Software for Multimedia

- Software controls the hardware to perform meaningful task
- Software is divided into two parts
  1. Systems software
     - Programs that actually control the hardware as resources
     - Facilitate the use of resources by other software
  2. Applications software
     - Programs that use the hardware and system software to perform a task
     - May be able to work on multiple platforms
     - From multimedia perspective, application software is further subdivided into two categories
       (a) Content generators
       (b) Delivery software

System software

- Controls aspects of operation of a computer
- Closely bound to hardware, and may be partially portable to a different computer (hardware as well as software perspective)
- Used to run the computer
- Collection of programs may form the operating system for the computer
  - Includes software such as device drivers
  - Boundaries between such programs may be fuzzy (windows is part of Mac and Windows but no Unix)
- Operating systems
  - Acts as a mediator between user and hardware
  - The user interacts with the interface provided by the operating system
  - Behind the scenes, the OS controls all the available hardware and software resources and their distribution to applications
  - Important choice for multimedia developer in terms of facilities provided by the OS
  - OS itself depends on the hardware, and if a hardware has been already selected, the choice of OS may be limited
  - Multimedia developer has to look at the OS choice for development as well as delivery platform
    * The speed of execution for various functions may vary drastically between different versions of even the same OS
    * Availability, efficiency, and speed of different functions
    * Networking facilities in the OS
    * Availability of development tools
  - Size of the OS with respect to available RAM
    * Important in delivery when the application may need to run on older versions of an OS
  - Availability and widespread use of an OS

    - May dictate the development on older versions as the application developed on the newest version of an OS may not run on older versions
    - Training needs for use of application
        - Some applications developed on Unix are delivered with user interface of Windows to minimize training
  - Fusion with existing environment
    - Multitude of OS versions may increase maintenance cost
    - Developers may not accept a different OS
    - May need to train developers to develop in different environments

- Utilities
  - Used to execute frequently needed tasks multiple times
  - Flexible to run with a wide range of data without modification
  - May come with the OS (the `df` utility) or may be added by the local installation (the `xfsm` utility)
  - Utilities may get incorporated into applications
    - Applications display the contents of a directory
    - In Unix, achieved using the library functions `opendir(3C)`, `readdir(3C)`, and `closedir(3C)`
  - Utilities are generally optimized for the OS, and make more efficient applications
  - Since utilities are used over and over again, bugs are removed (or become features[1])

- Networking software
  - Facilitates interactions between different machines
  - Machines may need to share programs/data/signals
  - Goals of networking
    - Saving money by means of sharing
    - Increasing the reliability of systems by providing alternative sets of resources on hot standby
    - Increasing accessibility of distant resources
        - Getting current weather conditions in Microsoft Flight Simulator 2002
    - Providing communication and cooperation link to various users of computers
        - Playing games over the internet
    - Increasing speed and efficiency of applications
        - Some work can be given to a different machine
        - Infra-red simulation on a different machine than regular image generator for flight simulation
  - Fundamental operations of networking software
    - Establish connections across physical network
    - Close open connections when not needed
    - Formatting information into packets for transmission
    - Correct addressing of packets
    - Sending packets over the network
    - Ensuring that packets on the network do not interfere with each other
    - Ensuring that packets are sent at appropriate speed, for network and recipient
    - Ensuring that packets are routed correctly along various paths on physical network
    - Interpret the address on packets for correct delivery
    - Receive packets and strip network-specific material to extract relevant information

