Win32 API Programming

- See also the old notes at:

  http://www.cs.binghamton.edu/~reckert/360/class2a.htm
  http://www.cs.binghamton.edu/~reckert/360/class3a.htm

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Win32 API Programming

- Event-driven, graphics oriented
- Example: User clicks mouse over a program's window area (an event) --
  - Windows decodes HW signals from mouse
  - figures out which window user has selected
  - sends a message to that window's program:
    - "User has clicked over (X,Y)"
    - "Do something and return control to me"
  - Program reads message data, does what's needed, returns control to Windows

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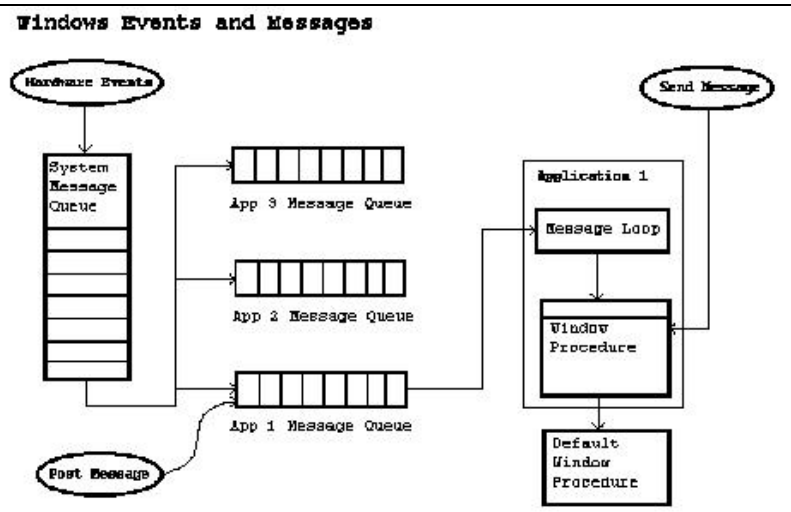

Overview of Win32 API Program Structure--2 main tasks:

- Initial activities
- Process messages from Windows
  - the message loop

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Pseudocode

- Initialize variables, memory space
- Create and show program's window
- Loop
  - Fetch any message sent from Windows to this program
  - If message is WM_QUIT
    - terminate program, return control to Windows
  - If message is something else
    - take actions based on message and parameters
    - return control to Windows
- End Loop

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Essential Parts of a Win32 API Pgm

- I. The source program (.c/.cpp file):
  - A. WinMain() function
    - 0. declarations, initialization, etc.
    - 1. register window "class"
    - 2. create a window based on a registered "class"
    - 3. show window, make it update its client area
    - 4. the message loop (get messages from Windows, dispatch back to Windows for forwarding to correct callback message-processing function, the WndProc)
  - B. WndProc(): the message-processing function
    - we write this function

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- II. The resource script (.rc file):
  - contains resource (Windows static) data
  - separate from code and dynamic data
  - compiled by a separate "Resource Compiler"
  - Resources determine the app's "look and feel"
  - Examples of Windows Resources:
    - Keyboard Accelerators, Bitmaps, Cursors, Dialog Box specs, Fonts, Icons, Menus, String Tables
  - Separation of resources and program code==>
    - separates tasks of programmer & designer
    - can change user interface without touching code

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The WinMain( ) Function

- int PASCAL WinMain (HINSTANCE hInstance,
  HINSTANCE hPrevInstance,
  LPSTR lpszCmdLine, int nCmdShow);
- WinMain() starts first
- integer exit code returned to Windows OS
- PASCAL: l-to-r parameter passing on stack
- 4 parameters passed in from Windows
  - hInstance: a "handle", identifies current pgm instance
  - lpszCmdLine: string containing command line args
  - nCmdShow: how window is to appear when shown

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Hungarian Notation

- help clarify variable types
- precede name with key letters representing type
- named after Hungarian Microsoft programmer, Charles Simonyi

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```
prefix  data type
 ---------------------------------
 by   BYTE (unsigned char)
 b    BOOL (int, TRUE=1 FALSE=0)
 c    char
 dw   DWORD (4-byte unsigned long)
 fn   function
 h    handle
 l    long (4 bytes)
 n    short (int) near pointer
 p    pointer
 sz   null-terminated char string
 w    word (two bytes)
 lpsz long ptr to null-terminated str
```

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RegisterClass(&wndclass);

