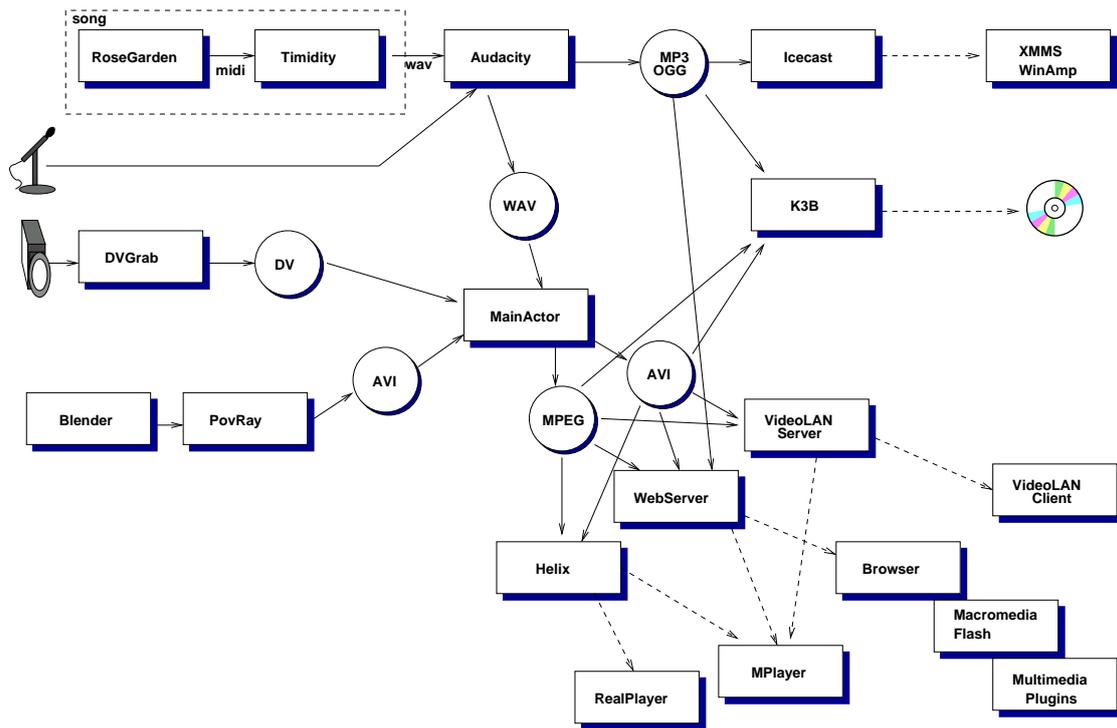[5] Sound & MIDI Software For Linux, *http://sound.condorow.net*

Figure 7: Example of Multimedia Application in Linux - Opensource