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Home Windows CE Product Information Windows CE Features

## Multimedia on Windows CE

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### Abstract

This paper discusses the multimedia capabilities of Microsoft® Windows CE 3.0 and the similarities and differences with other Microsoft Windows® operating systems.

### Overview

The digital revolution has taken the consumer electronics space by storm. Digital cable set top boxes offering hundreds of channels are quickly replacing older, analog cable boxes. Portable and even wireless digital audio and video players offer multiple hours of music playback at a much higher sound quality and fraction of the size of a portable tape player. The overall change in consumer electronics devices from analog to digital is both a radically new phenomenon and a natural evolution. Because of this evolution, it is now generally accepted that the PC will no longer be the only source for digital multimedia.

How does Windows CE fit into this picture? Windows CE now provides many of the rich multimedia capabilities found on PCs, but does so with smaller, more configurable components. These components can run on many of the high-performance CPUs supported by Windows CE. The modularity of Windows CE gives you flexibility in choosing which components your platform uses. When building an operating system image for your hardware using Platform Builder, you can decide whether you want a particular DirectX® or user interface component, communications protocol, or file system. This kind of flexibility allows you to ship only those technologies you are actually using on your platform, saving space and reducing complexity.

Windows CE 3.0 provides a complete solution for developing the next "killer" consumer appliance or application. A robust, powerful real-time operating system now provides a rich set of components for enabling digital multimedia devices.

If you're an Original Equipment Manufacturer (OEM), you can use Windows CE to develop flexible Internet or local storage Windows Media Audio (WMA) and Windows Media Video (WMV) players, Internet portal, Digital TV, and Internet juke boxes, as well as, other consumer electronics providing the same consistent, high-quality, performance available with current hardware-based devices. An OEM can develop a system employing low-cost, targeted hardware accelerating selected DirectX components. These capabilities are then accessed

through DirectX and Windows Media™ Technologies. The real-time system characteristics available with Windows CE are essential for a software system to duplicate current hardware device quality and reliability. Windows CE 3.0 includes a full integration of DirectX and multimedia components into the core OS and Platform Builder.

### **DirectX and Windows Media Technologies**

DirectX gives a developer fast low-level access to a system's sound and graphics hardware while continuing to operate through the high-level features of Windows CE's Win32® interfaces. It lets you interact with video and audio hardware installed on your system in a device-independent manner. You can improve an existing device or implement a new system together with its driver, without having to rewrite your application code. In addition, by adding DirectShow® and Windows Media Technology, DirectX provides the developer easy APIs to stream, parse, decode, and render compressed multimedia audio and video data streams.

DirectX is built on Microsoft's Component Object Model (COM) and consists of a set of fast low-level libraries that you can call to create and use objects such as surfaces, palettes, textures, and sound buffers. Layered over these low-level interfaces are APIs for implementing consumer audio and video devices, as well as broadband and Internet multimedia streaming. When combined with the full suite of Windows CE communication APIs, complete support for Internet and wireless multimedia streaming is easily implemented by an OEM.

### **DirectDraw**

Windows CE DirectDraw offers fast access to display hardware for rendering multimedia graphics and video, while retaining compatibility with the Windows graphics device interface (GDI). DirectDraw® is a specialized memory manager for both system and display device memory, with hardware acceleration where available. This is important to you because before DirectX you couldn't access your display memory directly. With DirectDraw, you can allocate and manipulate memory in both system and graphics memory, including hardware-accelerated transfers between the two. This allows you to do bit block transfers (`bltspage` flips (synchronize to video display vertical refresh), and overlays (place one image surface over another on the video display), and alpha destination blending (blend pixels from two surfaces using the source alpha image component). Windows CE DirectDraw also supports video YUV pixel formats and color conversion, as well as direct video access to the framebuffer.