```
typedef struct  tagWNDCLASS {
  UINT    style;
  LRESULT CALLBACK lpfnWndProc;
  int     cbClsExtra;
  int     cbWndExtra;
  HINSTANCE  hInstance;
  HICON   hIcon;
  HCURSOR hCursor;
  HBRUSH  hBackground;
  LPCSTR   lpszMenuName;
  LPCSTR   lpszClassName;     }  WNDCLASS;
```

```
WNDCLASS    wndclass;
if (!RegisterClass (&wndclass))  return 0;
```

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CreateWindow( ) arguments:

window class name

window caption

window style (Boolean OR of window style masks)

initial x , y position in pixels

initial width , height

parent window handle (if main window, NULL)

window menu handle (NULL if class menu used)

program instance handle (from Windows)

creation parameters (for extra data, usually NULL)

Returns a handle (hWnd) to the resulting window

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ShowWindow (hWnd,nCmdShow);

- makes window visible on screen
- hWnd: which window to make visible
- nCmdShow: how -- normal, minimized, etc.
  - set by Windows environment when program is started;
  - value is passed in from Windows;

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UpdateWindow (hWnd);

- Causes client area to be updated
- Painted with background brush

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The Message Loop

- User interaction ✍ a message sent to a window
- Lots of other kinds of actions ✍ messages
- A message structure:
  - HWND hwnd; // target window handle
  - UINT message; // message ID value: WM_***
  - WPARAM wParam; // data passed in message
  - LPARAM lParam; // more data in message
  - DWORD time; // time message was sent
  - POINT pt; // mouse cursor position (x,y)

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GetMessage()

- Program must keep checking for messages
- Use message loop with GetMessage()
- *BOOL GetMessage(*

  LPMSG lpMsg, // pointer to message struct

  HWND hWnd, // target window(s)

  // which windows do we want to get msgs from

  UINT wMsg1, // 1st message in range

  UINT wMsg2 // last message in range)

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GetMessage( )

- Reads next message from app's message queue
- Fills MSG structure pointed to by first parameter
- Place in a loop:

  while (GetMessage(&msg, NULL, 0, 0))
  { ... }
  return((int)msg.wParam);
- Returns non-0, except for WM_QUIT message
  - – Terminates message loop and returns control to Windows

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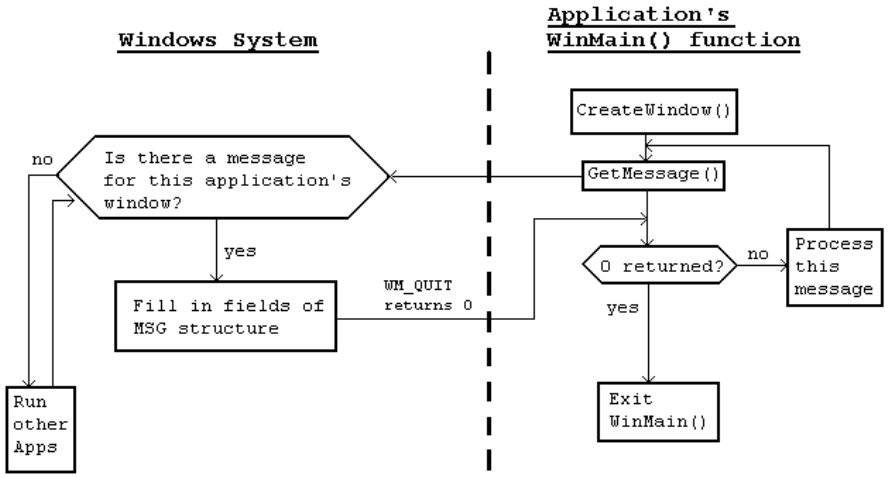
The Main Message Loop



