

AI Drift

Full Technical Specification: Thunking Mechanisms in Windows (16-bit → 32-bit)

Document version: 1.0 **Applicable to:** Windows 3.x, Windows 95/98/Me, Windows NT 3.1-4.0

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Introduction: The mixed-bitness problem

16-bit Windows versions 1.x and 2.x ran on Intel 8086/8088 in **real mode**, where a far pointer was a 16-bit segment value (shifted left by 4) plus a 16-bit offset, resulting in a 20-bit physical address. A significant change came with the **Windows/386** family (versions 2.03 and later in 1987), which first introduced a **protected mode** environment for 386 processors[reference:0]. This “386 Enhanced Mode” allowed the system to run multiple MS-DOS applications concurrently in extended memory, moving beyond the 640KB barrier. It was during this period that a far pointer evolved into a **selector:offset** pair, where the selector was an index into a descriptor table[reference:1].

32-bit systems (Windows NT, 95) introduced the **flat model**: a 32-bit linear address (0:32), with `int` size = 32 bits, stack `SS:ESP`, and support for up to 4GB of virtual address space.

Direct calling between 16-bit code (real or protected mode) and 32-bit flat-model code is impossible because of:

- different pointer formats (16:16 far pointer vs 0:32 linear),
- different sizes of basic types (16-bit `int` vs 32-bit `int`),
- different stack conventions (`SS:SP` vs `SS:ESP`),
- the need to switch processor decoding mode (D-bit in segment descriptors for protected mode, or switching between real and protected modes).

A **thunk** is a piece of code (or a set of functions) that transparently transforms a call between these incompatible execution environments.

However, the concept of thunking is much older and broader than the 16-to-32-bit transition. Already

in the real-mode era, Windows faced two fundamental problems that thunks were invented to solve:

1. **Segment swapping (overlays)** – In real mode, code segments could be discarded or moved to disk to save memory. When a far call was made to a function in a potentially absent segment, a mechanism was needed to check presence, reload the segment from disk if necessary, and then transfer control. This was performed by a **call thunk** (or **instance thunk**). The Windows API function `MakeProcInstance` created such a thunk dynamically, binding a far pointer to a specific instance's data segment (loading `hInstance` into `AX` before jumping to a system reload thunk).
2. **Return from a discarded segment** – After a function returned, the return address (`CS:IP`) on the stack might point to a code segment that had been swapped out. To handle this gracefully, Windows used a **return thunk**. The undocumented `CallProcInstance` function acted as such a thunk, checking the presence of the target segment, reloading it if needed, and then jumping to the original return address. This mechanism allowed cooperative multitasking without an MMU, relying on software-managed segment validity.

Thus, even in pure 16-bit Windows, thunks were essential for memory management and for correctly routing callbacks (window procedures, timer procs, etc.) to the appropriate instance's data segment. Later, as 32-bit flat model emerged, the same core idea — a small piece of glue code that translates between different calling conventions, pointer formats, and memory models — was extended to bridge 16-bit and 32-bit code, giving birth to Generic Thunk (NT), Universal Thunk (Win32s), Flat Thunk (Windows 95), and the low-level Thunklet building blocks.

This document describes all these thunk variants in technical detail, from the early real-mode thunks to the last 16-32 bridges used in Windows 9x and NT.

1. Instance Thunk (Win16)

1.1 Purpose and architecture

In 16-bit Windows, multiple instances of the same application share code but each has its own **data segment (DS)**. When Windows calls a callback function (window procedure, `EnumFonts`, `SetTimer`, etc.), the system does not know which DS to set. `MakeProcInstance` creates a small thunk that, before calling the real function, loads the instance handle (`hInstance`) into register `AX`. The receiving function must start with a prolog that loads `DS` from `AX`.

Thunk placement: The thunk is created in the **data segment** of the calling module (usually `DGROUP`). Windows can move data segments in memory, so the kernel maintains an internal table of all created thunks to update them when segments are moved.