[1] A feature is a bug with seniority

    - Perform error detection/correction and request retransmission, if necessary
    - Reassemble multipacket messages in correct sequence before forwarding to appropriate application
    - Maximize the efficiency of information flow on the network
- Layering
    - Networking software structured by creating layers at conceptual level
    - Each layer responsible for a different aspect of network control
    - Each layer designed to provide a service to the layer above it and to hide the complications of lower levels of processing (level of abstraction)
    - Number of layers chosen to meet several criteria
        - Each layer should be self contained, requiring minimum amount of input from the next higher (calling) layer, and passing the minimum essential data to the next lower layer (standardized, minimal interfaces)
        - Each layer should be a logical entity that performs just one major segment of the networking algorithm
        - A new layer should be created for every major level of abstraction needed, but there should not be so many layers that simplification is lost
    - OSI (Open Systems Interconnection) model with 7 layers
- Transmission
    - Application program formats data according to standardized protocol for input interface to highest layer of network for transmission
    - Networking software at layer 7 manipulates the data and attaches an application header to the message before sending it to layer 6
    - Application header keeps information needed by recipient's layer 7
    - Each succeeding layers adds more information to the packet
    - Layer 1 carries the packet over physical medium
    - Message may go directly to recipient, or may get routed by various hubs, bridges, routers, and gateways
    - At destination, messages moves up the layers, gets decodes, and finally, layer 7 passes the intended data packet to application
    - It appears as if each layer at sender directly communicates with the corresponding layer at the recipient (direct communication) but it actually goes down the layers to do so (virtual communication)
- Network topologies
    - Topology of physical connections used by network to transmit data
    - Three basic elements of a network
        1. Systems on which applications execute (hosts)
        2. Medium of transmission, including wires (subnet)
        3. Switching elements or interfaces between hosts and subnets responsible for routing (packet switching nodes)
    - Major topologies: point-to-point and broadcast
    - Each host connected to a packet switching node (PSN)
    - Possible to have many nodes connected to a single PSN
    - Point-to-point networks
        - Each PSN is connected to at least one PSN directly, possibly connected to many PSNs
        - Used mostly in wide area networks (WANs)
        - Message can be sent directly from one PSN to another, or switched through intervening PSNs
        - Store-and-forward or packet switching delivery
    - Broadcast channel
        - All PSNs connected to one communications backbone

        - All PSNs receive the message sent by any PSN
        - Used in local area networks (LANs)
    - Communications protocols
        - Any two hosts sending data at the same time may result in *collision*
        - Software should *know* about *when* to send a message
        - Achieved using protocols
        - Common hardware protocols include ethernet, token ring, and ATM
        - Message passing protocols
            - Provide rules for formatting and transmitting messages over the network
            - Implemented at different level of network architecture
            - HTTP, SMTP, AppleTalk, TCP/IP, SNA
    - Servers
        - Computer with specified responsibilities in a network
        - Common to have more storage capacity and more computational power compared to other machines in the network
        - Server can contain applications, and may act as traffic controller for data over the network
        - Network may even have special purpose servers
            - Database server
            - File server, for shared access to files
            - Web server
            - Mail server
            - Print server
    - Client/Server organization
        - One server may serve many clients
        - Significant portion of processing has to be done on client side

Development software

- Programs that enable the preparation of content (may or may not participate in delivery)
- Graphics applications
    - Categorized in terms of types of images to be processed
    - Still images: scanning software
        - Two main aspects of still images in multimedia: capture and editing
        - Storage format is important as well
        - Images captured by scanning or digital cameras
        - User may be able to modify some parameters of images during capture
        - Trial scan in scanners
        - Important considerations in scanner selection
            - Compatibility with current hardware
            - Flexibility and control over scanning process
            - User-friendliness
    - Still images: image processing software
        - Allows modification of image after capture
        - Orientation of image