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Message Processing

- What goes inside the message loop:

TranslateMessage (&msg)—

– "Cooks" keyboard input

– Converts raw key codes to ANSI codes

– Only important if WM_CHAR message is to be handled

DispatchMessage (&msg)—

– Sends message on to Windows, which

– Forwards it to program's "Window Procedure":

WndProc()—

- 2nd member of WNDCLASS structure
- Programmer must write this function

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The Window Procedure

- "Callback" function (called by Windows)
- Should contain a switch/case statement :
  - Looks at message ID of current message
  - Acts appropriately on "interesting" messages
  - Forwards other messages to default Window procedure--*DefWindowProc()*

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WndProc()

LRESULT CALLBACK WndProc (
HWND hWnd, UINT wMessage,
WPARAM wParam, LPARAM lParam)

- Parameters—
  - Same as first four fields of MSG structure:
    - window associated with message
    - message ID (what message is)
    - message data (wParam and lParam)
- Return value--
  - Result of message handling
    - 0 means message was handled

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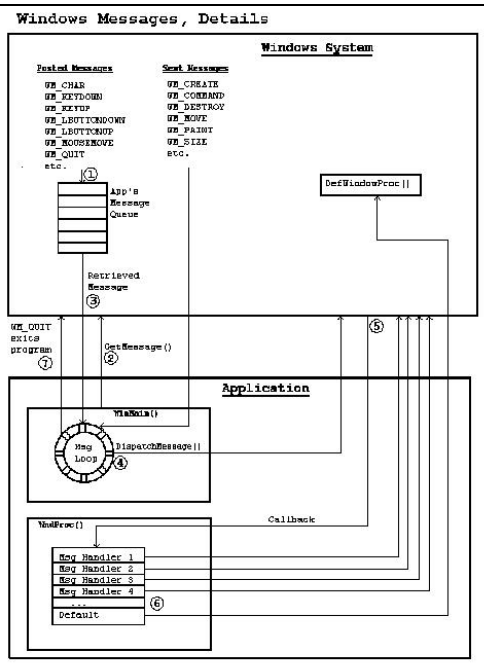

The WM_DESTROY Message

- Sent by OS when window is destroyed
- WndProc() should respond by calling:
  - *PostQuitMessage();*
  - Windows sends WM_QUIT msg to queue
  - wParam = 0 implies:
    - 0 returned by *GetMessage()* in *WinMain()*
    - normal return to Windows
    - so program exits *WinMain()*'s message loop
    - And returns to Windows

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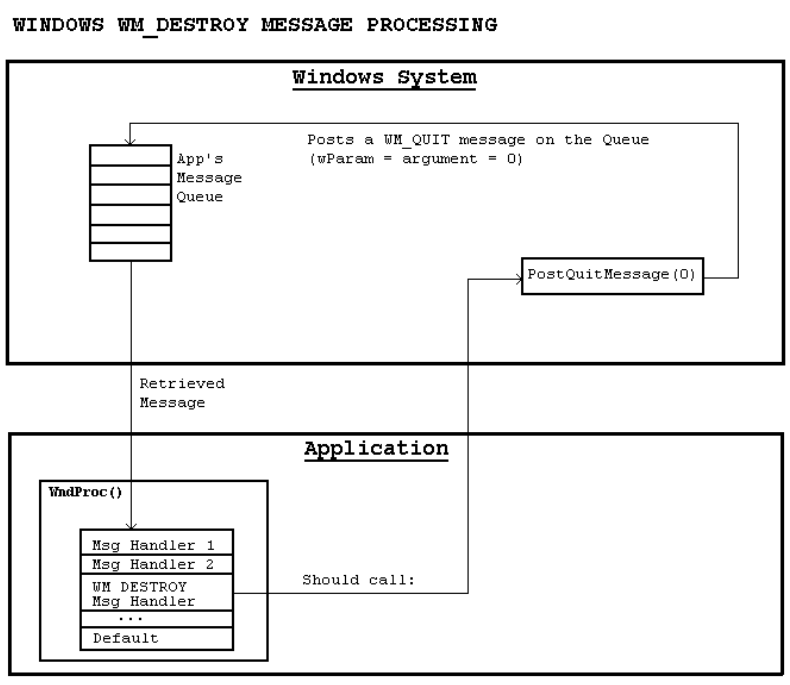

Example Program

- See First Windows Program: winapp1.cpp
- URL:

http://www.cs.binghamton.edu/~reckert/360/winapp1-cpp.html

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Some other important messages

- WM_COMMAND--User clicked on menu item
  - LOWORD(wParam)=menu item ID
- WM_?BUTTONDOWN--left/right mouse button pressed
  - ? = L, R, or M
  - lParam=x,y coordinates
- WM_MOUSEMOVE--mouse moved
  - lParam=x,y coordinates
- WM_CHAR--User pressed valid ANSI code character or keyboard key combination
  - wParam=ANSI code
- WM_PAINT--window was exposed, should be redrawn
- WM_KEYDOWN--keyboard key pressed
  - wParam=virtual key code

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II. The Resource Script (.rc file)

- Resources--static data
- Example: a menu
- Defined in a script (.rc) file--

