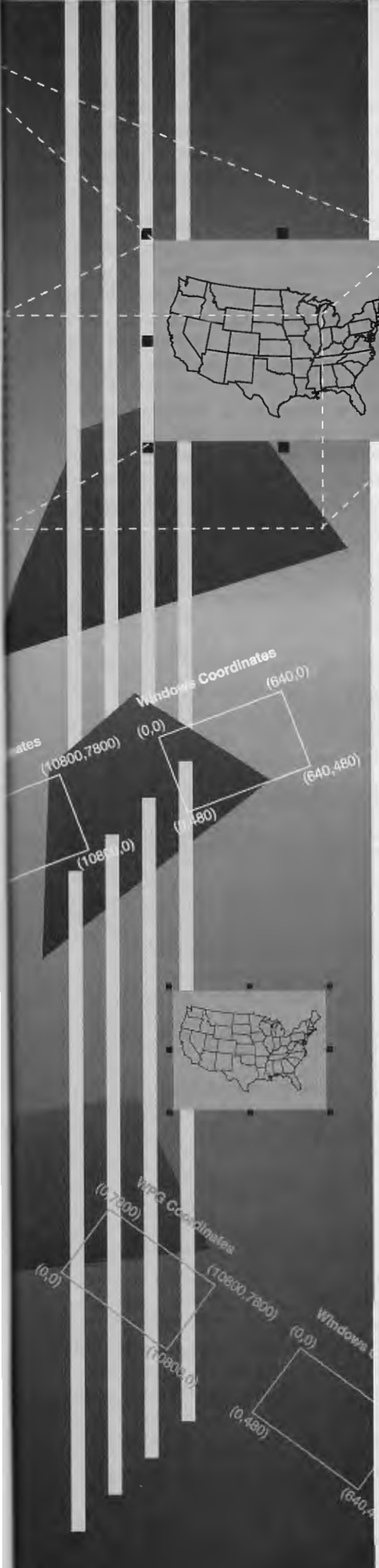

A Filter for WordPerfect Graphics Files

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Borland C++ v4.02
Symantec C++ v6.10
Visual C++ v1.5

A graphics filter is code that enables a program to read images created by other programs in foreign formats, converting them to whatever format the program uses internally. If the program defines its graphics filters as DLLs with a specific function interface, then new graphics filters can be added without altering the original program. In this article I explain the basic principles of writing an interactive filter/viewer for vector graphics images in Windows, using WordPerfect's WPG format for illustration. The application discussed here, SHOWWPG, can read WPG v5.x files from disk, scale them interactively as is done in WordPerfect, and copy them to the clipboard as Windows metafiles. In other words: the incoming foreign format is WPG, and the internal native format is Windows metafile; SHOWWPG converts WPG files to Windows metafiles. Since a Windows metafile is a static list of GDI calls, there is little distinction between rendering the image and translating it to Windows metafile format; the same code is used to do both. SHOWWPG is too long to be printed in its entirety, so the code listings (funcs.c – Listing 1) focus on a few pivotal issues; the entire source code is on this issue's code disk (see the table of contents for availability information).

WordPerfect graphics files consist of vector graphics. In vector graphics, images consist of a series of primitives, such as lines, polygons, ellipses, and so on. Each primitive record in the vector graphics file contains coordinates defining the primitive; a line record, for example, would contain (*x1, y1*) values for the first endpoint and (*x2, y2*) values for the second endpoint. Drawing and CAD programs typically implement vector formats because of the natural scaling such formats afford (doubling all coordinates doubles the size of the image). This contrasts to bitmapped or raster graphics, where color codes for each pixel in a rectangular region define an image. Bitmap formats include PCX, BMP, and TIF, natural formats for paint programs and for scanners.

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Converting Records

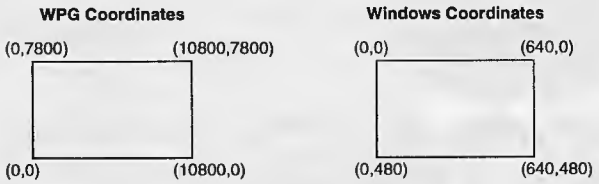
A vector graphics filter traverses the incoming file record by record, converting each record to its equivalent in the native format. SHOWWPG's traverser function is *PlayWPGFile()*, which goes through the WPG file in memory, calling function *DrawWPGRecord()* to convert each record to equivalent Windows GDI calls. *DrawWPGRecord()* switches on the type of WPG record, calling utility functions to convert records (*DrawLine()*, *DrawPoly()*, *DrawEllipse()*, and so on). Windows' device independence comes to the rescue here — if you pass *DrawWPGRecord()* a screen device context, then it renders the WPG image on the screen, while if you pass it a metafile device context, it creates a metafile. Windows makes little distinction between a vector graphics viewer and filter.