Windows CE DirectSound interfaces are generally fully consistent with the Windows DX 6.1 version of the APIs. Windows CE 3.0 includes support for `AlphaBlit` with an *Src over Dest* operation, which is the most generally useful operation for compositing a source image over a destination image. The operation can be repeated to composite a series of source images in back-to-front order into a single destination surface.

One way to think about this blending operation is as follows. When viewing a background or destination pixel value (`RGBdest`, `ALPHAdest`) stored in the DirectDraw primary surface through a translucent intermediate pixel (`RGBsrc`, `ALPHAsrc`) stored in another source DirectDraw surface, the combined source over destination blended pixel value is:

$$\text{RGBOver} = \text{ALPHAsrc} * \text{RGBsrc} + (1 - \text{ALPHAsrc}) * \text{RGBdest}$$

and

$$\text{ALPHAover} = \text{ALPHAsrc} * \text{ALPHAsrc} + (1 - \text{ALPHAsrc}) * \text{ALPHAdest}$$

Alpha blending can be performed only if the destination surface has a non-palettized pixel format such as RGB or YUV. The source surface for the blt may have either a palletized or a non-palletized format.

Even though Windows CE DirectDraw interfaces are generally fully consistent with the Windows version of the APIs, sometimes they can differ slightly. For example, surfaces are never lost in Windows CE under normal circumstances and interactions with GDI surfaces through non-GDI primaries can be different. Invalidation of Windows CE surfaces may occur when the display mode is changed or a surface in exclusive mode is created, loses or gains focus, or receives WM\_SYSCOMMAND or SC\_MONITORPOWER. All surfaces are invalidated on StartExclusiveMode.

Because a special interface IDirectDrawSurface5 has been added to support AlphaBlit, you will need to first create an IDirectDrawSurface4 and then QueryInterface for IDirectDrawSurface5.

DirectDraw 6.1 uniqueness values and multi-monitor capabilities are not supported because of the need to keep the system memory footprint as small as possible.

Windows CE DirectDraw includes sample DDHAL drivers (called DDGPE) for commercial graphics chips that an OEM can either use directly or modify to provide their own device drivers.

### **DirectSound**

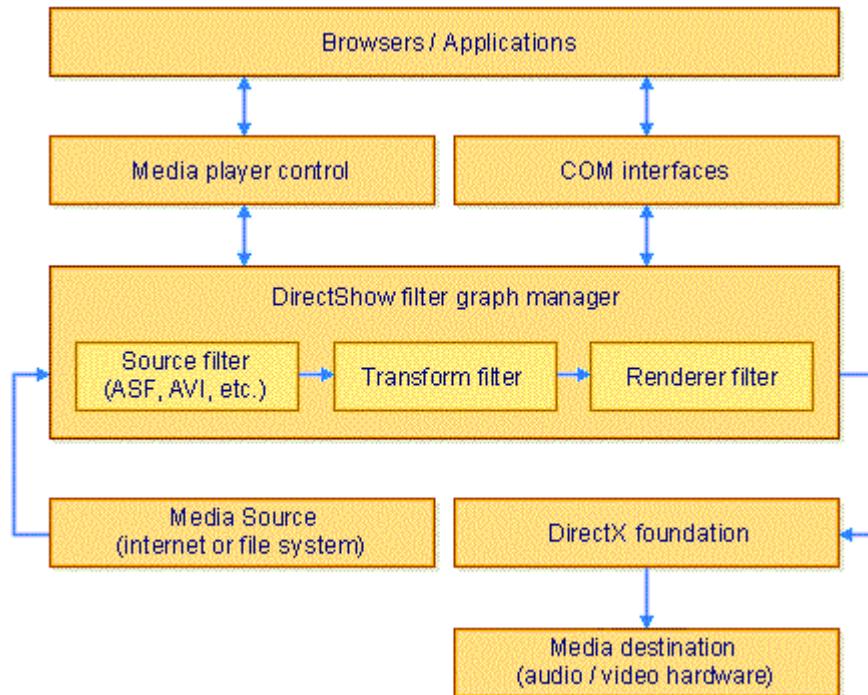
Windows CE DirectSound provides fast access to your audio rendering hardware and allows you to mix and play back audio data in a variety of formats, at various rates, and in either mono or stereo, as well as capture it. It stores individual sounds in separate buffers and can mix an arbitrary number of them together simultaneously to produce the desired output. The storage and mixing are done using pulse code modulation (PCM) to optimize processing throughput. With DirectSound®, you get low-level yet device-independent access to your sound device, enhanced automatically with hardware acceleration when it's available.