```
#include "resource.h"
  MYMENU MENU
  BEGIN
    MENUITEM "&Circle",       ID_CIRCLE
   MENUITEM "&Rectangle",    ID_RECTANGLE
   MENUITEM "Clear &Screen",ID_CLEARSCREEN
   MENUITEM "&Quit",         ID_QUIT
  END
```

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The Resource header (.h file)

```
// resource.h
#define ID_CIRCLE      40006
#define ID_RECTANGLE   40007
#define ID_CLEARSCREEN 40008
#define ID_QUIT        40009
```

- Must be #included in .CPP and .RC files
- Can use Visual Studio's resource editors to prepare .rc and .h visually
  - ID numbers generated automatically

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Key Idea with Menus:

- when menu item is selected
  - Windows sends a WM_COMMAND msg
  - low word of wParam=selected item ID
  - extract with macro LOWORD()
  - then do switch/case on LOWORD(wParam) to perform correct action

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Text and Graphics Output

- Displaying something in a window
- Text and graphics done one pixel at a time
- Any size/shape/position possible
- Design goal: Device Independence

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Device Independent Graphics Interface

- Windows programs don't access hardware devices directly
- Make calls to generic drawing functions within the Windows 'Graphics Device Interface' (GDI) -- a DLL
- The GDI translates these into HW commands

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Device Context

