Videoconferencing on Personal Computers with TCP/IP

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Introduction

Videoconferencing systems for PC's over TCP/IP Local Area Networks and Wide Area Networks present substantial installation and configuration challenges. In addition to the videoconferencing applications, a videoconferencing system uses and frequently modifies five subsystems within a personal computer:

- Video Display
- Video Capture
- Audio Output
- Audio Input
- TCP/IP Network (both Network Interface Card and TCP/IP software)

Each subsystem is complex in its own right. Thus, problems will likely occur somewhere during the installation and configuration of a videoconferencing system. As yet, videoconferencing hardware and software is not standard on most PC's. Installation must occur at the user site. Generally, PC's vary significantly with different hardware and software installed on each PC. Even an experienced installer can encounter a new situation on a particular user's PC.

All versions of Windows - Windows 3.1, Windows for Workgroups 3.11, Windows 95, the upcoming "Memphis", and Windows NT are built on a complex system of operating system components and vendor-supplied device drivers. Some device drivers manage actual hardware devices such as video display adapters, video capture boards, sound cards, and network interface cards. Other device drivers share many properties with the hardware device drivers but implement TCP/IP protocols and other software features of the system.

Device drivers are extremely powerful as they access the hardware and software at a privileged level in all versions of Windows. Even in Windows 3.1 and Windows 95, which can allow applications to overwrite memory within the operating system or other applications, device drivers operate at a privileged level which allows the drivers to do even more damage than an application. Because of this device drivers can cause severe problems, inexplicable crashes, and strange conflicts between devices. Most configuration and installation problems involve the device drivers.

While it is impossible to anticipate the many situations that will be encountered in the field, this document provides an overview of the installation and configuration issues for videoconferencing systems on PC's over TCP/IP networks.

Windows Basics

Some basic facts about the Windows operating systems help understand the installation and configuration problems common to Windows systems that arise during installation of a videoconferencing system.

Windows 3.1 Has No Memory Protection

Microsoft Windows 3.1 and Windows for Workgroups 3.11 (essentially Windows 3.1 with some networking add-ons) have no memory protection. Sophisticated operating systems such as UNIX or Windows NT use hardware features of the CPU to prevent an application from overwriting memory belonging to either other applications or especially the operating system. As a consequence it is easy for applications, dynamic link libraries, essentially anything in Windows, to corrupt the system, some times in obscure ways. This leads to the rule: "*When in doubt, reboot.*"

If a Windows 3.1 or Windows for Workgroups 3.11 computer begins to behave strangely, this may mean a bug in an application has corrupted the system. Rebooting will frequently fix these problems.

Windows 95 Isn't Much Better

While Windows 95 claims to have some improvements in the area of interprocess memory protection, it still has many of the problems of Windows 3.1 and Windows for Workgroups. *"When in doubt, reboot."* is still a good rule of thumb.

Windows NT is Better

Windows NT does provide memory protection. Applications, dynamic link libraries, and other components that run in Windows NT user mode cannot overwrite memory in other applications or the operating system. However, code that runs in kernel mode such as device drivers can still cause these problems. Because of this, it is still worth rebooting when problems occur.

Device Drivers

Windows provides Application Programming Interfaces (APIs) that allow programmers to write application software that is independent of the details of specific pieces of hardware. For example, a Windows 3.1 application will use the Graphic Device Interface (GDI) to display bitmaps (such as video frames) on the video display. The application does not need to know anything about the video display card. The video display card could be a Diamond, an ATI, or a Number Nine video card. To make this work, manufacturers of video cards, sound cards, network cards, and other PC hardware must provide a device driver which allows the Windows system to access their hardware. Windows communicates with the device driver and hides the details from the application. The device driver in turn hides the details of the hardware from the Windows operating system.

Device drivers can be very complex components comprising many files. The files may be installed in different places on the hard drive, although \WINDOWS\SYSTEM is the most common. The Windows operating system needs to know the location of the drivers and sometimes configuration information for the drivers such as IRQ's, IO ports, and other options.

Windows has the notion of a Device Driver Interface or DDI. A Windows device driver is expected to export certain functions specified in the Windows Device Driver Kits (DDKs) which the Windows operating system invokes. The DDI is often implemented in a dynamic link library with the file extension .DRV In Windows 3.1 and Windows 95, actual access to the hardware, the handling of hardware interrupts, any real-time functions that are incompatible with the Windows scheduling system, are implemented in VxDs, or Virtual Device Drivers, which operate at a very privileged level in the system. A device driver may consists of several dynamic link libraries and several VxDs.

