CHAPTER 16: THE PALETTE MANAGER - UNVEILING THE WORLD OF 256 COLORS

This chapter delves into the realm of the Windows Palette Manager, a tool born out of necessity due to certain hardware limitations.

A paletter lookup table on video boards works like:



While modern video adapters often support higher color depths like 24-bit or 16-bit, certain setups, particularly on laptops or in high-resolution modes, are constrained to 8 bits per pixel. This limitation translates to a palette of only 256 simultaneous colors.

The question arises: What can be accomplished with a palette of 256 colors? While 16 colors are insufficient for displaying realistic images, and thousands or millions of colors are more than ample for such tasks, the middle ground of 256 colors presents unique challenges.

To effectively showcase real-world images with this limited palette, colors must be carefully selected for each specific image. A one-size-fits-all "standard" set of 256 colors isn't feasible, as it won't cater to the diverse needs of every application.

Enter the Windows Palette Manager. This tool is designed for precisely specifying the colors required by a program when operating in an 8-bit video mode.

If your programs exclusively run in higher bit depths, you may not encounter the need for the Palette Manager. Nevertheless, this chapter holds valuable insights, particularly in tying up loose ends related to bitmap handling.

Key Points:

Hardware Limitations: Certain video adapters restrict color depth to 8 bits per pixel, allowing only 256 colors simultaneously.

Palette Manager's Purpose: Tailored for programs operating in 8-bit video modes, the Palette Manager enables the specification of essential colors.

Color Selection Challenge: Unlike higher color depths, where a standard set suffices, 256 colors require careful curation for each application's unique needs.

Understanding the Palette Manager is crucial for developers navigating the constraints of 8-bit video modes.

While it may not be applicable in all scenarios, its insights into color management are invaluable, especially when working with real-world images in resource-limited environments.

The 20 reserved colors in 256-color video modes:



The 20 reserved colors in 256-color video modes are part of the Windows Palette Manager, and they serve as standard colors that are predefined for system use. These colors are reserved to maintain consistency across applications running in an 8-bit video mode. Here is a description of each of the 20 reserved colors:

1. Black (Pixel Bits: 00000000, RGB Value: 00 00 00)
2. Dark Red (Pixel Bits: 00000001, RGB Value: 80 00 00)
3. Dark Green (Pixel Bits: 00000010, RGB Value: 00 80 00)
4. Dark Yellow (Pixel Bits: 00000011, RGB Value: 80 80 00)
5. Dark Blue (Pixel Bits: 00000100, RGB Value: 00 00 80)
6. Dark Magenta (Pixel Bits: 00000101, RGB Value: 80 00 80)
7. Dark Cyan (Pixel Bits: 00000110, RGB Value: 00 80 80)
8. Light Gray (Pixel Bits: 00000111, RGB Value: C0 C0 C0)
9. White (Pixel Bits: 11111111, RGB Value: FF FF FF)
10. Cyan (Pixel Bits: 11111110, RGB Value: 00 FF FF)
11. Magenta (Pixel Bits: 11111101, RGB Value: FF 00 FF)
12. Blue (Pixel Bits: 11111100, RGB Value: 00 00 FF)
13. Dark Gray (Pixel Bits: 11111000, RGB Value: 80 80 80)
14. Medium Gray (Pixel Bits: 11110111, RGB Value: A0 A0 A4)
15. Cream (Pixel Bits: 11110110, RGB Value: FF FB F0)
16. Sky Blue (Pixel Bits: 11110101, RGB Value: A6 CA F0)
17. Money Green (Pixel Bits: 11110100, RGB Value: C0 DC C0)
18. Reserved
19. Reserved
20. Reserved

In 256-color display modes, Windows manages a system palette that mirrors the video card's hardware color lookup table. This system palette controls the available colors for display.

By default, Windows provides a specific set of colors as the system palette, which is depicted in Figure above.

It holds 256 colors, 20 of which are fixed for system elements, while applications can customize the remaining 236.

Applications can adjust these colors using logical palettes. If multiple applications use logical palettes, Windows prioritizes the active window (the one in the foreground with a highlighted title bar), ensuring its color choices take precedence.

In scenarios where multiple applications are using logical palettes simultaneously, Windows gives the highest priority to the active window.