Since different formats have different capabilities, record matching is an imperfect business. Simple records like lines and polylines (a series of connected line segments) convert directly from WPG format to equivalent GDI calls. Ellipse records present difficulties, since WPG ellipses can include elliptical arcs, pie slices, chords, and rotated ellipses. The first three can be matched to Windows *Arc()*, *Pie()*, and *Chord()* calls, but since Windows doesn't provide for rotated ellipses, you would have to write your own algorithm to implement this feature.

SHOWWPG takes some pains to implement WPG's "fill attribute" record. A fill attribute is a color and pattern setting used to fill the interior of all subsequent polygons in the WPG file until the next fill attribute record is encountered. This is the same concept as Windows' brushes, used to fill polygonal areas. SHOWWPG calls *SetBrush()* every time a fill attribute record is encountered. *SetBrush()* creates and selects a Windows brush matching the WPG fill attribute record, making sure to delete the previous brush to prevent all these brushes from adding permanently to Windows' global heap. If the fill attribute record includes a pattern, SHOWWPG creates a Windows bitmap matching the pattern, then calls Windows' *CreateDIBPatternBrush()* to create a brush based on the bitmap. Fortunately, Windows provides for 8-pixel-square pattern brushes, the largest fill pattern encountered in WPG fill attribute records.

WPG's "line attribute" matches the Windows concept of "pen", specifying color, style, and width settings whenever lines are drawn. This record is difficult to implement, since Windows' pen support is minimal. SHOWWPG implements WPG line-attribute color settings by creating and selecting Windows pens, much as with fill attributes and brushes. Since Windows pens have few styles available, and those only at one pixel

Figure 1 *Mapping WordPerfect graphics and Windows screen coordinates*



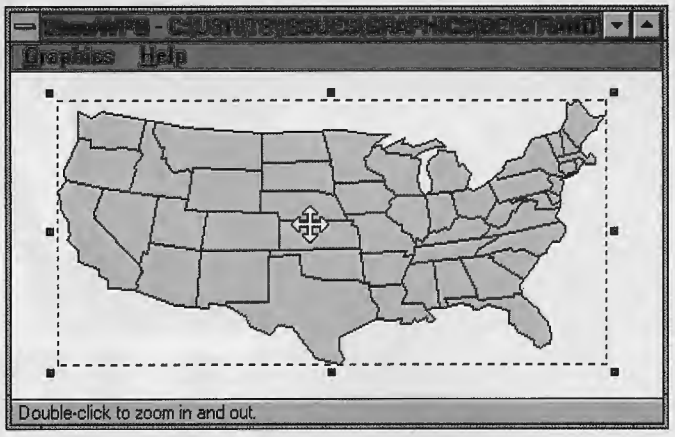


Figure 2 *SHOWWPG displaying a WPG file*

thickness, supporting fill attribute style and width settings would require an appeal to Windows' *LineDDA()* call, enabling Windows' line-drawing with any attributes.

SHOWWPG doesn't attempt to implement text or embedded bitmaps, both possible in WPG files. The traverser, *PlayWPGFile()*, ignores and skips over unimplemented records. Implementing a new record type requires adding the record as a case constant in *PlayWPGFile()*'s switch, then calling and writing the function to support the new record (that is, translating it into GDI calls).

Scaling

Converting one vector format to another always involves scaling of coordinates, a core idea. Both WordPerfect graphics and Windows have the concept of a polyline, a series of straight line segments connected end to end. But Windows' *Polyline()* cannot directly render the image from the WPG file because the coordinate systems are different. Coordinates in WPG files are based on WPG space, which is 10,800 units wide by 7800 units high with the origin, or (0,0) point, in the lower left. This differs

markedly from standard screen resolutions of 640x480 or 800x600, with the origin at the upper left (see Figure 1).