    - May or may not be able to rotate the images by arbitrary angles
    - Mirror image
    - Size and shape of image
    - Contrast and brightness
    - Color
    - Alteration of content
    - Texture
    - Compression and storage
    - Format
- Still images: image creation (painting and drawing) software
    - Image can be *bit-mapped*, or mathematically defined *vector drawing*
    - Use `xpaint` or `gimp` to create bit-mapped images
    - Use LaTeX picture environment to create vector drawings
    - Vector command requires less data compared to bit-mapped pixels
    - Vector command needs to redraw image every time it is needed
    - Vector command may not be able to produce complex images that are realistic
    - Vector commands are easy to edit, and more precise
    - Bit map is faster and more efficient
    - Drawing tools vs painting tools
- Motion images: digital video
    - Television video is analog; images stored frame by frame as analog data
    - Computer video is digital; frames are composed of pixels
    - Images are created by taking advantage of *persistence of vision*
    - Display 30 frames per second
    - Frames must be presented within the required time (time-dependent medium)
    - May produce strain on computer and network
        - 640×480 frame with 3 colors @ 30 frames per second
        - Storage requirement for 1 minute video clip
    - Solutions to the problem
        - Video screen may be shrunk (RealPlayer)
        - Display images at less than 30 frames per second (videophone)
        - Compress data so that fewer bytes are required to define a frame (MPEG)
        - If compression is used, decompression must be extremely fast to keep up the frame rate
        - Video cards may have hardware acceleration for decompression and display
    - Three basic stages for use of motion images in multimedia
        1. Capture (hardware; video capture cards)
            - Conversion of analog TV signal into digital
            - May require compression as well
            - Should be able to do so with minimal user intervention
        2. Editing (software; mostly cut and paste)
            - All image editing tools (rotation/picture quality adjustment/contrast/brightness/gain control)
            - Modify individual frames to correct imperfections
            - Superimpose titles
            - Cut and paste
            - Fade-in and dissolve
            - Timing and synchronization of frames to control soundtrack

3. Presentation (software, with hardware support)
   · Standard playback, from first frame to last
   · May include on-screen pause and resume
   · May also include slider for fast forward and rewind

– Motion images: animation
  * Process of creating a series of images, each slightly different from pervious one
  * Give an impression of motion when viewed at a specified pace
  * Used to bring an image to *life*
  * Rotate globe at the rate of one rotation every six seconds
    · Must create 360 frames, each at an angle of 1°
    · May also create a solid view and rotate the view
  * Algorithms to rotate and translate portions of image
    · More complex image, more complex algorithm
    · Algorithm to move cross hair
    · May add blurring effect to show motion
    · Modifying light and shadow position
    · Morphing
    · Inverse kinematics for realistic motion of living beings

• Sound applications
  – Computer can store sound in digital format
  – Digital format is converted, using a digital-to-analog converter, into electrical signals to drive a loud speaker
  – Computer can also store digital representation of attributes such as frequency, amplitude, reverberation, and duration
  – The attributes can be used to control a speech synthesizer as with the control of a MIDI synthesizer
  – Distinction between the two forms is analogous to bit-mapped and vector-generated graphs
  – Analog-to-digital conversion is more common for multimedia applications
  – Sound as a continuous or analog phenomenon
    * Captured using an analog-to-digital converter
    * Sound capture software contains three major components
      1. System software calls to control the ADC
      2. System software calls to store the resulting data
      3. User-interface for control by developer
    * Sampling rate – Rate at which samples are captured
    * Digitizing rate – Rate at which samples are converted to digital
    * More samples means better fidelity but larger file
    * CD-quality recording sampled at 44.1 kHz with 16-bit resolution in stereo, requiring 10.5 MB for one-minute sound file
    * Television quality recording is sampled at 22.05 kHz, with 8 bit resolution
  – The stored data file can be displayed on screen as a sound wave
    * Useful for editing
    * Sound data includes temporal information as well as pitch, volume, and timbre
    * Temporal sequence can be modified by deleting a segment or by changing the speed of a segment
    * Editing should be such that the transition should be blended; no abrupt cuts should be allowed
  – Sound can be filtered to remove certain frequencies