The active window refers to the window that currently has the highlighted title bar and appears in the foreground of all other windows.

This ensures that the active application's color choices take precedence over other applications, providing a consistent and coherent visual experience.

To explore this concept practically, we'll examine a sample program later in this chapter. To align with these examples, consider switching your display to 256-color mode.

Access display settings by right-clicking on your desktop, selecting "Properties," and choosing the "Settings" tab.

Key points:

* System palette: Master color table for Windows in 256-color modes.
* Logical palettes: Application-specific color customizations.
* Active window priority: Windows prioritizes the active application's colors.
* Switching to 256-color mode: Recommended for compatibility with examples.

Additional notes:

* While modern systems often use higher color depths, understanding system palettes is still relevant for legacy applications and specific development scenarios.
* The specific process for adjusting display settings may vary slightly depending on your Windows version.

GRAYS1 PROGRAM



The GRAYS1 program is designed to display 65 shades of gray as a "fountain" of color, ranging from black to white. It does not use the Windows Palette Manager but instead directly creates and fills rectangles with varying shades of gray.

The program starts by defining the necessary headers and function prototypes. It then defines the WinMain function, which is the entry point of the program. Inside WinMain, the program registers a window class, creates a window, and enters the message loop.

The WndProc function is the window procedure for handling messages related to the program's window. It handles messages such as WM\_SIZE, WM\_PAINT, and WM\_DESTROY.

In the WM\_SIZE message case, the cxClient and cyClient variables are updated with the width and height of the client area of the window, respectively.

In the WM\_PAINT message case, the program prepares to paint the window. It begins by obtaining a device context (hdc) and a paint structure (ps) using the BeginPaint function. Then, a loop is executed 65 times to create and fill rectangles with varying shades of gray.

Inside the loop, the rect structure is defined to represent the dimensions of each rectangle. The left and right coordinates of the rectangle are calculated based on the current iteration and the total number of shades. The top and bottom coordinates are set to cover the entire height of the client area.

A brush (hBrush) is created using the CreateSolidBrush function, specifying the RGB values for the gray color. The RGB values are derived from the current iteration to create a gradient effect.

The FillRect function is then used to fill the current rectangle with the gray color represented by the brush. After filling the rectangle, the brush is deleted to release the associated resources.

Finally, the program calls EndPaint to signal the end of the painting process and returns 0 to indicate that the message has been handled.

In the WM\_DESTROY message case, the program posts a quit message to exit the message loop and terminate the program.

If any other messages are received or not handled in the WndProc function, the program calls DefWindowProc to perform the default window procedure for those messages.



*Let's dive deeper into the GRAYS1 program and explore the section where color palettes are mentioned.*

In the given code, the GRAYS1 program does not use the Windows Palette Manager. Instead, it directly creates and fills rectangles with varying shades of gray using the RGB color model.

The concept of color palettes in computer graphics refers to a limited set of colors that are available for use in a particular system or application. In the Windows operating system, a palette is a data structure that holds a fixed number of colors, typically 256 colors. The Windows Palette Manager is responsible for managing and mapping colors from the system palette to the colors used by an application.

However, in the GRAYS1 program, the focus is on displaying shades of gray rather than utilizing a predefined color palette. The program achieves this by dynamically calculating and creating shades of gray using the CreateSolidBrush function and RGB values.

Within the WM\_PAINT message case, a loop is executed 65 times to create 65 rectangles, each representing a different shade of gray. The RGB values for each shade are calculated as min (255, 4 \* i), where i is the current iteration of the loop.

By multiplying i by 4 and clamping the result to a maximum of 255, the program ensures that the RGB values stay within the valid range for a grayscale color. This calculation creates a gradient effect, where the shades of gray become progressively lighter as i increases.

The CreateSolidBrush function is then used to create a brush with the calculated RGB values, representing the current shade of gray. The FillRect function fills the current rectangle with the gray color represented by the brush.

It's important to note that by creating and using brushes directly, the GRAYS1 program bypasses the Windows Palette Manager and the limitations of a fixed color palette. Instead, it dynamically generates and displays the shades of gray as a "fountain" of color in the client area of the window.

This approach allows for greater flexibility in displaying a wider range of shades and gradients, as it leverages the full RGB color space rather than being constrained by a predefined palette.