In converting from WPG space to a screen space of 640x480, for example, I apply a scaling transformation to a point (*x,y*) in WPG space to calculate its corresponding point (*x',y'*) on the screen. Wherever (*x,y*) is located in WPG space, its corresponding point (*x',y'*) is in the same relative position on the screen. A scaling transformation is denoted by:

```
(x,y) --> (x',y')
```

where *x'* and *y'* are separate *x* and *y* transformations:

```
x' = scaleX * x + offsX
y' = scaleY * y + offsY
```

You can calculate what scale factors and offsets to use by picking two WPG coordinates and deciding which Windows coordinates you want to map them to. For example,

Listing 1 *funcs.c — Core functions for WPG graphics filter*

```
long WINAPI _export WndProc(HWND hWnd, UINT message,
                            UINT wParam, LONG lParam)
/*
  USE: SHOWWPG's main window procedure.
  IN:  Standard WndProc() parameters.
   WM_CREATE  : Set normal caption
   WM_ACTIVATE: Set minimized caption
   WM_SIZE    : Update global ClientRect
   WM_COMMAND : IDM_RETRIEVE triggers GetOpenFileName()
                IDM_COPY copies to clipboard
                IDM_ABOUT shows About DlgBox
   WM_PAINT   : Traverse and display WPG file
   WM_MOUSEMOVE  : Pass along to Modify()
   WM_LBUTTONDOWN:  to size or translate
   WM_LBUTTONUP  :        "
   WM_LBUTTONDBLCLK: Pass along to Modify() to zoom in
   WM_RBUTTONDBLCLK: Pass along to Modify() to zoom out
   WM_DESTROY    : Finalize.

   hBuf is a key global variable that is non-NULL if
   and only if it is a valid memory handle to a WPG
   file. Check hBuf to see if you have a file to show.
*/
{
  HANDLE hNewMem;   /* temp handle to file mem */
  PAINTSTRUCT ps;   /* needed in WM_PAINT */
  HDC    hDC;       /* needed in WM_PAINT */
  LPSTR  lpls;      /* ptr to last '\' in string */
  static FARPROC lpDlg;   /* for About box function */

  switch (message)
    {
    case WM_CREATE:
      /* Write default caption for main window. */
      wsprintf(Caption, "%s - (Untitled)", AppName);
      SetWindowText(hWnd, Caption);
      /* Default iconic name is just app name. */
      lstrcpy(IconicName, AppName);
      break;  /* WM_CREATE */

    case WM_ACTIVATE:
      /* When minimized, use AppName only for caption,
       * else full caption.
       */
      SetWindowText(hWnd, IsIconic(hWnd) ? IconicName :
                    Caption);
      break;  /* WM_ACTIVATE */

    case WM_SIZE:
      /* Update global ClientRect. */
      GetClientRect(hWnd, &ClientRect);
      break;  /* WM_SIZE */

    case WM_COMMAND:
      switch (wParam)
        {
        case IDM_RETRIEVE:
          /* Get file name, read into memory. */
          if ((hNewMem = LoadWPGFile(hWnd)) == NULL)
            break;
          /* If hBuf valid, free it and reset. */
          if (hBuf) GlobalFree(hBuf);
          hBuf = hNewMem;
          break;  /* IDM_RETRIEVE */

        case IDM_COPY:
          /* hBuf non-NULL means file is in memory. */
          if (hBuf)  CopyWMFToClipBoard(hWnd);
          break;  /* IDM_COPY */

        case IDM_ABOUT:
          lpDlg=MakeProcInstance((FARPROC)AboutDlgProc,
                hInst);
          DialogBox(hInst, "AboutBox", hWnd, lpDlg);
          FreeProcInstance(lpDlg);
          break;  /* IDM_ABOUT */
        }
```