1.2 Thunk memory format (disassembled code)

A typical thunk occupies **8-16 bytes** (depending on alignment). Real code from Windows 3.1:

```
; Thunk created by MakeProcInstance
; Address of thunk is returned as FARPROC
mov     ax, 1234h           ; B8 34 12 – hInstance will be placed here
jmp     far ptr 5678:0000h ; EA 00 00 78 56 – target function address
```

(seg:off)

Sometimes the thunk is padded with a 0x66 prefix (not used in pure Win16). After the thunk is called, control passes to a system reload thunk that loads the code segment if needed.

1.3 API and ordinals

Function	Export	Ordinal (KERNEL.EXE 3.10)
MakeProcInstance	by name	51 (unofficial)
FreeProcInstance	by name	52 (confirmed)
CallProcInstance	by name	missing (undocumented)

FreeProcInstance (ordinal 52) removes the thunk from internal kernel tables and frees memory.

1.4 Full creation and call cycle

```
// 1. Create thunk
FARPROC lpfThunk = MakeProcInstance((FARPROC)MyCallback, hInst);

// 2. Pass thunk to Windows API
SetTimer(hWnd, ID_TIMER, 1000, (TIMERPROC)lpfThunk);

// 3. Inside MyCallback (must have special prolog)
void FAR PASCAL MyCallback(HWND hWnd, UINT msg, UINT id, DWORD time) {
    // Compiler with -GA -GEa generates:
    //   push bp
    //   mov bp, sp
    //   push ds
    //   mov ds, ax      ; AX = hInstance from thunk
    //   ... function body ...
}

// 4. Free
FreeProcInstance(lpfThunk);
```

1.5 Compiler options for callback functions

Microsoft C 6.0/7.0 and Visual C++ 1.x require: * **-GA** – load DS from AX on function entry (for callbacks). * **-GEa** – generate prolog for all exported functions (manages data segment).

Without these flags, the function will use the wrong DS, leading to a general protection fault.

1.6 Role of "CallProcInstance"

CallProcInstance is an **undocumented kernel function** that invoked a thunk passed via registers ES:BX. Prototype:

```
LONG FAR PASCAL CallProcInstance(HWND hWnd, WORD wParam, WORD wParam, LONG lParam);
```

It was used internally by CallWindowProc and other dispatchers. It does not exist in modern 32-bit systems.

2. Generic Thunk (Windows NT)

2.1 WOW architecture in NT

In Windows NT, all 16-bit applications run inside a single process **NTVDM.EXE** (NT Virtual DOS Machine). Each 16-bit application is a **separate thread** inside NTVDM. They all share a single address space but have different TDBs (Task Database). 32-bit DLLs are loaded directly into the NTVDM process address space. Thanks to this, 16-bit code can call 32-bit functions via Generic Thunk.

2.2 KRNL386.EXE exports (ordinals 513-517)

The 16-bit library KRNL386.EXE (shipped with Windows NT) added new exports:

Ordinal	Export name	Purpose
513	LoadLibraryEx32W	Loads a 32-bit DLL into NTVDM space.
514	FreeLibrary32W	Unloads a 32-bit DLL.
515	GetProcAddress32W	Returns linear address (0:32) of an exported function.
516	GetVDMPointer32W	Converts a 16:16 pointer to a 32-bit linear address.
517	CallProc32W	Calls a 32-bit function with parameter conversion (Pascal calling convention).

Later CallProcEx32W appeared (no fixed ordinal), supporting `__cdecl` and the flag `CPEX_DEST_CDECL`.

2.3 API functions: prototypes and parameters

"LoadLibraryEx32W"

```
HINSTANCE32 LoadLibraryEx32W(LPSTR lpszFile, HFILE hFile, DWORD dwFlags);
// lpszFile - DLL name (ANSI)
// hFile - unused (0)
// dwFlags - can be DONT_RESOLVE_DLL_REFERENCES (0x00000001)
// returns 32-bit handle (HINSTANCE32)
```

"FreeLibrary32W"

```
BOOL FreeLibrary32W(HINSTANCE32 hInst);
```

```
// hInst – handle from LoadLibraryEx32W
```

"GetProcAddress32W"

```
FARPROC GetProcAddress32W(HINSTANCE32 hInst, LPCSTR lpszProc);
// lpszProc – function name or ordinal if HIWORD(lpszProc)==0
// returns linear address (0:32)
```