- Windows apps don't draw directly on hardware
- Draw on "Device Context" (DC)
  - Is associated with a physical device
  - Abstracts the device it represents
  - Like a painter's canvas
  - Must be "gotten" from Windows
  - Specifies drawing attribute settings
    - e.g., text color
  - Contains drawing objects
    - e.g., pens, brushes, bitmaps, fonts

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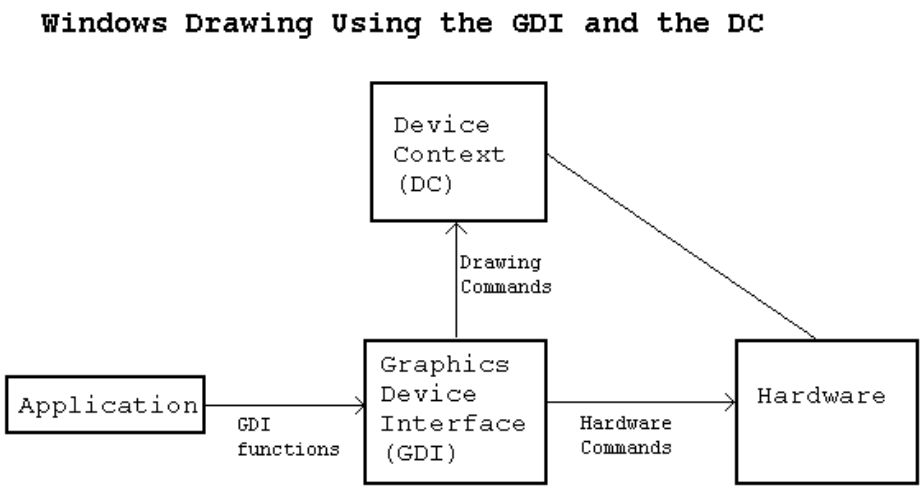
The DC and the GDI



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Some GDI Attribute Settings

ATTRIBUTE	DEFAULT	FUNCTION
Background color	white	SetBkColor()
Background mode	OPAQUE	SetBkMode()
Current Position	(0,0)	MoveToEx()
Drawing Mode	R2COPYPEN	SetROP2()
Mapping Mode	MM_TEXT	SetMapMode()
Text Color	Black	SetTextColor()

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Some GDI Drawing Objects

Object	Default	What it is
Bitmap	none	image object
Brush	WHITE_BRUSH	area fill object
Font	SYSTEM_FONT	text font object
Pen	BLACK_PEN	line-drawing object
Color Palette	DEFAULT_PALETTE	colors

- Can be created with GDI functions
- Must be "selected" into a DC to be used

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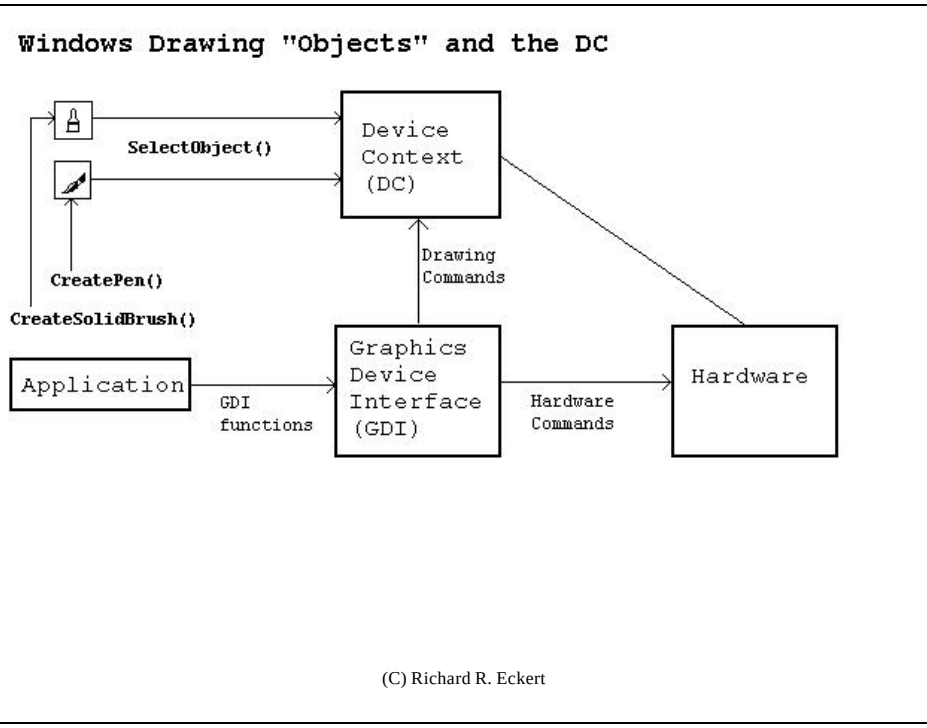

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Color in Windows

- Uses four-byte numbers to represent colors
- Simplest method--direct color:
  - typedef DWORD COLORREF;