VxD's are not used in Windows NT. Microsoft is attempting to unify the device driver systems on "Memphis" and Windows NT 5.0 through the Win32 Driver Model (WDM).

Device drivers are extremely powerful. Bugs in device drivers can lead to crashes and very strange behavior. The symptoms may be very far removed from the problem. For example, a bug in a video card driver may lead to repeated system crashes after another application or device is installed due to a low level conflict. Based on the symptoms, a user might conclude the PC hardware is failing or the new application is at fault.

Many installation and configuration problems on Windows systems are due to bugs in device drivers, problems in installing the device drivers in the right places, and subtle conflicts between device drivers and other device drivers or applications.

INI files and the System Registry

The Windows operating systems need to know where to find device drivers (and many other things). In Windows 3.1 and Windows for Workgroups 3.11, this is handled almost exclusively through the INI files which are ASCII text files with directives indicating the location of installed drivers, names of drivers, and the configuration of the drivers. The INI files control the appearance and layout of windows as well. Windows 3.1 and Windows for Workgroups rely mainly on two INI files: WIN.INI and SYSTEM.INI WIN.INI contains information on the Windows user interface such as desktop colors, fonts, and so forth. Generally, installation and configuration problems are not associated with WIN.INI SYSTEM.INI, on the other hand, contains information on the device drivers used by Windows. If a driver is incorrectly specified or configured in SYSTEM.INI, severe problems can occur. These files may be viewed directly through a text editor. Applications may read, update, and create INI files through a standard Windows API. The Windows 3.1 Control Panel actually provides a GUI for the WIN.INI and SYSTEM.INI files.

When a video card or other piece of hardware is installed on Windows 3.1, the installation software will copy drivers to the hard disk and update SYSTEM.INI with directives specifying the location and configuration of the drivers.

In Windows 95 and Windows NT, Microsoft attempted to replace WIN.INI, SYSTEM.INI, and may other application specific INI files with a unified *System Registry*. The System Registry is a binary, not human readable, database which is supposed to contain all of the installation and configuration information for drivers, applications, hardware, and other parts of the system. Because of backward compatibility issues, in fact the INI files are still used in Windows 95. The system registry has the major consequence that manual editing of the System Registry is virtually impossible (it can be done through an application called REGEDIT but this is very risky due to the complexity of the System Registry). Under Windows 95, users must rely on installation programs and the Windows 95 Control Panel to resolve configuration issues.

Control Panel

The different Windows operating systems contain an application or group of applications known as the Control Panel. The Control Panel differs slightly between Windows 3.1, Windows 95, and Windows NT. Device drivers may be installed , removed, or reconfigured through the Control Panel. Other aspects of Windows may be configured through the Control Panel. Under Windows 3.1 and Windows for Workgroups, the Control Panel applications such as **Drivers** view and update the SYSTEM.INI file. Under Windows 95 and Windows NT, the Control Panel applications view and update the System Registry.

INF Files

An INF file is an ASCII text file that contains directives that tell Windows how to install software. For example, under Windows 3.1, if you select the Drivers icon in the Control Panel, click on the Add... button to add a driver, and select the floppy disk as the driver source, the Drivers application looks for a file called OEMSETUP.INF. The OEMSETUP.INF file contains directive that indicate which files to copy from the disk, the destination directories for the files, what line to update or add in the SYTEM.INI file, and any other changes. If Drivers cannot find the OEMSETUP.INF file, it will complain. The driver software manufacturer provides the OEMSETUP.INF file.

Windows 95 also uses INF files.

Video Display

Videoconferencing systems make heavy use of the PC's video display: video adapter card and video drivers.

Video display drivers can contain subtle bugs that can conflict with applications, including the videoconferencing applications, causing many problems including general protection faults and updating problems on the screen. In general, make sure to have the latest drivers for a video card. Most major video card and video chip vendors provide drivers on their Web sites and ftp sites. Use the video card drivers rather than generic video chip drivers where possible. For example, for Diamond Multimedia video cards, both Diamond and S3, the manufacturer of the video chips used in the Diamond Multimedia video cards, provide video drivers. Diamond has substantially enhanced the drivers for Diamond cards over the drivers provided by S3.

It can be very unclear that a faulty display driver is the cause of a problem in a PC.