Here's a clearer and more concise explanation of the program's behavior in 256 color mode:

During the WM\_PAINT message, the program paints 65 rectangles using different gray shades, ranging from black to white.

Dithering: To achieve these shades, Windows employs a technique called "dithering." It blends combinations of the four pure colors available in the system palette (black, dark gray, light gray, and white) to simulate additional shades, resulting in a grainy pattern.

Lines and text: In contrast, lines and text in Windows are typically drawn using only the pure colors, without dithering.

Bitmaps: When displaying bitmaps in 256-color mode, Windows approximates them using the 20 standard system colors, often leading to color inaccuracies. Dithering is not typically applied to bitmaps.

Palette Manager functions and messages: The GRAYS2 program, featured in Figure 16-3, demonstrates key concepts of color management in Windows through the use of Palette Manager functions and messages.

Key takeaways:

Limited color palette: In 256-color mode, Windows has a restricted set of colors.

Dithering for filled areas: Windows uses dithering to simulate additional colors within filled areas.

Pure colors for lines and text: Lines and text are drawn using only the pure colors available in the system palette.

Color approximations for bitmaps: Bitmaps are approximated using the standard system colors, often resulting in inaccuracies.

Palette Manager for color control: The Palette Manager functions and messages provide a way for applications to manage color palettes in Windows.

The GRAYS2 program is a Windows application that displays a gradient of gray shades using the Palette Manager. Let's break down its functionality into paragraphs:

GRAYS2 PROGRAM





Application Structure:

The program is structured as a Windows application with a standard WinMain function and a window procedure (WndProc).

It defines a window class (WNDCLASS) with basic attributes such as the window procedure, background brush, icon, and cursor.

Palette Initialization (WM\_CREATE):

Upon window creation, the program sets up a LOGPALETTE structure to define a custom palette containing 65 shades of gray.

Each palette entry is assigned RGB values representing varying intensities of gray.

The CreatePalette function is then called to create a logical palette based on the provided information.

Handling Window Size (WM\_SIZE):

The program handles the WM\_SIZE message to update the client area dimensions whenever the window is resized. This information is crucial for drawing the gradient.

Painting the Gradient (WM\_PAINT):

In response to the WM\_PAINT message, the program begins painting by obtaining a device context (HDC) using BeginPaint.

It selects the custom palette into the device context and realizes the palette to make it effective for the current device.

The gradient is drawn by creating a series of rectangles, each filled with a solid brush of a specific gray shade. The shades vary from black to white.

Palette Interaction (WM\_QUERYNEWPALETTE, WM\_PALETTECHANGED):

The program handles palette-related messages to ensure proper interaction with the system and other applications.

WM\_QUERYNEWPALETTE is used to respond to a request for palette selection, indicating whether the application has a palette to select.

WM\_PALETTECHANGED is used to handle changes in the system palette, updating the application's palette if necessary.

Cleanup on Window Destruction (WM\_DESTROY):

Upon window destruction, the program deletes the logical palette using DeleteObject and posts a quit message to terminate the application.

The Palette Manager plays a crucial role in managing colors in Windows applications, particularly when dealing with limited color environments such as 8-bit video modes.

The GRAYS2 program exemplifies the use of the Palette Manager to create a logical palette and display a gradient of gray shades. Let's delve into the detailed explanation:



Creating a Logical Palette:

The initial step involves creating a logical palette using the CreatePalette function.

In the WM\_CREATE message handler, the program initializes a LOGPALETTE structure to define its custom palette. The structure includes a version, the number of entries, and an array of PALETTEENTRY structures.

Each PALETTEENTRY structure represents an RGB color value. The program sets up 65 shades of gray, calculating the appropriate intensity values and storing them in the palette.

Palette Initialization Details:

The LOGPALETTE structure is defined with compatibility information and an array of PALETTEENTRY structures.

Each PALETTEENTRY structure consists of red, green, and blue color components, each represented by a byte. The peFlags field is set to 0.

Memory is allocated for the LOGPALETTE structure and additional PALETTEENTRY structures to accommodate the desired number of shades.

Palette Selection and Realization:

During the WM\_PAINT message processing, the program selects the logical palette into the device context using SelectPalette. The logical palette is then "realized" in the device context using RealizePalette.