"GetVDMPointer32W"

```
DWORD GetVDMPointer32W(LPVOID lpAddress, UINT fMode);
// lpAddress – 16:16 pointer (selector:offset)
// fMode – 1 = protected mode selector:offset; 0 = real-mode segment:offset
// returns 32-bit linear address or NULL
```

"CallProc32W" (Pascal)

```
DWORD CallProc32W(FARPROC lpFunction, DWORD dwAddrConvert, DWORD dwParams,
...);
// lpFunction – linear address from GetProcAddress32W
// dwAddrConvert – bitmask (LSB = 1st parameter)
// dwParams – number of parameters (0..32)
// ... – parameters (each must be DWORD)
```

"CallProcEx32W" (cdecl)

```
DWORD FAR CDECL CallProcEx32W(DWORD nParams, DWORD fAddressConvert,
                               DWORD lpProcAddress, ...);
// nParams – low bits = parameter count; high bit (0x80000000) =
CPEX_DEST_CDECL
// fAddressConvert – bitmask
// lpProcAddress – linear address
```

2.4 Bitness switching: 66h/67h prefixes and far call

On x86 processors (386+), each code segment has a **D** bit in its descriptor: * D=0 → 16-bit decoding (default IP, SP, operands are 16-bit) * D=1 → 32-bit decoding

Prefix **66h** (operand size override) temporarily toggles operand size to the opposite. Prefix **67h** (address size override) toggles address size.

The code inside `CallProc32W` (executed in a 16-bit segment, D=0) looks like this:

```
; 16-bit code (D=0)
push bp
```

```

mov bp, sp
db 66h           ; operand size override – next instruction is 32-
bit
call far [bp+4] ; reads 6 bytes: selector (2) + 32-bit offset (4)
mov sp, bp
pop bp
retf

```

A selector with D=1 is loaded → the processor switches to 32-bit mode for instructions at lpFunction. Return from the 32-bit function must be via retf (or retf with 66h prefix if returning to a 16-bit segment).

2.5 Algorithm of "CallProc32W" and "CallProcEx32W"

Pseudo-code based on Finnegan's article and reverse engineering:

```

DWORD CallProcEx32W(DWORD nParams, DWORD fAddrConv, DWORD lpFunc, ...) {
    DWORD args[32];
    va_list valist;
    va_start(valist, lpFunc);
    for (int i = 0; i < (nParams & 0x1F); i++) {
        DWORD arg = va_arg(valist, DWORD);
        if (fAddrConv & (1 << i)) {
            // convert 16:16 to linear via GetVDMPointer32W
            args[i] = GetVDMPointer32W((LPVOID)(DWORD)arg, 1);
        } else {
            args[i] = arg;
        }
    }
    va_end(valist);

    // switch to 32-bit stack (inside NTVDM)
    // copy args to 32-bit stack
    // perform far call with 66h prefix to lpFunc
    // copy result from EAX to return DWORD
    // restore 16-bit stack
    return eax_result;
}

```

2.6 Memory management: "GlobalFix" / "GlobalUnfix"

Microsoft documentation (Win32 SDK for NT) requires: if you pass a pointer to data in a **moveable** segment (allocated with GlobalAlloc and GMEM_MOVEABLE) to CallProcEx32W, you must fix that segment before the call and unfix it after.

```

HGLOBAL hMem = GlobalAlloc(GMEM_MOVEABLE, 1024);
LPSTR p = GlobalLock(hMem);
GlobalFix(hMem); // prevent moving

```

```
// call CallProcEx32W with p
GlobalUnfix(hMem);
GlobalUnlock(hMem);
```

This is less critical on Windows NT due to virtual memory, but on Windows 95/98 (where Generic Thunk partially worked) it was mandatory.