The digital video standards used in videoconferencing such as H.261 and H.263 work in the YCrCb color space rather than the RGB color space used by video cards and monitors. The latest generations of video chips provide hardware color space conversion. The chip converts the decoded video from the YCrCb (luminance-color difference) video into RGB in hardware, providing a substantial speedup. Many chips provide hardware accelerated scaling of images. The need or desire to install a video card with these advanced features may arise.

Under Windows 95, color space conversion and scaling are accessed through the DirectDraw API. The DirectDraw HAL (Hardware Abstraction Layer) provides the actual device driver. Under Windows 3.1, the standard Graphic Device Interface (GDI) provides no support for hardware color space conversion or scaling. The standard device drivers for video cards under Windows 3.1 are GDI device drivers. Intel defined a standard called DCI, Display Control Interface, that supports advanced features such as hardware color space conversion and scaling. Under Windows 95, the correct DirectDraw device driver for a video card must be installed to access the hardware color space conversion and scaling features. Under Windows 3.1 or Windows for Workgroups 3.11, a DCI driver must be installed to access these features. The videoconferencing application must support DirectDraw or DCI as appropriate. An application that uses the GDI calls cannot access the hardware acceleration features in general.

Videoconferencing applications often include documentation, readme files, and so forth that list known conflicts or problems with video display hardware and drivers.

Things To Do for Video Display Problems

- Reboot.

- Check for IRQ or other resource conflict.

- Check the videoconferencing system documentation for notes on problems with the video card.

- Make sure that you have the correct or latest version of the video display adapter device driver.

- Reinstall the video card using the Windows Control Panel.

- Reinstall the video card using the video card's installation program.

- On Windows 3.1, manually install the drivers by editing SYSTEM.INI (make backup of original SYSTEM.INI)

- Install a new or different video card.

Video Capture

Videoconferencing systems require a video capture system. A video capture system includes a video camera, typically an NTSC or PAL composite video camera, and a video capture card, either an ISA bus or PCI bus capture card. Usually, these are not provided pre-installed on the PC. Thus, installation of a videoconferencing system on a PC almost always involves installation of a video capture card and camera. Usually, the video capture hardware is provided with the video conferencing applications.

Installing a video capture card requires opening the PC case and inserting the card in an available ISA or PCI slot as available. Seating problems may occur, where the card appears to be seated in the slot but the electrical contact is imperfect or broken. In this case, the software will report a failure to find the video capture card, or other symptoms may occur.

The video capture card usually has either a composite video input or a composite and an S-Video input. The camera must be attached to this input. In some cases, the electrical connection will be imperfect even though the cables appear plugged in. In these cases, the installer must manipulate the cables until a working connection is established.

Some ISA video capture cards require selection of the IRQ interrupts through jumpers on the ISA board, although this is becoming less common. Other ISA cards may be configured through software. Plug and Play compliant ISA and PCI cards may sometimes experience resource conflicts due to bugs in the Plug and Play implementations.

Video capture is handled through Video for Windows drivers. The most recent version of the 16 bit Video for Windows for Windows 3.1 and Windows for Workgroups is Video for Windows 1.1e. A version of Video for Windows with 32 bit video compressors and unknown other differences from Video for Windows 1.1e ships with Windows 95. This Video for Windows (95) provides the video capture functions in Windows 95. ActiveMovie 1.0, which ships with Windows 95 OEM Service Release 2 (OSR2) and can be installed on earlier releases of Windows 95, does not provide any support for video capture. The video capture card installation software should install a Video for Windows video capture driver. This driver is identified by the line:

MSVIDEO=xxxx.drv

in the **[drivers]** section of the Microsoft Windows SYSTEM.INI file.

Things To Do for Video Capture Problems

- Reboot.

- Check for IRQ or other resource conflict.

- Check the cables connecting the camera to the video capture card. Jiggle and adjust the cables in case there is a faulty electrical connection.

- Check that the video capture card is properly seated in its' slot on the motherboard.

- Check the videoconferencing system documentation for notes on problems with the video capture card.

- Make sure that you have the correct or latest version of the video display adapter device driver.

- Reinstall the video card using the Windows Control Panel.

- Reinstall the video card using the video card's installation program.

- On Windows 3.1, manually install the drivers by editing SYSTEM.INI (make backup of original SYSTEM.INI)

- Install a new or different video card.

Audio Input and Output

Most PC's are equipped with sound cards or sound systems on the motherboard. Some video capture cards include sound playback and sound capture on the video capture card (for example, the MovieMan card). Some videoconferencing systems include an audio card for sound capture and playback (for example, Intel ProShare). If all goes well, the audio capture and playback required by a videoconferencing system will work flawlessly. Unfortunately, as with the video and networking components required by videoconferencing systems, installation and configuration problems may occur.