Listing 1 *continued*

```
      break;  /* WM_COMMAND */

    case WM_PAINT:
      hDC = BeginPaint(hWnd, &ps);
      if (hBuf)  PaintWindow(hDC);
      EndPaint(hWnd, &ps);
      break;  /* WM_PAINT */

    case WM_MOUSEMOVE:
    case WM_LBUTTONDOWN:
    case WM_LBUTTONUP:
    case WM_LBUTTONDBLCLK:
    case WM_RBUTTONDBLCLK:
      if (hBuf)
        Modify(hWnd, message, lParam);
      else
        /* SetCursor() every MOUSEMOVE if no file. */
        SetCursor(HCursor[NO_HIT]);
      break;  /* WM_MOUSEMOVE... */

    case WM_DESTROY:
      /* Free memory handle if valid. */
      if (hBuf)  GlobalFree(hBuf);
      if ((lpls = _fstrrchr(FileName, '\\')) != NULL)
        {
        /* Excise file name so only path left. */
        *lpls = 0;
        /* Write current path to SHOWWPG.INI. */
        WritePrivateProfileString("Defaults", "Path",
                                  FileName, "SHOWWPG.INI");
        }
      PostQuitMessage(0);
      break;

    default:  /* Passes it on if unproccessed */
      return DefWindowProc(hWnd,message,wParam,lParam);
    }  /* switch */

  return (NULL);
}

void LOCAL Modify(HWND hWnd, UINT message, LONG lParam)
/*
  USE:  Sizing and translating tool.
  IN:   WndProc() parameters passed along.
  NOTE: State tool with route WAITING-->START_MODIFYING
   -->MODIFYING-->WAITING. START_MODIFYING is the state
   for the first WM_MOUSEMOVE after tool has started.
   There are 9 modifications: translation + 8 types of
   resizing. Which modification is triggered depends on
   which hot spot the cursor was in at WM_LBUTTONDOWN.
   Each modification has its own section in
   RestrictCursor(), DrawDraggingRect(), UpdateScale(),
   functions called respectively at WM_LBUTTONDOWN,
   WM_MOUSEMOVE, and WM_LBUTTONUP (RestrictCusor()
   initializes, DrawDraggingRect() draws interactively,
   UpdateScale() finalizes).
*/
{
  HDC hDC;           /* DC to draw on */
  static POINT pt;   /* button-down point */
  static HPEN hPen;  /* dashed pen */
  static HRGN hRgn;  /* clip region */
  static int hs;     /* hot spot index */
  static int state;  /* system state */

  switch (message)
    {
    case WM_LBUTTONDOWN:
      if (state == WAITING)
        if ((hs = PtinHotSpot(&TargetRect,
                    MAKEPOINT(lParam))) != NO_HIT)
          {
          state = START_MODIFYING;
          hPen = CreatePen(PS_DOT, 1, 0L);
          hRgn = CreateRectRgn(0, 0, ClientRect.right,
                      ClientRect.bottom-(ILINE_HT+2));
          pt = MAKEPOINT(lParam);
          RestrictCursor(hs, hWnd, &pt);
          }
      break;  /* WM_LBUTTONDOWN */

    case WM_MOUSEMOVE:
      switch (state)
        {
        case WAITING:
          /* Set Cursor for hot spot or Arrow. */
          SetCursor(HCursor[PtinHotSpot(&TargetRect,
                                MAKEPOINT(lParam))]);
          break;
        case START_MODIFYING:
          state = MODIFYING;
          hDC = GetDC(hWnd);
          SelectObject(hDC, hRgn);
          /* Erase Framed rect (XOR mode). */
          SetROP2(hDC, R2_NOTXORPEN);
          FrameOurRect(hDC, &TargetRect);
          /* Draw rect with SOLID pen first time. */
          DrawDraggingRect(hs, hDC, pt);
          pt = MAKEPOINT(lParam);
          /* Switch to DASHED pen for next draw rect.*/
          SelectObject(hDC, hPen);
          DrawDraggingRect(hs, hDC, pt);
          ReleaseDC(hWnd, hDC);
          break;
        case MODIFYING:
          hDC = GetDC(hWnd);
          /* Draw in XOR mode with DASHED pen. */
          SetROP2(hDC, R2_NOTXORPEN);
          SelectObject(hDC, hPen);
          SelectObject(hDC, hRgn);
          /* Erase last rect. */
          DrawDraggingRect(hs, hDC, pt);
          pt = MAKEPOINT(lParam);
          /* Draw new rect. */
          DrawDraggingRect(hs, hDC, pt);
          ReleaseDC(hWnd, hDC);
          break;
        }  /*  switch (state) */
      break;  /* WM_MOUSEMOVE */

    case WM_LBUTTONUP:
      if (state==MODIFYING || state==START_MODIFYING)
        {
        DeleteObject(hPen);
        DeleteObject(hRgn);
        UpdateScale(hs, pt);
        /* Set Cursor for hot spot or Arrow. */
        SetCursor(HCursor[PtinHotSpot(&TargetRect,
                                MAKEPOINT(lParam))]);
        /* RePaint only if modification started. */
        if (state == MODIFYING)
          InvalidateRect(hWnd, NULL, TRUE);
        state = WAITING;
        }
      break;  /* WM_LBUTTONUP */

    case WM_LBUTTONDBLCLK:
      if (state == WAITING &&
          PtInRect(&TargetRect, MAKEPOINT(lParam)))
        {
        UpdateScale(ZOOM_IN, pt);
        InvalidateRect(hWnd, NULL, TRUE);
        }
      break;  /* WM_LBUTTONDBLCLK */

    case WM_RBUTTONDBLCLK:
      if (state == WAITING &&
          PtInRect(&TargetRect, MAKEPOINT(lParam)))
        {
```