    - Possible through use of different types of filters
    - Low-pass filter
    - High-pass filter
    - Band-pass filter
  - Manipulations available on modern audio processing software
    - Trimming and splicing the sound file (cut and paste)
    - Adjusting sound parameters such as volume and brightness
    - Fading in and out of segments of sounds
    - Shifting the pitch of a segment
    - Changing the format for storage
    - Adding special effects such as reverberation or echo
    - Altering the time dimension
  - Sound replay
    - Digitized data is transmitted to a DA converter
    - Converter produces the analog signal to drive the loudspeakers
    - Replay subsystem acts as an interface between user and OS
      - Identify the file containing digitized sound
      - Specify the point to begin playback by loading appropriate block within the sound file
      - Start replay by transmitting data to DA converter
      - Pause if asked by user, but remember the point of pause in the file
      - Restart playback by causing OS to resume data transmission to DA converter
      - Stop playback by turning off transmission to DA converter

- Text applications
  - Used for instructions and data presentations
  - Words or phrases may be linked to other hypermedia links
  - Text may be modified by using image processing or animation to achieve more striking or artistic effects
  - Difference between multimedia and common text editing
    - Multimedia text is almost always intended for display on screen; no printing
  - Two primary aspects of material for multimedia
    1. Text as words – content, meaning, spelling
    2. Text as image – appearance, font size, color, layout, animation
  - Text as words
    - Employ a standard text editing program (not processing) such as `vi`
    - Create the text, not intended for hard copy printing
    - Two parts of a text file – text and formatting information
    - Both parts physically interspersed in the text file
    - Text processing software understands the commands and produces the final output
    - WYSIWYG software, possibly splitting into two windows
    - Formatting functions or tags define the desired effects
  - Text as images
    - Text processor processes formatting commands as they are encountered and affects the rendering of text for display/printing
    - The requisite instructions are generated that are interpreted every time the multimedia presentation is run (inefficient and time consuming)

    - Special effects with the text (morphing, distorting, animation) may be impossible to achieve
    - Preferable to use pregenerated bitmapped images of text
    - Text can be stretched or distorted using image processing algorithms
        - Image of text can be treated as any other image
    - Longer text can be processed and saved as a document and incorporated into a multimedia presentation (think PDF)
    - Standardization of storage formats
        - Postscript and PDF
        - Pioneered by Adobe
    - Text stored as image cannot be easily modified

- Web development
  - Web multimedia is inherently networked
    - Many hyperlinks, both internal and external to document
    - External links may point to web sites that are external to local network
  - The presentation format may not be known
    - User may be constrained to a smaller screen size
    - User may not have the specified fonts installed/available
    - User may not be able to see all colors due to display limitation for number of colors supported
  - Presentation may not have all elements synchronized
  - Markup languages
    - In use for more than 20 years now
    - GML and SGML
    - Based on 'tags'
        - Used to encode content-related information
        - Also encode formatting
        - Different formatting conventions (angular brackets or period)
        - `roff`, LaTeX and HTML
        - Meta tags
  - Java and JavaScript
    - Security issues in Java
    - Sandbox model
  - Web browsers and plug-ins
    - Used for multimedia delivery
    - Plug-ins are used to extend the capability of browsers

- Multimedia authoring
  - Tools used to develop multimedia presentations
    - Easiest example provided by Netscape to compose HTML document
    - Used by a non-programmer to develop presentations
  - Qualities of good authoring software
    - Easy to use; good user interface
    - Appropriate colors (use just the basic ones)
    - Image size and aspect ratio (can display on all monitors)
    - Animation speed (not distorted by fast/slow processors)
    - Sound quality

    - File access speed

Delivery software

- Stand-alone programs
  - Run-time module
  - Directly run on a computre, without any additional program or player
  - Images produced or manipulated in X windows
  - Advantage – Speed
  - Disadvantage – Entire code to be recompiled if there is a change in presentation
- Players
  - Interpret the commands from a data file and performs the function
  - Modify images and view them through `xv`
  - `xv` has only a limited functionality to manipulate images
  - Advantage – Production independent of delivery; Flexibility
  - Disadvantage – Extra player installation; Add time to production/delivery