Windows CE DirectSound interfaces are generally fully consistent with the Windows DX 6.1 version of the APIs. Some minor differences can occur because the Windows and Windows CE driver models are not identical. For example, DirectSound buffers are never lost under normal condition and do not need to be restored. DirectSound 6.1 sound hardware memory compaction, 3-D sound capabilities, and IKsProperty sets are not supported.

Windows CE DirectSound includes sample DSHAL drivers for commercial several audio chips that an OEM can either use directly or modify to provide their own device drivers.

### **Windows Media Fundamentals**

Windows CE DirectShow provides the foundation for multimedia services on Windows CE. Using DirectShow, it is easy to provide the user with a rich multimedia experience. In addition, a communication structure has been built on top of DirectShow to make the application developer's job easier. How everything fits together is illustrated in the following diagram:



The application either has the Window Media Player (WMP) control embedded within it, or communicates via COM with the DirectShow Filter Graph Manager interfaces (sometimes directly with the filters themselves). In either case, DirectShow manages the flow of data from the source to the hardware. What follows is a look at the sections the application developer needs to understand: the WMP control, WMT, and DirectShow.

### **Windows Media Player Control**

Recognizing the importance of multimedia playback control to viewing Web content, Microsoft created the Windows Media Player (WMP) control. This technology enables the Windows Media Player functionality to exist as a Microsoft ActiveX control inside a Web page along with other content and hosted by the Windows CE Web browser. The WMP control is a versatile tool for presenting local and streaming multimedia files. Combined with DirectShow, it supports Windows Media Technologies and other major media file formats, including Windows Media Container files (.ASF and .ASX files, as well as the older .AVI files), Motion Pictures Experts Group (MPEG- 1 and MPEG-4) formats (MPG and MPE files), and audio formats such as MP3, MIDI, WAV, and AIFF. All these file formats can be streamed from locally stored files using just the WMP control, and, when combined with the Microsoft Windows Media Technologies, streaming over networks is supported.

The Windows Media Player control for Windows CE is almost identical to the version of the control that is available for x86-based PCs. Windows CE provides a subset of the desktop WMP control's features that enable a smaller, robust control yet encapsulating all the key features of the WMP control required by embedded devices. In addition, the Windows CE WMP control supports an essential subset of the properties, methods, and

events from the desktop control. There is no support for backward compatibility with the older NetShow® player control since this functionality has been encapsulated in the WMP control. In addition, certain UI elements, such as the context menu, Display panel, Closed Captioning panel, and Go To Bar, are not supported, but can be easily supported on a Web page using scripting.

PPT streaming or hotspots ASF authoring features are not supported. With URL flipping, it is still possible to have the WMP control playing media in one frame while displaying slides or other graphics in another frame. Clickable hotspots can turn images or video clips into hyperlinks or script locations and can also be implemented with the proper usage of URL scripting commands embedded at certain times in an ASF file.

If you are trying to build a device or application that supports all existing Internet media content, you must make sure the control recognizes and correctly handles all the different ways to deliver content over the Internet. The WMPHLPR sample provides an example of how to enable the WMP control to playback media accessed via the Anchor (<A>) tag. Using this sample, when a user clicks on a media file link, the browser navigates to a page that hosts the control. The media file is passed to the control and playback begins from within the browser. This behavior is quite useful for set-top boxes, Internet portal devices, or any other device with either limited memory or a desire to run completely within a single window.