given a 640x480 screen, you might decide to map WPG coordinate *(0,0)* to Windows coordinate *(0,480)* and WPG coordinate *(10800,7800)* to Windows coordinate *(640,0)*, as shown in Figure 1. Two equations arise from associating each *x* with its corresponding *x'*:

```
0 = scaleX * 0  + offsX
640 = scaleX * 10800 + offsX
```

Solving these equations results in *offsX = 0* and *scaleX = 640/10800 = 0.059*. After similar calculations in *y*, the specific scale transformation can be written down:

```
x' = 0.059 * x
y' = -0.061 * y + 480
```

The scale factors 0.059 and -0.061 indicate that the original coordinates are shrunk to about 6% of their original values in order to fit on the screen; the minus sign reverses the sense of *y* due to the different placement of the origin. An offset of 480 must then be added to the *y* coordinate to get the image on the screen. SHOWWPG's function *CalcScaleParms()* calculates the scale parameters based on the current target rectangle, much as in this example, except that any target rectangle may be used. The term "scale parameters" includes scale factor and offset for both *x* and *y*.

A straight line between *(x1,y1)* and *(x2,y2)* in WPG space is rendered by first scaling the two points and then drawing the line between the scaled points with Windows' *MoveTo()* and *LineTo()*. For a polyline, first scale all the coordinates and then pass the scaled points to Windows'

Listing 1 *continued*

```
        UpdateScale(ZOOM_OUT, pt);
        InvalidateRect(hWnd, NULL, TRUE);
        }
      break;  /* WM_RBUTTONDBLCLK */
    }  /* switch (message) */
}

BYTE LOCAL DrawWPGRecord(HDC hDC, LPBYTE FAR *p,
                         SCALE sc)
/*
  USE:  Decipher and draw WPG record.
  IN:   hDC  = handle to DC in which to draw
        *p = ptr to start of WPG record
        sc = SCALE struct to use in drawing record
  OUT:  *p = ptr to start of next record
  RET:  Return record type.
  NOTE: p is a ptr to a ptr to the start of the WPG
   record. The ptr scans thru the record and ends by
   pointing to the next record. The actual ptr, main-
   tained by the caller, is updated as well (this is
   why we need a ptr to a ptr). Note that:

                 p = ptr to ptr
                *p = ptr
               **p = data
*/
{
  BYTE  recType;     /* WPG record type */
  DWORD recLen;      /* WPG record length, as DWORD */

  /* Get RecordType, advance ptr. */
  recType  = *(*p)++;

  recLen = GetRecordLength(p);

  /* Process record. Each type of record being handled
   * appears as a case constant; records not listed are
   * ignored and jumped over.
   */
  switch(recType)
    {
    case WPG_FILLATTR:
      SetBrush(hDC, *p, SET_MID);
      break;
    case WPG_LINEATTR:
      SetPen(hDC, *p, SET_MID);
      break;
    case WPG_LINE:
      DrawLine(hDC, *p, sc);
      break;
    case WPG_POLYLINE:
    case WPG_POLYGON:
      DrawPoly(hDC, *p, sc, recType);
      break;
    case WPG_ELLIPSE:
      DrawEllipse(hDC, *p, sc);
      break;
    }  /* switch */

  /* Advance ptr to next record for caller. */
  *p += recLen;

  return(recType);
```

Polyline(). This is the magical core of vector graphics – the scaled image looks the same as the original!