2.7 Full code example (16-bit → 32-bit)

```
// 16-bit module (WOWTST16.EXE)
#include <windows.h>

HINSTANCE32 hK32;
FARPROC pfnGetTickCount;

void InitThunk() {
    hK32 = LoadLibraryEx32W("KERNEL32.DLL", NULL, 0);
    pfnGetTickCount = GetProcAddress32W(hK32, "GetTickCount");
}

DWORD GetTickCount32() {
    return CallProcEx32W(1, 0, (DWORD)pfnGetTickCount, 0);
}

void CallWithString(LPSTR str) {
    DWORD linear = GetVDMPointer32W(str, 1);
    // call 32-bit function that expects LPSTR
    CallProcEx32W(1, PARAM_01, (DWORD)pfnSomeFunc, linear);
}
```

2.8 Limitations and known issues

* **Supported only on Windows NT/2000/XP** (officially not supported on Windows 95/98/Me, though some versions might partially work). * Maximum number of parameters - **32** (due to DWORD bitmask). * Cannot pass a 16-bit callback pointer to a 32-bit function (e.g., EnumWindows). * CallProc32W uses Pascal calling convention, making it hard to call varargs functions (use CallProcEx32W instead). * Manual memory management with GlobalFix is required.

3. Universal Thunk (Win32s)

3.1 Win32s architecture and place of Universal Thunk

Win32s is an add-on component for Windows 3.1 that allows running 32-bit applications in a 16-bit Windows environment. It is implemented as a set of thunks that translate Win32 API calls to 16-bit counterparts. Universal Thunk is an extension that allows a **32-bit application** to call arbitrary **16-bit DLLs** (and, in a limited form, vice versa).

3.2 Four-component UT ecosystem

To use Universal Thunk, four components are needed:

32-bit application (EXE) - wants to use a 16-bit DLL. # **32-bit interface DLL** - contains code that calls `UTRegister`. # **16-bit interface DLL** - exports `UT16Init` and `UT16Proc`. # **Target 16-bit DLL** - contains the real logic (may be the same as #3).

The 32-bit interface DLL and the 16-bit interface DLL are linked via `UTRegister`. Win32s automatically loads the 16-bit DLL and calls its initialisation routine.

3.3 Universal Thunk API

All functions are exported from `KERNEL32.DLL` (in the Win32s environment). Prototypes in `w32sut.h` (from Win32 SDK).

```

BOOL UTRegister(
    HANDLE hModule,           // handle of 32-bit DLL
    (GetModuleHandle(NULL) for EXE)
    LPCSTR lpsz16BitDLL,     // name of 16-bit interface DLL (no
    path)
    LPCSTR lpszInitFunc,     // name of init function (UT16Init)
    LPCSTR lpszStepdownFunc, // name of dispatcher (UT16Proc)
    UT32PROC *ppfnStepdownThunk, // [out] pointer to stepdown thunk
    (32→16)
    FARPROC pfnCallback32,   // [in] 32-bit callback (NULL if not
    needed)
    LPVOID lpvData           // [in] data for UT16Init (translated to
    16:16)
);
void UTUnRegister(HANDLE hModule);
LPVOID UTSelectorOffsetToLinear(LPVOID lp16); // 16:16 → 0:32
LPVOID UTLinearToSelectorOffset(LPVOID lp32); // 0:32 → 16:16

```

3.4 Initialisation protocol: "UT16Init" and "UT16Proc"

The 16-bit interface DLL must export two functions (often with ordinals 2 and 3):

```

// UT16Init - called by Win32s after loading the 16-bit DLL
DWORD FAR PASCAL UT16Init(UT16CBPROC pfnCallback32, LPVOID lpvData) {
    // pfnCallback32 - pointer to stepup thunk (allows 16-bit code to call
    32-bit)
    // lpvData - data from UTRegister (translated to 16:16)
    // save pfnCallback32 for future callbacks
    return TRUE; // return FALSE to abort registration
}

// UT16Proc - dispatcher called via stepdown thunk

```

```

DWORD FAR PASCAL UT16Proc(LPVOID lpvData, DWORD dwFunctionCode) {
    switch (dwFunctionCode) {
        case 1: return Some16BitFunction(lpvData);
        case 2: return AnotherFunction(lpvData, ...);
    }
    return 0;
}

```

Stepdown thunk - a pointer returned via `ppfnStepdownThunk`. 32-bit code can call it, passing data and a function code. Win32s translates the call into `UT16Proc`.

Stepup thunk - a pointer passed to `UT16Init`. 16-bit code can call it to execute a 32-bit callback function.