Windows CE 3.0 also provides a WMP sample application. This stand-alone application hosts the WMP control to provide media playback. This is useful in those situations where a browser is not necessary.

### **Windows Media Technologies**

Windows CE Window Media Technologies (WMT) is a set of COM interfaces and codecs that support a broad range of server and client applications that stream audio, video, and script commands as a continuous flow of data.

Today, Windows CE supports client playback using advanced Windows Media formats and major codecs, such as Windows Media Audio, Microsoft MPEG-4 video, and Sipro ACELP.net low bit-rate speech.

What follows is a look at the formats, features, protocols, and codecs supported by WMT on Windows CE. Occasionally, the Windows CE implementation of WMT differs from other versions of Windows. When this is the case, the differences and their workarounds are discussed.

### **Windows Media Formats**

To store and stream data, WMT uses the Advanced Streaming Format (ASF). ASF is an application level multimedia transmission file format (as opposed to a wire or transmission control format) for arranging and organizing synchronized multimedia data. ASF supports media data delivery over a wide variety of networks, network bandwidths, and protocols. It is optimized for streaming multimedia packets over both low bit-rate and broadband networks.

Windows CE also supports the Advanced Stream Redirector v3 (ASX) and Windows Media Station (NSC) metafiles. The ASX metafile provides mechanisms by which a client can support hyperlinks to streams, support specification of multiple pieces of source content, and the protocol rollover rules the client will use to process them, as well as support for media playlists.

The Microsoft Windows Media Station metafile serves to describe a particular channel to an ASF client wishing

to access that channel. The model for access to a channel is similar to a television accessing a broadcast channel. This metafile is used for multicasting support.

#### **Windows Media Features**

Windows CE provides WMT client DirectShow filters that allow playback of ASF streams sent using UDP, TCP, and HTTP protocols (as described in the next section on protocols). Windows CE WMT supports smart streaming using a multi-data rate encoded ASF file, where multiple streams with different bit rates are created in one ASF file and the client negotiates with the server for the appropriate stream. The server then automatically adjusts the stream depending on playback conditions and can select from multiple video streams based on available network bandwidth.

With smart streaming, the Windows CE WMT client can dynamically thin the stream based on the available bandwidth using an algorithm that adjust delivery smoothly from full frames down to key-frame only. If necessary, the WMT client can ask the server to send only audio and no video packets. As bandwidth is reduced, audio is always given the highest priority since it is usually critical to the user experience. As network bandwidth conditions improve, WMT can progressively step the video bit-rate back up to restore the viewing to an optimal level. In addition, the WMT UDP resend capability allows the client, if time is available, to request missing packets from the server. Finally, WMT also provides ASX event-driven stream switching where the client sends ASX control commands to the server.

Windows CE WMT does not support older ASX v2.0 or v1.0 formats. All of the functionality of these earlier versions has been encapsulated into ASX v3.0. The **PREVIEWDURATION**, **BANNER**, or **LOGO** ASX elements are not supported for Windows CE. Preview mode can be implemented within an application using the WMP control by providing access to playback control via scripting. The functionality of the **BANNER** and **LOGO** elements can be implemented through DHTML and scripting.

Windows Media Technologies for Windows CE provides support for Authentication. Authentication involves user validation before any information exchange takes place. When a client initiates a request to the server that has authentication enabled, the server challenges the client to confirm its identity. Typically, this amounts to inspecting the name and password of the user account under various authentication protocols. For any given interaction, both client and server must adhere to one agreed protocol. The WMT supports the following two protocols, HTTP-Basic for Internet applications and NTLM which is suitable for Intranet applications.

On the desktop NTLM uses authentication information established when the user logs on, it requires the client and server to be on the same or trusted domains. Since Windows CE does not allow a user to log in, the WMT pops up a dialog box to extract the authentication information when NTLM authentication is required.

#### **Windows Media Protocols**

The following protocols are supported by the WMT: multicasting, local file streaming, HTTP streaming, and MMS streaming.