The Target Rectangle

In general, the target for display is not the entire screen, but a rectangle smaller than the screen, resizable by the user. This target rectangle is a key global variable, called *TargetRect*, in SHOWWPG. The user resizes the target rectangle by dragging little black boxes at the corners and sides of the rectangle, as is done in WordPerfect, or by double-clicking for zooms (left double-click to zoom in, right double-click to zoom out). After the user resizes the target rectangle, the image within the rectangle is scaled, with the scaling transformation mapping WPG space into the target rectangle. The scaling transformation is developed as in the example above, except that the WPG file maps to the target rectangle only, rather than to the entire screen. After the scaling transformation is applied, *PlayWPGFile()* renders the scaled image. The current scale transformation, depending on *TargetRect*, is stored in another key global structure, *Scale*, which holds the scale factors and offsets.

The function *InitScaleParms()* calculates an image's initial target rectangle when the file is loaded. The image's WPG space size, together with reasonable margins, is used to calculate a target rectangle fitting in the middle of the client area. From that point, the user adjusts the target rectangle interactively, with SHOWWPG updating scale parameters at each adjustment, until a new file is loaded and *InitScaleParms()* starts the cycle anew.

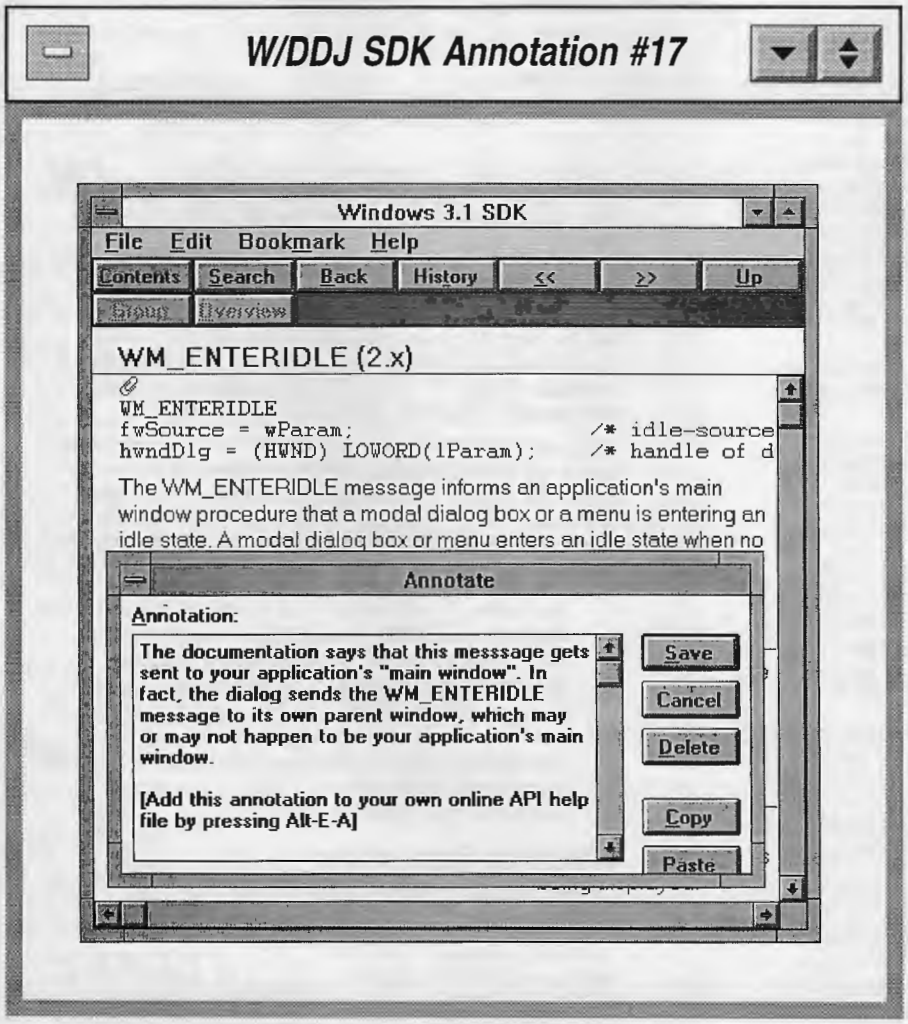
Reading a WPG File into Memory

SHOWWPG provides a common dialog box that lets the user choose WPG files to render. The program calls *GlobalAlloc()* for a memory block sufficient to hold the entire file:

```
hMem = GlobalAlloc(fileSize);
```

The memory block remains valid, continuing to hold the file, until another file is chosen. The file data is not changed, but serves as the image archive for rendering. Scaled data (for indeterminately sized polylines, for example) is stored in supplementary memory blocks. Iterated scaling (scaling already scaled data) can corrupt an image, so I always want to be one step away from the original.