Under Windows 3.1 and Windows for Workgroups 3.11, audio input and output is handled through waveform audio devices, or WAVE. The Windows 3.1 and Windows 3.11 operating system sound system is usually referred to as WAVE. The sound device drivers are known as WAVE device drivers. There are also MIDI, MIXER, and AUX drivers as part of the Windows sound system, but these are less relevant to a videoconferencing system. Windows software applications capture or play audio through the waveform audio API. These functions, exported by the MMSYSTEM.DLL dynamic link library in Windows, include *waveIn...* and *waveOut...* functions. The wave API is supported in both 16 bit and 32 bit Windows programming.

Sound card manufacturers provide WAVE device drivers that allow MMSYSTEM.DLL to communicate with their hardware.

In Windows 3.1, the Windows multimedia system in turns calls a WAVE device driver. The WAVE device driver is specified by lines such as:

WAVE=moviea0.drv

WAVE=somecard.drv

in the **[drivers]** section of the SYSTEM.INI file. More than one waveform audio device may be installed, hence WAVE, WAVE1, WAVE2, etc. By default, Windows will select the best wave device for sound playback or capture.

The waveform audio drivers such as moviea0.drv in the example above (the driver for the sound features of the MovieMan board) are Windows dynamic link libraries that export functions that MMSYSTEM expects to find. These functions are specified in the Windows Device Driver Kit (DDK) and are also known as the Device Driver Interface or DDI. DLL's such as moviea0.drv handle the interface between MMSYSTEM.DLL and the device driver. The direct access to the soundcard hardware, hardware interrupt handling, and so forth is usually not handled in the DRV file. Instead, it is handled by a Windows VxD, Virtual Device Driver. A VxD is a low level Windows component that runs at a privileged level, bypassing the Windows scheduler and other features of Windows. A VxD can be truly preemptive unlike the cooperative multitasking of Windows applications and DLLs. The VxD is specified by lines such as:

device=movieman.386

in the **[386Enh]** section of SYSTEM.INI VxD's are usually identified by the file extensions .386 or .VXD

Windows 95 substantially complicates audio capture and playback. To maintain backward compatibility with Windows 3.1 applications and hardware, Windows 95 has a WAVE system. However, Windows 95 uses the Windows 95 System Registry where possible. Hardware and software developed specifically for Windows 3.1 will use the SYSTEM.INI file, but newer hardware and software will use the System Registry, but may still provide a WAVE audio driver.

Windows 95 adds a new sound system, in addition to WAVE, DirectSound which is part of DirectX. DirectSound includes a new API for playback of sound in applications. DirectSound also provides a new type of hardware device drivers, the DirectSound Hardware Abstraction Layer (HAL). A Windows 95 application may be written using the DirectSound API. DirectSound hardware drivers are not the same thing as WAVE hardware device drivers.

Under Windows 95, issues include is the application a WAVE application or a DirectSound application. Are the WAVE drivers correct and up to date? Are the DirectSound drivers correct and up to date? Which of the many versions of DirectX and DirectSound are installed on the Windows 95 Personal Computer.

As mentioned above, although Windows NT supports the same APIs as Windows 3.1 and Windows 95, the actual drivers that communicate with the sound hardware are different. Whereas a Windows 3.1 driver can work under Windows 95, Windows 95 and Windows NT *drivers* are not binary compatible. Microsoft hopes to make the Memphis and Windows NT 5.0 drivers binary compatibly, mostly by converting the Windows 95 driver system to the Windows NT driver system. Will this really make life easier? Probably not due to the need to still support WAVE, DirectSound drivers for Windows 95, and other complications.

Things To Do for Audio Problems

- Reboot.
- Check the speaker and microphone connections.
- Check that the sound card is properly seated in its slot on the motherboard.

- Check for IRQ or other resource conflicts between the sound cards and other devices in the system.

- Check the videoconferencing system documentation for notes on problems with the sound card.

- Make sure that you have installed the correct or latest version of the sound card device driver.

- Reinstall the sound card using the Windows Control Panel.

- Reinstall the sound card using the sound card's installation program.

- On Windows 3.1, manually install the drivers by editing SYSTEM.INI (make backup of original SYSTEM.INI)

- Install a new or different sound card.