3.5 Translation lists (xlist)

For passing complex structures (with many pointers), the third parameter of the stepdown thunk can be a translation list. Convention: when calling the stepdown thunk, three parameters are passed: `lpvData`, `dwFunctionCode`, `LPVOID *xlist`. If `xlist` is not `NULL`, Win32s traverses the array (until `NULL`) and for each pointer (which is a pointer to a pointer) translates it from 0:32 to 16:16 before calling `UT16Proc`.

Example (from Oney's article):

```

LPVOID *xlist = malloc(4 * sizeof(LPVOID));
xlist[0] = &stepdownargs.format; // pointer to string
xlist[1] = &stepdownargs.substargs;
xlist[2] = NULL;
DWORD result = (*stepdownThunk)(&stepdownargs, 0, xlist);

```

3.6 Memory management issues: 256 selectors, 32KB limit, "GlobalAlloc"

256 selector problem: Win32s creates an alias selector for each 64KB block of virtual memory allocated via `VirtualAlloc`, so that 16-bit code can access it. The LDT can hold at most 256 selectors for this purpose. If the application allocates many small blocks (e.g., via `new` or `HeapAlloc`), selectors run out and `UTLinearToSelectorOffset` starts returning `NULL`.

Solution: use `GlobalAlloc` with `GMEM_MOVEABLE`. Global memory uses a different translation mechanism (via the GDI heap) that does not consume LDT selectors.

32KB limit: Win32s imposes a limit: the maximum size of a memory block that can be safely passed through UT is 32KB. This is because only one alias selector is created per block, and accessing beyond 32KB may cause a fault.

Additionally, before calling the stepdown thunk, if you pass a pointer to moveable memory (`GlobalAlloc` with `GMEM_MOVEABLE`), you must fix it with `GlobalFix`.

3.7 Real-world example: Tcl/Tk

In the Tcl 8.x source code for Windows, Universal Thunk was used to call 16-bit functions. Snippet:

```
// tclWin32s.c
HINSTANCE hKernel = LoadLibrary("KERNEL32.DLL");
UTREGISTER utRegister = (UTREGISTER)GetProcAddress(hKernel, "UTRegister");
UTUNREGISTER utUnregister = (UTUNREGISTER)GetProcAddress(hKernel,
"UTUnregister");
if (utRegister) {
    utRegister(hInst, "TCL16.DLL", "UT16Init", "UT16Proc", &stepdown, NULL,
NULL);
}
// ...
utUnregister(hInst);
```

3.8 Limitations and undocumented features

* **Win32s only**: Universal Thunk does not work on Windows NT, 95, or 98. * **One UT per module**: Each 32-bit module can register only one Universal Thunk. * **Complexity**: Requires two interface DLLs. * **Unreliable**: Because of the selector limitation, crashes are common. * **No support**: Microsoft discontinued Win32s after Windows 95.

4. Flat Thunk (Windows 95/98/Me)

4.1 Windows 9x architecture and bidirectional calls

Windows 95/98 has two independent kernels: * **16-bit** (KRNL386.EXE, USER.EXE, GDI.EXE) – for legacy applications. * **32-bit** (KERNEL32.DLL, USER32.DLL, GDI32.DLL) – for new applications.

They communicate via built-in internal thunks. **Flat Thunk** is a mechanism that allows user code to create similar bidirectional bridges. The key difference from Generic/Universal Thunk: a single tool **Thunk.exe** generates a pair of DLLs (16 and 32) that automatically translate calls in both directions.

4.2 Quick Thunk and the "QT_Thunk" function

At the heart of Flat Thunk lies an **undocumented function** QT_Thunk, exported from KERNEL32.DLL. Its prototype (reconstructed by Matt Pietrek):

```
DWORD QT_Thunk(DWORD functionIndex, DWORD argCount, DWORD *args);
```

* **functionIndex** – index of the function in the 16-bit dispatcher table (generated by Thunk.exe). * **argCount** – number of arguments (up to 32). * **args** – array of DWORD values to be passed to the 16-bit code.

QT_Thunk performs: # Saves 32-bit context (registers, stack). # Switches to a 16-bit stack (SS:SP). # For each argument: if the argument is a pointer (determined by the .THK description), converts 0:32 → 16:16. # Calls the 16-bit code via a far call. # Converts the result from DX:AX to EAX. # Restores the 32-bit context. # Returns the result.