Choosing a new image displaces any existing image, so the code frees the current *hMem* (with *GlobalFree()*) before generating a new *hMem* for the new image. Failing to free unused memory handles is a dire error in Windows, since unfreed blocks continue to occupy the global memory heap, reducing the amount of memory available to all applications for the rest of the Windows session.



Interactive Aspects

After a WPG file has been loaded into memory, the user can resize or translate the target rectangle by dragging the little black box knobs on its corners and edges or by double-clicking to zoom. Figure 2 shows how the program displays a WPG file. SHOWWPG takes note when the cursor is over one of the knobs, adjusting the cursor shape accordingly. The upper right knob, for example, is linked to the "northeast – southwest" arrow cursor, the same one Windows itself uses to signal the availability of resizing when a cursor passes over the upper right corner of a window. The program responds to a left button down in one of the knobs by initiating a drag. The eight knobs are called hot spots for this reason. The target rectangle itself is the ninth hot spot; it is linked to the arrow cross and to translation when dragging ensues. The nine hot spots are determined by the target rectangle, with function *PtInHotSpot()* returning the index of the hot spot a point is in, if any.

The drags are managed by function *Modify()*, a tool sensitive to the

stream of mouse events and their meaning. Pressing the left mouse button down on the knob at the top left of *TargetRect*, for example, begins the top left drag, where the top left corner is moved but the opposite right bottom corner is anchored at its original location. The corner drags affect both scale factors since both dimensions of *TargetRect* are changed. The top-middle drag, initiated by pressing the left button down on the top middle knob, causes only the top edge of *TargetRect* to move. In this case, the *x* scale factor remains unchanged, while the *y* scale factor will change depending on the top edge's position at the end of the drag. Translating is also available by dragging *TargetRect* itself; in this case only the offsets and not the scale factors are affected. There are nine different kinds of drag, each one a different modification. Double-clicking triggers automatic zooms without any dragging. When a drag or zoom is done, both the target rectangle and scaling transformation must be updated.

The drags have much in common. All are initiated by the user's pressing the left mouse button down in a hot spot; all are in progress as the user moves the mouse, or drags; and all need to update the global structures *TargetRect* and *Scale* when the drag is done. The common functionality calls for a single function to manage all nine drags — function *Modify()*. This way only one block of code would need to be rewritten to change the way drags work — perhaps implementing the right mouse button or shift-drag (dragging with the shift key down).

Listing 1 *continued*

```
}

void LOCAL InitScaleParms(HANDLE hMem, LPSCALE lps,
                          LPRECT lpr)
/*
  USE:  Initialize target rect and scale parameters.
  IN:   hMem = handle to memory containing WPG data.
  OUT:  lps = ptr to scale parameters structure
        lpr = ptr to target rectangle : region on the
              screen into which image is mapped.
  NOTE: Uses global ClientRect, sets global WPGsp.
*/
{
  LPBYTE lpWPG;    /* ptr to WPG data */
  double scaleX;   /* X scale factor */
  double scaleY;   /* Y scale factor */
  int top;   /* top of target rect if loose fit - y */
  int left;  /* left of target rect if loose fit - x */

  /* Generate ptr to WPG data. */
  lpWPG = (LPBYTE) GlobalLock(hMem);

  /* If find WPG_START1 as first record, use for WPG
   * space; else use defaults set at initialization.
   */
  if (*(lpWPG + WPG_OFFS_FIRSTREC) == WPG_START1)
    WPGsp = *((LPSIZE)(lpWPG + WPG_OFFS_WPGSIZE));

  /* Unlock memory handle. */
  GlobalUnlock(hMem);

  /* Calc scale factors in both dimensions. */
  scaleX = (double) ClientRect.right  / WPGsp.cx;
```

Modify() implements a state table to respond appropriately to sequences of mouse events. A left button down (Windows message *WM_LBUTTONDOWN*) on a hot spot triggers a state transition from *WAITING* to *START_MODIFYING*, causing drag initialization. As the drag progresses, sending a stream of *WM_MOUSEMOVE*s to *Modify()*, the state changes to *MODIFYING*, in which the dashed target rectangle on screen is updated continuously as the mouse moves. Finally, when the left button is released (signaled by receipt of message *WM_LBUTTONUP*), the entire image is resized according to the new target rectangle, and the state reverts to *WAITING*, the quiescent state between drags. State tables are a way to grasp complex interactive sequences like this. Dragging represents a circuit through the state table,

```
WAITING -> START_MODIFYING -> MODIFYING -> WAITING
```

with state transitions triggered by receipt of a certain message while in a certain state.