TCP/IP Network

Entire books have been written on installing and configuring Personal Computers on TCP/IP networks.

Many videoconferencing systems work with only certain PC implementations of TCP/IP. If this happens to be the standard Microsoft TCP/IP implementations for Windows 95 or Windows for Workgroups, the better usually. But installing a videoconferencing system may require installation of TCP/IP on the PC's as well.

Typically, installation of TCP/IP requires:

- PC TCP/IP software

- IP Address for the PC

- Subnet Mask

- Broadcast Address for the PC

- IP Address of the Router or Gateway on the network

- IP Address of the Domain Name Server

- Network Interface Card and Drivers for the Network Interface Card

- Physical Interface to the Network (such as Ethernet tap)

At this point, most network card drivers are NDIS, Network Device Interface Specification, drivers. NDIS is a specification from Microsoft for network interface card drivers. TCP/IP network software is written to call NDIS drivers to translate IP into the underlying network card, usually Ethernet frames. There are different versions of NDIS, NDIS2.0 and NDIS 3.0 for example. An NDIS 5.0 is being developed.

Novel defined a network driver specification known as ODI, Open Datalink Interface. ODI drivers are occasionally used. A TCP/IP implementation, often known as a protocol stack, must be written to use ODI (or NDIS).

Installing and configuring TCP/IP networks is a large topic. Unfortunately, many of the problems with installing and configuring videoconferencing systems are problems with installing and configuring TCP/IP networks on PC's. An excellent book is:

Networking Personal Computers with TCP/IP, by Craig Hunt, O'Reilly and Associates, Cambridge, 1995

Things To Do for Network Problems

• First and foremost, use the PING command to verify a connection exists. PING the Gateway or another PC on the same physical network. If PING fails, then either the IP network is configured wrong (wrong router address, ip address, something) or something lower level such as a faulty network card installation has happened. If PING works, the problem is probably not the TCP/IP network even though you think it is. Though very simple, PING is the most useful tool for detecting and tracking network problems on a TCP/IP network.

• Check for IRQ or other resource conflict.

• Check that the network card is properly seated in its' slot on the motherboard.

• Check the videoconferencing system documentation for notes on problems with the network card.

• Make sure that you have the correct or latest version of the network card device driver.

• Reinstall the network card using the Windows Control Panel.

• Reinstall the network card using the video card's installation program.

• On Windows 3.1, manually install the drivers by editing SYSTEM.INI (make backup of original SYSTEM.INI)

• Install a new or different network card.

Videoconference Application

Videoconferencing Clients

Videoconferencing systems invariably come with installation or setup programs. These are often InstallShield or another commercial installation program. The setup program will install all software components including applications. The setup program frequently installs video capture and sound boards that come with the videoconferencing system.

Unfortunately, setup programs sometimes fail. When in doubt, uninstall the videoconferencing system and rerun the setup program. In a surprising number of cases, this will help.

Conference Manager

Many videoconferencing systems require an associated product usually known as a conference manager that runs on a server on the network. The conference manager manages the videoconferencing system and can limit the number of conferences to prevent network congestion. In some systems, the conference manager implements a name service or directory.

Frankly, conference managers add unnecessarily to the complexity of initial setup and configuration of the videoconferencing system. The main justification for such a tool is limiting network congestion. Initial users will establish only a few 1-500 Kbps video conference calls which rarely taxes an Ethernet. The conference managers should be an optional product or upgrade to be added when videoconferencing usage grows to the point where network congestion requires action. If a videoconferencing system is that popular, the action might be to upgrade the network rather than limit the number of calls.

Unfortunately, some of the videoconferencing systems, such as PictureTel's LiveLAN, absolutely require a conference manager running on a server. Fortunately, the conference manager is simply a network application. Most of the issues will be either the conference manager itself or setting up the server on the TCP/IP network.

CD-ROM Access

Most applications and operating systems are distributed on CD-ROMs. If the CD-ROM drive becomes inaccessible, then this is a major problem in many cases. It may be impossible to install the videconferencing application.

Conclusion

PC Videoconferencing systems over TCP/IP networks can involve extensive PC and network installation and configuration. Unfortunately, installation and configuration of hardware and software on PC's can be complicated. On the positive side, installation and configuration of hardware and software on PC's is not rocket science. There are a lot of steps, especially for a complex system like a videoconferencing product. Individually, the steps are simple, but many simple steps leads to a complex process. Support personnel or users must avoid being intimidated by either the number of steps or the frequently bizarre symptoms of installation problems on Windows.