Selecting a palette into the device context is crucial for the system to map the colors to the actual physical palette of the video board.

The SelectPalette function returns the handle of the previous logical palette, allowing for restoration if needed.

Color Specification and Use of PALETTERGB:

The program continues to use the familiar RGB macro to specify colors in the logical palette. However, it introduces the concept of "Palette RGB" values using the PALETTERGB macro.

A "Palette RGB" color is similar to an RGB color but with the high byte of the COLORREF value set to 2.

Rules are provided for using colors in the logical palette, emphasizing the need to specify colors using Palette RGB values or Palette Index values when working with a selected palette.

Handling Palette Management Support:

Notably, the program does not explicitly check whether the video display driver supports palette management.

In scenarios where palette management is not supported (non-256 color video modes), the program functions similarly to a version (GRAYS1) that does not utilize the Palette Manager.

In essence, GRAYS2 demonstrates a meticulous process of creating, selecting, and realizing a logical palette to effectively manage and display a gradient of gray shades, showcasing the nuanced interaction with the Palette Manager in a Windows environment.

LOGICAL PALETTE DEFINITION:



In the provided code snippet, we're dealing with the implementation of the Windows Palette Manager in the context of the GRAYS2 program. Let's break down the code and discuss its functionality in the context of logical palettes, color representation, and palette management.

The LOGPALETTE structure is a fundamental part of Windows Palette Manager. It holds information about a logical palette, including the palette version, the number of entries, and an array of PALETTEENTRY structures. Each PALETTEENTRY structure represents an RGB color value and flags.

Palette Entry Structure:

The PALETTEENTRY structure defines individual entries within the logical palette. It consists of fields representing the red, green, and blue color components, along with additional flags.

Logical Palette Creation:

The GRAYS2 program dynamically allocates memory for the LOGPALETTE structure, including space for an array of PALETTEENTRY structures. It then initializes the logical palette by setting the version, the number of entries, and RGB color values for each entry in a loop. The logical palette is created using the CreatePalette function, and memory is freed after its creation.

WM\_PAINT Handling:

When handling the WM\_PAINT message, the program begins painting by obtaining the device context (hdc) using BeginPaint. It then selects and realizes the logical palette in the device context using SelectPalette and RealizePalette. This step is crucial for mapping the colors in the logical palette to the system palette, aligning them with the physical palette of the video board.

The program proceeds to draw a "fountain of grays" by iterating over the 65 shades defined in the logical palette. For each shade, it creates a solid brush using the CreateSolidBrush function and the PALETTERGB macro. This macro is used to specify colors from the logical palette, ensuring that the additional colors are utilized. The drawn rectangle is then filled with the brush, and the brush is appropriately deleted.

Finally, the painting process is concluded using EndPaint.

Explanation Summary:

In summary, the provided code demonstrates the creation and utilization of a logical palette in the GRAYS2 program. This logical palette is essential for managing and displaying a range of gray shades, and the program ensures proper integration with the Windows Palette Manager during the painting process.

PALETTE MANAGER PRIORITY AND COLOR MAPPING:

In a multi-program environment using the Palette Manager, the active window takes precedence over the palette. The system prioritizes the most recently active window and subsequent windows accordingly.

When a new program becomes active, the Windows Palette Manager may need to reorganize the system palette table.

If a program defines a color in its logical palette identical to one of the 20 reserved colors, Windows will map that logical palette entry to the corresponding reserved color.

Moreover, if multiple applications specify the same color in their logical palettes, they will share the system palette entry.

The program can influence this behavior by using the PC\_NOCOLLAPSE flag in the peFlags field of the PALETTEENTRY structure.

Palette Manager Messages:

Two crucial messages, WM\_QUERYNEWPALETTE and WM\_PALETTECHANGED, are integral to organizing the system palette.

WM\_QUERYNEWPALETTE:

Sent to a main window when it is about to become active, this message requires processing by programs utilizing the Palette Manager.

In the context of GRAYS2, the program handles this message by obtaining a device context handle, selecting the palette into it, calling RealizePalette, and then invalidating the window to trigger a WM\_PAINT message.

The window procedure returns TRUE if it realizes its logical palette and FALSE otherwise.