```
 ------------------------------------------------------
| 0 |  Blue (0-255) | Green (0-255) | Red (0-255)  |
 ------------------------------------------------------
```

  - MSB=0:
    - ==> RGB color used (default)
    - other bytes specify R, G, B intensities

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RGB() Macro

- Specify Red, Green, Blue intensities
- RGB() generates a COLORREF value
- Can be used in color-setting functions), e.g.

```
COLORREF  cr;
cr = RGB (0,0,255);   /* bright blue */
```

- Example usage in a program

```
SetTextColor (hDC, RGB(255,0,0)); //red text
SetBkColor (hDC, RGB(0,0,255)); //blue bkgnd
```

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A Typical Sequence With Drawing Objects:

```
HPEN    hOldP, hNewP;
HDC     hDC;
hDC = GetDC(hWnd);
hNewP = CreatePen(PS_SOLID, 3, RGB(0,0,255));
hOldP = (HPEN)SelectObject(hDC, hNewP);
// NOW DO SOME DRAWING WITH THE NEW PEN
SelectObject(hDC,hOldP); //displace pen from DC
DeleteObject(hNewP); //now can be deleted
ReleaseDC(hWnd,hDC);
```

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Some GDI Drawing Primitives

- *Arc(hDC,x1,y1,x2,y2,xStart,yStart,xEnd,yEnd);*
- *Ellipse (hDc, x1,y1,x2,y2);*
- *MovetoEx (hDC,x1,y1,lpPoint);*
- *LineTo (hDC,x1,y1);*
- *Polygon (hDC,points_array,nCount);*
- *Polyline (hDC,points_array,nCount);*
- *Rectangle (hDC,x1,y1,x2,y2);*
- *SetPixel (hDC,x1,y1,colref);*
- *TextOut (hDC,x,y,lpString,cbString);*
- *Many more (see on-line help)*

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Stock Objects

- predefined in Windows
- obtain with GetStockObject();
  - gets a handle to a predefined pen/brush/font
- Stock objects are maintained by Windows
  - should not be deleted!
- Example

  SelectObject (hDC,
  GetStockObject(BLACK_PEN));

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Some Stock Objects

Some Object Choices:

Pen	BLACK_PEN, WHITE_PEN
Brush	DKGRAY_BRUSH, GRAY_BRUSH, BLACK_BRUSH, LTGRAY_BRUSH, NULL_BRUSH, WHITE_BRUSH
Font	ANSI_FIXED_FONT, ANSI_VAR_FONT, DEVICE_DEFAULT_FONT, SYSTEM_FONT, OEM_FIXED_FONT, SYSTEM_FIXED_FONT

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The winapp2.cpp Application

- Details of WndProc()--
  - menu item clicked==>WM_COMMAND message
    - LOWORD(wParam)==ID_RECTANGLE ("Rectangle" menu item clicked):
      - draw red-outlined rectangle (pen) with solid cyan interior (brush)
    - LOWORD(wParam)==ID_CIRCLE ("Circle" clicked):
      - draw blue-outlined circle (pen) with crosshatched magenta interior (brush)

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  - LOWORD(wParam)==ID_CLEAR ("Clear Screen" clicked):
    - call InvalidateRect() ==> Windows sends WM_PAINT message
      - client area needs to be repainted
      - default Window Procedure repaints client area with class background brush
      - effectively erases window's client area
  - LOWORD(wParam)==ID_QUIT ("Quit" clicked):
    - program calls DestroyWindow()
    - causes Windows to destroy window
    - and send a WM_DESTROY message
    - Handler posts WM_QUIT message
      - Which causes program to exit message loop and terminate

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- left mouse button pressed ==> WM_LBUTTONDOWN message
  - get cursor's x,y coordinates from lParam
    - use LOWORD & HIWORD macros
    - output "L" at (x,y) on screen DC with TextOut()
- right mouse button pressed ==> WM_RBUTTONDOWN message
    - output "R" at (x,y) on screen DC with TextOut()

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  - User hits ANSI character keyboard key/s ==> WM_CHAR message (wParam=char code)
    - copy character into a buffer
    - output buffer to upper left corner with TextOut()
  - User takes action to close window (double clicks on System menu or hits Alt-F4) ==> WM_DESTROY message
    - post WM_QUIT message to app's queue
    - causes program to exit event loop and return control to Windows

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Using Visual Studio to Create a Win32 API Application with a Menu and an Icon

1. Get into Visual Studio, open a New Project, and create an empty Win32 application
2. Create a new Visual C++ source file, type or paste in the code (winapp2.cpp), and save it as a C++ source file in the app's subdirectory
   - must have: #include "resource.h"
3. Add it to the project

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4. Create the Icon Resource (and the .rc file)
   - Select 'Project | Add Resource | Icon | New'
     - Brings up icon editor
   - Draw desired icon
   - Click on IDI_ICON1 in "Resource View" to bring up the "Properties" window and change the icon ID to "MYICON"
     - Don't forget the quote marks
   - Give a name to .ico file (or leave the default name)

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5. Select ‘Project | Add Resource | Menu | New’
   - Brings up the menu editor
     - Type the caption: &Circle in the “Type Here” rectangle
     - In resulting "Properties" box, Select “False” for “Pop-up”
     - Click on the resulting Circle menu item to bring up the “Properties” box again.
     - Note the default ID of ID_CIRCLE
   - Click on the next rectangle over in the menu editor
     - Repeat the above steps using caption: &Rectangle
     - Keep the default IDs
   - Repeat for: Clear &Screen, &Quit menu items
     - Keep default IDs

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6. Click on “IDI_MENU1” in “Resource View” to bring up the “Properties” window and change the menu ID to “MYMENU”
   - Don’t forget the quote marks
7. Build the project

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Copy Project to a Diskette or CD

- To save space, delete all the temporary files from the application's Debug Directories
  - Everything except the application itself (the .exe file)
- Also delete the VC++ Intellisense Database file from the topmost directory
- Copy the entire topmost directory to your diskette or CD-ROM
- If using a public computer, delete the workspace directory from the hard disk

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