Multicast enables the client to receive multicast streams. It allows the administrator to send one copy of the content to many users on the network, as long as that network is multicast-enabled. IP Multicast streaming is done through ASF with the Microsoft Windows Media Station Metafile. Networks that are not multicast-enabled and ASF files not being streamed from a Windows Media server are sent through unicast. Unicast means that

one stream is sent for every request.

WMT can provide local file streaming for systems with persistent storage. Data is read from persistent storage into a buffer in main memory and rendered. Local file streaming provides lower latency and a significant physical memory savings over reading the entire ASF file from the persistent store into main physical memory before rendering the file.

MMS is Microsoft's proprietary protocol for streaming media. A typical MMS session uses a TCP connection for sending and receiving media control commands, and a UDP or TCP connection for streaming the data. Invoking the MMS protocol using **mms://** invokes the protocol rollover mechanism. The client first tries to receive the stream through UDP. If UDP does not work, the stream automatically rolls over to TCP transmission. Finally, if TCP does not work, the client will try to receive the stream through HTTP. *MMSU* enables the client to receive streams through UDP. It is well suited to audio because it sends packets regardless of connection quality. Therefore, users hear fewer delays or pauses. If time allows, missed packets are requested and resent. *MMST* enables the client to receive streams through TCP. TCP forms a reliable stream—if packets are lost, the stream stops and lost packets are recovered. Users experience more delays and pauses over a network that is congested when using MMST.

A regular HTTP server can be used to deliver ASF data streams but there are several reasons to use the Windows Media Server instead. The packets within an ASF data stream must be delivered sequentially, one per network packet, for the full benefit of data streaming to be realized. Only an ASF-compatible server such as Windows Media Server will avoid fragmentation by transmitting ASF packets one at a time, encapsulated neatly within individual Internet or other network protocol packets. The error correction, streaming playback, and bit-rate optimization inherent to ASF depend on the client and server not having to figure out where ASF data packets begin and end on the fly. An HTTP server doesn't have this ability because it doesn't recognize the significance of ASF packets; it just shoves data to the client as quickly as possible by filling each network packet with an arbitrary amount of data. Additionally, several features of Windows Media, such as the ability to fast-forward or rewind ASF data streams, are not available on a regular Web server.

#### **Windows Media Codecs**

The following list shows the supported codecs that can be contained within an ASF file. Windows CE WMT will only support content that is created with the Windows Media Tools. The Windows Media Encoder uses templates to encode live source or AVI, WAV, or MP3 content into ASF formats with the codecs listed in the table below. The templates also provide the option of using other codecs, but DirectShow for Windows CE only supports WMT codecs. While other codecs that are supported by DirectShow for Windows CE (such as Cinepak or MPEG-1) can be created within an ASF file using other authoring tools, there can be no guarantee as to their streaming performance, and their use is not recommended.

- Windows Media Video (includes ISO MPEG-4)
- Windows Media Audio
- Voice Age (Sipro) ACELP.net
- MPEG-1 layer 3

The componentization of the WMT for Windows CE allows you to build a fully customizable streaming media client that is tailored to your specific streaming environment. The WMT for CE has been fragmented such that you can decide which components to include in your application. Each of the following components can be selected as appropriate:

- MMS streaming
- HTTP streaming
- File streaming
- Broadcast and Multi Bit Rate Streaming
- Windows Media Station support
- ASX support
- Codecs

### **DirectShow**

DirectShow provides the underlying services for playback of multimedia streams either from local files or over a network from a server. Specifically, DirectShow enables playback of video and audio content compressed in various file and streaming formats, including Windows Media, MPEG, Audio-Video Interleaved (AVI), and WAV.

Applications control filter graph activities by communicating with the filter graph manager. You can do this either indirectly by using the Microsoft Windows Media Player control, or directly by calling COM interface methods.