WM\_PALETTECHANGED:

When the system palette changes due to a WM\_QUERYNEWPALETTE message, Windows sends the WM\_PALETTECHANGED message to all main windows, starting with the most active window.

The wParam value passed to the window procedure is the handle of the active window.

A program should process this message only if wParam is not equal to the program's window handle.

Generally, programs using a customized palette call SelectPalette and RealizePalette while processing this message.

System Palette Organization:

Upon subsequent calls to RealizePalette during the WM\_PALETTECHANGED message, Windows checks for matches of RGB colors in the logical palette with those already loaded in the system palette.

If two programs require the same color, the same system palette entry is shared. If no unused system palette entries exist, the color in the logical palette is mapped to the closest color from the 20 reserved entries.

Handling WM\_PALETTECHANGED:

For programs concerned about the appearance of the client area when inactive, processing the WM\_PALETTECHANGED message is essential.

GRAYS2 demonstrates one approach by obtaining a device context, selecting the palette into it, and calling RealizePalette.

Instead of calling InvalidateRect, GRAYS2 opts for UpdateColors, a function typically more efficient than repainting the window.

It changes the values of pixels in the window to help preserve the previous colors.

GRAYS3 PROGRAM



In the GRAYS3 program, several changes and enhancements have been introduced compared to GRAYS2, primarily focusing on how colors are managed and displayed using the Palette Manager. Let's delve into the key modifications:



Palette Management Approach:

Instead of using the PALETTERGB macro as in GRAYS2, GRAYS3 employs the PALETTEINDEX macro during the WM\_PAINT message processing. This macro is used to specify colors based on the index within the logical palette.

Palette Entry Specification:

The program still creates a logical palette using the LOGPALETTE structure, similar to GRAYS2. The palette consists of 65 entries, each representing a different shade of gray. The entries are specified with varying levels of red, green, and blue components, providing a gradient effect.

Palette Realization in WM\_PAINT:

During the WM\_PAINT message processing, the program selects the logical palette into the device context and calls RealizePalette to map the colors to the system palette. However, in GRAYS3, the colors are drawn using the PALETTEINDEX macro, indicating an index within the logical palette, which simplifies color specification.

Drawing with PALETTEINDEX:

The fountain of grays is drawn in the client area of the window using a loop. For each iteration, a rectangle representing a segment of the window is filled with a solid brush created using the PALETTEINDEX macro. This approach directly references the index in the logical palette to determine the color.

Handling Palette Change Messages:

The program responds to the WM\_QUERYNEWPALETTE message, which is sent when the window is about to become active. In this case, it obtains the device context, selects and realizes the palette, and invalidates the window to trigger a repaint.

Additionally, the WM\_PALETTECHANGED message is processed, ensuring that the program updates its colors if another window's palette has changed. This involves selecting and realizing the palette in response to the system palette change.

Efficient UpdateColors Function:

GRAYS3 introduces the use of the UpdateColors function instead of directly repainting the window in response to a palette change.

This function efficiently updates the pixel values in the window to preserve the previous colors without the need for a full repaint.

Palette indices and Palette RGB colors represent different ways of specifying colors in Windows applications.

A Palette Index color consists of a high byte set to 1, and the low byte represents an index into the logical palette currently selected in the device context.

In the case of GRAYS3, the logical palette used has a total of 65 entries, with indices ranging from 0 to 64.

Each index corresponds to a specific color in the palette, allowing for a wide range of shades.

For example, PALETTEINDEX(0) represents black, PALETTEINDEX(32) represents medium gray, and PALETTEINDEX(64) represents white.

Using palette indices offers efficiency advantages over using RGB values because Windows does not need to perform a nearest-color search.

Instead of specifying the RGB values directly, the program can simply reference the desired color by its corresponding palette index.

This approach eliminates the need for Windows to search for the closest matching color in the palette, resulting in faster color retrieval and rendering.

By utilizing palette indices, Windows applications can leverage the predefined logical palette and directly access the desired colors without additional calculations.

This approach is particularly beneficial in scenarios where palette manipulation is supported and a limited color depth, such as 256 colors, is used.

In summary, palette indices provide a more efficient means of specifying colors in Windows applications compared to RGB values.