Details about each kind of drag are relegated to helper functions like *DrawDraggingRect()*, which is called in states *START_MODIFYING* and *MODIFYING* to redraw the dashed target rectangle as it is being dragged. Another helper is *UpdateScale()*, which updates *TargetRect* and *Scale* as appropriate when the drag is finished. *UpdateScale()* consists mainly of a switch updating *TargetRect* appropriately depending on the type of modification. A top left drag, for example, begins when *Modify()* learns that the drag started with the

Listing 1 *continued*

```
scaleY = (double) ClientRect.bottom / WPGsp.cy;

/* Fit target rect into client rectangle with same
 * aspect ratio as WPG space, allowing for margins.
 */
if (scaleX < scaleY)
  {
  /* TargetRect fits snugly left and right, with
   * extra space top and bottom.
   */
  scaleX *= (1.0 - 2.0 * INIT_MARGIN);
  /* Calc TargetRect with margin based on INIT_MARGIN
   * on left/right, margin = top units on top/bottom
   */
  top = (ClientRect.bottom - scaleX * WPGsp.cy) / 2;
  lpr->left = ClientRect.right * INIT_MARGIN;
  lpr->top = top;
  lpr->right = ClientRect.right * (1.0-INIT_MARGIN);
  lpr->bottom = ClientRect.bottom - top;
  /* Calc scale parms based on this TargetRect.*/
  CalcScaleParms(WPGsp, *lpr, lps);
  }
else
  {
  /* Target rect fits snugly top and bottom, with
   * extra space left and right.
   */
  scaleY *= (1.0 - 2.0 * INIT_MARGIN);
  /* Calc TargetRect with margin based on INIT_MARGIN
   * on top/bottom, margin = left units on left/right
   */
  left = (ClientRect.right - scaleY * WPGsp.cx) / 2;
```

Listing 1 *continued*

```
    lpr->top = ClientRect.bottom * INIT_MARGIN;
    lpr->left = left;
    lpr->bottom =ClientRect.bottom * (1.0-INIT_MARGIN);
    lpr->right = ClientRect.right - left;
    /* Calc scale parms based on this TargetRect. */
    CalcScaleParms(WPGsp, *lpr, lps);
    }
}

void LOCAL CalcScaleParms(SIZE wpgsp, RECT tr,
                          LPSCALE lps)
/*
   USE:  Calculate scale parameters.
   IN:   wpgsp = WPG space size, x = width, y = height
         tr    = target rect on screen where image goes
   OUT:  lps = ptr to struct with scale parameters
*/
{
  /* Scale equation solutions in x. */
  lps->scaleX = (double) (tr.right - tr.left)/wpgsp.cx;
  lps->offsX = tr.left;

  /* Scale equation solutions in y. */
  lps->scaleY = (double) (tr.top - tr.bottom)/wpgsp.cy;
  lps->offsY = tr.bottom;
}
```

user's depressing the left mouse button on the top left knob, or hot spot. When the user later releases the left mouse button, after dragging, *Modify()* calls *UpdateScale(hs, pt)* to adjust *TargetRect* appropriately, where *hs* is the hot spot variable holding the type of modification and *pt* is the point at which the user released the left mouse button. This is the new top left corner of *TargetRect* and is all the information needed to recalculate *TargetRect*. Once the switch has determined the new *TargetRect*, *UpdateScale()* calculates the new scale parameters and stores them in global structure *Scale*.

SHOWWPG as a Graphics Filter

Writing GDI calls to a screen DC (display context) displays the image, while writing the GDI calls to a metafile DC creates a metafile. A Windows metafile is a static list of GDI calls which can be saved as a disk file or, as in SHOWWPG, copied to the clipboard. One of *PlayWPGFile()*'s parameters is an *hDC*, or handle to a display context; this is the sole determinant of whether the image is displayed or translated to a metafile. Once the metafile has been transferred to the clipboard, you have truly captured it in the Windows system, since any Windows application capable of pasting metafiles from the clipboard can now retrieve the image. The image can be manipulated or added to within the retrieving program, and resaved in the native format of the program or any other format the program can export to. SHOWWPG has filtered the WPG graphic into Windows. □