At the heart of the DirectShow, services are modular sets of pluggable components called filters that can be arranged depending upon media type into a connected configuration called a filter graph. Filters operate on data streams to read, parse, decode, format, or render them.

Filters are arranged in a configuration called a filter graph, controlled by the Filter Graph Manager (FGM). A DirectShow filter graph (see Figure 1) consists of a directed sequence of filters from source to final renderers all connected by input and output filter pins. Filter pins negotiate which media types they will support. The FGM controls the multimedia data flow between the graph filters. Because DirectShow has a flexible, re-configurable filter graph architecture, DirectShow can support playback and streaming of many media types using the same software components. Developers can also extend DirectShow multimedia support by writing their own filters.

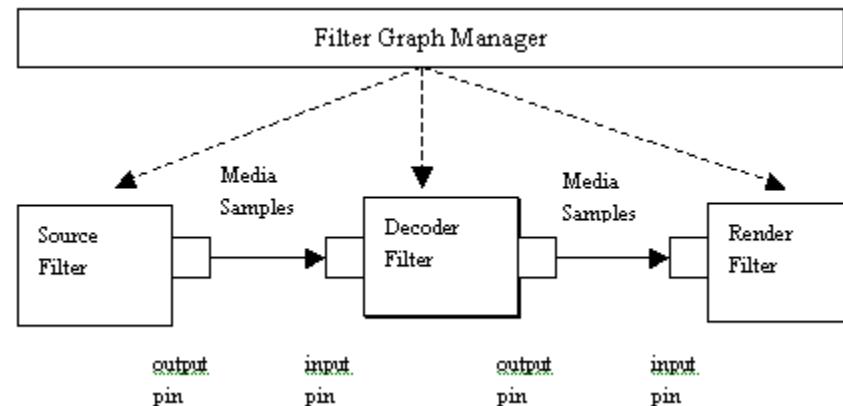


Figure 1 – DirectShow Filter Graph

### **Filters**

Filters are registered DirectShow classes and perform most media processing tasks. Filter tasks include:

- Source acquisition (e.g., acquire a media stream)
- Parsing (e.g., perform packet reading, splitting, and formatting on the stream)
- Transformation (e.g., decode WMA and MPEG-4 audio and video streams), and
- Rendering (e.g., generate audio PCM or video RGB/YUV output at the right time and pass data on to DirectSound and DirectDraw)

Filters use several types of interfaces, such as pins, enumerators, transports, and clock interfaces to perform their tasks. Filters implement and expose numerous interfaces. The FGM uses these interfaces to create, connect, and control the graph. A filter will always implement the **IBaseFilter** interface that contains methods to:

- Run, stop, and pause filter state
- Retrieve filter and vendor information
- Get and set the reference clock
- Retrieve filter state information
- Enumerate filter pins
- Locate pins when rebuilding a filter graph

### **Supported Filters**

Windows CE 3.0 provides the following DX 6.1 DirectShow filters:

- Source Filters - File Source (Asynchronous and URL)
- Parsers and splitters - MPEG-1 Stream Splitter, AVI Splitter, QuickTime Parser, WAVE Parser, MIDI Parser, ASF Parser
- Decoders - MSAudio Decoder, MPEG-1 Audio Decoder, MPEG-1 Video Decoder, MPEG-4 Video Decoder, AVI Decompressor, ACM Audio Decompressor
- Renderers - Audio Renderer (using WaveOut), DirectSound Audio Renderer, MIDI Audio Renderer, Video Renderer (using either DirectDraw or GDI)
- Miscellaneous filters - Overlay Mixer

In order to support streaming of Windows Media Formats, special ASF/ASX streamer source and WMA codec transform filters are provided. In addition, the Fraunhofer IIS MP3 audio and Voice Age (Sipro) ACELP.net speech codecs use the Audio Compression Manager (ACM) wrapper Audio Decompressor transform filter.

### **For More Information**

You can find additional information about Windows CE features in the [Windows CE Product Information](#) section of this Web site.

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