By referencing the desired color through the index, the need for a nearest-color search is eliminated, resulting in improved performance and streamlined color retrieval.

GRAYS3 refines the color management process by utilizing the PALETTEINDEX macro, simplifying color specification, and maintains responsiveness to palette changes with efficient updates, offering an enhanced visual experience compared to GRAYS2.

QUERY PALETTE SUPPORT

In Windows applications, the Palette Manager provides efficient color mapping and manipulation capabilities, particularly in video display modes with limited color depths like 256 colors.

To determine whether the device driver supports the Palette Manager, the program can use the GetDeviceCaps function with the RASTERCAPS parameter.

By performing a bitwise AND operation between the return value and the constant RC\_PALETTE, the program can check if the value is nonzero, indicating support for palette manipulation.

The GetDeviceCaps function also provides other important information related to the palette.

The call GetDeviceCaps (hdc, SIZEPALETTE) returns the total size of the palette table on the video board, typically 256 for 8 bits per pixel video display modes.

The function call GetDeviceCaps (hdc, NUMRESERVED) returns the number of colors in the palette table that the device driver reserves for system purposes, usually 20.

These reserved colors are the only pure colors that a Windows application can use without invoking the Palette Manager in a 256-color video mode.

The GetDeviceCaps (hdc, COLORRES) function call provides the resolution (in bits) of the RGB color values loaded into the hardware palette table, indicating the precision of the digital-to-analog converters (ADCs) used by the video display adapter. For example, a value of 18 indicates the usage of 6-bit ADCs, while a value of 24 indicates the usage of 8-bit ADCs.

By examining the color resolution value, a Windows program can make informed decisions about color usage.

For instance, if the color resolution is 18, requesting 128 shades of gray would be unnecessary because only 64 discrete shades of gray are possible.

Requesting more shades would lead to redundant entries in the hardware palette table.

In summary, by querying the Palette Manager support and using the GetDeviceCaps function, Windows applications can determine palette capabilities, such as support for palette manipulation, the size of the palette table, the reserved colors, and the color resolution of the hardware palette. This information assists in making optimal color choices and utilizing the available colors effectively in various video display modes.

*How does the Palette Manager handle situations where the device driver does not support palette manipulation? Can you provide an example of how the Palette Manager functions are used to work with the palette indices in GRAYS3? What are some other advantages of using palette indices instead of RGB values in Windows applications?*

When the device driver does not support palette manipulation, the Palette Manager functions gracefully adapt, and Windows continues to function without palette enhancements.

In such cases, the application essentially operates as if the Palette Manager were not utilized.

The advantages provided by the Palette Manager, such as accessing additional colors beyond the standard system palette, become relevant only in video modes that support palette management, typically those with 256 colors.

Let's delve into an example of how the Palette Manager functions are employed to work with palette indices in GRAYS3.

In this program, the logical palette is created with 65 entries during the WM\_CREATE message.

Later, during the WM\_PAINT message, the selected and realized palette is used to draw a series of rectangles representing different shades of gray.

Notably, the PALETTEINDEX macro is employed to specify the color of the solid brush when creating these rectangles.

Here's an excerpt of the relevant code from GRAYS3:



In this code, the PALETTEINDEX macro is employed to specify the color when creating a solid brush (CreateSolidBrush). The index 'i' is used to access different shades of gray from the logical palette. This method is more efficient than using RGB values, as Windows does not need to perform a nearest-color search, and it directly references the index in the logical palette.

The advantages of using palette indices over RGB values in Windows applications extend beyond efficiency. Some notable advantages include:

Reduced Memory Usage: Palette indices typically require less memory than RGB values, as they refer to predefined colors in a palette rather than storing full RGB color information.



Improved Performance: Since palette indices directly map to entries in the logical palette, color selection and rendering are faster compared to the computation involved in matching RGB values.



Compatibility: Palette indices facilitate compatibility with legacy systems and older display technologies that rely on palette-based color representation.



Consistent Color Mapping: Using palette indices ensures consistent color mapping, especially when dealing with limited color environments, leading to predictable and reliable color rendering.



In summary, the Palette Manager, when used with palette indices, offers efficiency, reduced memory usage, improved performance, and compatibility advantages in Windows applications, particularly in scenarios where palette manipulation is supported by the display hardware.