4.3 Algorithm of "QT_Thunk" (according to Matt Pietrek)

Pseudo-code from "Windows 95 System Programming Secrets" (1996):

```

DWORD QT_Thunk(DWORD func, DWORD nArgs, DWORD *pArgs) {
    // save FS, GS, EBP, ESI, EDI, DS, ES, SS
    // switch DS to 32-bit data selector
    // switch stack: esp -> temporary 16-bit stack
    for (i=0; i<nArgs; i++) {
        DWORD arg = pArgs[i];
        if (bit i set in thunk descriptor) {
            // convert 0:32 to 16:16 (allocate selector)
            push seg, off
        } else {
            push low16(arg), high16(arg) // actually push DWORD
        }
    }
    push func (index)
    call far [16-bit dispatcher]
    // result in DX:AX
    // restore context
    return (DWORD)AX | ((DWORD)DX << 16);
}

```

4.4 Thunk Compiler (THUNK.EXE): .THK file format

Thunk.exe (included in the Platform SDK for Windows 95) reads a text .THK file and generates an assembly .ASM file. Example:

```

// sample.thk
typedef struct tagPOINT {
    int x;
    int y;
} POINT;

BOOL WINAPI GetCursorPos(POINT FAR* lpPoint) = 16; // function on the 16-bit side

param(lpPoint) = inout; // pointer is translated and data copied both ways

```

Directives: * = 16 - function resides in a 16-bit DLL (called from 32-bit). * = 32 - function resides in a 32-bit DLL (called from 16-bit). * param(parameter) = in | out | inout - direction of data transfer (for pointer translation).

Thunk.exe generates a single .ASM file containing: - A function description table (for QT_Thunk). - 32-bit proxy functions (to be called from 32-bit code). - 16-bit proxy functions (to be called from 16-bit code).

4.5 Building a 16-bit and 32-bit DLL pair with Thunk.exe

Steps:

Create mylib.thk with function descriptions. # Run thunk mylib.thk mylib.asm. # Build the 32-bit DLL:

```
<code bash>
ml /c /DIS_32 mylib.asm
cl /c /GD mylib32.c
link mylib32.obj mylib32.obj /DLL /OUT:MYLIB32.DLL
</code>
```

Build the 16-bit DLL:

```
<code bash>
ml /c /DIS_16 mylib.asm
cl /c /AS /G2 mylib16.c
link mylib16.obj mylib16.obj /DLL /OUT:MYLIB16.DLL
</code>
```

The 32-bit application calls MYLIB32.DLL, which uses QT_Thunk to talk to MYLIB16.DLL.

4.6 Differences between Flat Thunk and Generic/Universal Thunk

Feature	Flat Thunk	Generic Thunk	Universal Thunk
Platform	Windows 95/98	Windows NT	Win32s
Direction	16↔32 bidirectional	16→32	32→16
Code generation	Thunk.exe	manual via API	manual via UTRegister
Platform dependence	High	Medium	Very high
Callback support	Yes (via .THK)	No	Yes (via stepup thunk)

5. Thunklet (low-level WOW building block)

5.1 Definition and role

Thunklet is the smallest executable block of code (usually 16 bytes) that performs bitness switching and transfers control between 16-bit and 32-bit code. Thunklet is not a public API; it is an internal mechanism of the Windows NT kernel (WOW) and, to some extent, Windows 95. All high-level thunks (Generic, Flat) are built from thunklets.

5.2 "_THUNKLET" structure (16 bytes)

From the Wine project (include/wine/thunk.h):

```
typedef struct _THUNKLET {
    WORD    opcodes[4];        // 8 bytes of machine code
    DWORD   lpFunction;       // 4 bytes: 32-bit linear address of target
    function
    WORD    wRelayID;         // 2 bytes: unique identifier (for callbacks)
    WORD    wReserved;        // 2 bytes: alignment
} THUNKLET;
```

opcodes - machine code that when executed: - Saves registers. - Loads the 32-bit address from lpFunction. - Switches bitness (66h prefix) and performs a call far. - Restores registers and returns.

5.3 Client Thunklet and Server Thunklet

* **Client Thunklet** (16-bit → 32-bit call): Called from 16-bit code. It switches the processor to 32-bit mode and calls the function at lpFunction. After return, it switches back. * **Server Thunklet** (return / callback 32-bit → 16-bit): Used for callbacks. It stores the 16-bit return address and stack selector. When called, it switches to the 16-bit stack and passes control.

5.4 Hidden KERNEL Thunklet API (ordinals 560-568, 604-612, 619-622)

The 16-bit KRNL386.EXE (the version for Windows NT) contains additional exports intended for internal WOW use. They are undocumented but known from reverse engineering (Wine, IDA Pro).

Ordinal range	Presumed purpose
560-568	Thunklet management: AllocThunklet, FreeThunklet, GetThunklet, SetThunkletFunction
604-612	Address translation: LinearToSelector, SelectorToLinear, FixPointer
619-622	Client callbacks: CallClientThunk, ReplyClientThunk

Example hypothetical call:

```
// Get Thunklet by ID (undocumented, ordinal 560)
THUNKLET FAR* GetThunklet(WORD wRelayID, WORD wType);

// Bind Thunklet to a function (ordinal 562)
void SetThunkletFunction(THUNKLET FAR* pThunk, DWORD lpFunction);
```

5.5 Example machine code of a Thunklet (from Windows NT)

Disassembled Thunklet from KRNL386.EXE (16-bit segment):

```

; Client Thunklet (call 32-bit function)
push    bp
mov     bp, sp
db     66h                ; operand size override
call   far [bp+4]        ; call address stored in lpFunction
mov     sp, bp
pop     bp
retf
    
```

Here [bp+4] is the location on the stack where the 32-bit address (from lpFunction) is placed before the call. The 66h prefix forces the processor to interpret the call far as 32-bit (reads 6 bytes: selector+offset).

5.6 Implementation in Wine

Wine, emulating the Win32 API on Unix-like systems, implements thunklets to support 16-bit applications (NTVDM). In `dlls/wow32/thunk.c`:

```

THUNKLET *THUNK_Alloc(void) {
    THUNKLET *thunk = VirtualAlloc(NULL, sizeof(THUNKLET), MEM_COMMIT,
    PAGE_READWRITE);
    // fill opcodes with default code (push bp, mov bp, sp, db 66h, call
    ...)
    memcpy(thunk->opcodes, defaultThunkCode, 8);
    thunk->wRelayID = 0;
    thunk->lpFunction = 0;
    return thunk;
}

void THUNK_SetFunction(THUNKLET *thunk, DWORD func) {
    thunk->lpFunction = func;
}
    
```

Wine also contains `elf_is_in_thunk_area`, used by debuggers to determine whether an address belongs to the thunklet area.

Comparison table of all mechanisms

Mechanism	OS	Direction	Thunk size	API / tool	Bitness switching	Pointer translation	Callback 16→32	Memory management
Instance Thunk	Win16 (3.x)	16→16 callback	8-16 bytes	MakeProcInstance	not needed (same bitness)	not needed (DS from AX)	N/A	not required
Generic Thunk	WinNT 3.1-4.0	16→32	built into CallProc32W	LoadLibraryEx32W etc.	66h prefix + far call	GetVDMPointer32W	no	GlobalFix
Universal Thunk	Win32s	32→16 (and back)	external (stepdown thunk)	UTRegister, UTUnRegister	via Win32s kernel	UTSelectorOffsetToLinear	yes (stepup thunk)	GlobalFix, 256 selectors, 32KB limit
Flat Thunk	Win95/98/Me	16↔32 bidirectional	generated by THUNK.EXE	QT_Thunk, Thunk.exe	QT_Thunk	built into QT_Thunk	yes (via .THK)	GlobalFix, GlobalAlloc

Mechanism	OS	Direction	Thunk size	API / tool	Bitness switching	Pointer translation	Callback 16→32	Memory management
Thunklet	internal WOW (NT/95)	low-level block	16 bytes	hidden API (KRNL386 ordinals)	66h prefix + jmp	via separate functions	via RelayID	not required

Conclusion

All five thunking mechanisms were developed during the transition from 16-bit Windows to 32-bit Windows. Each solved a specific problem on a specific platform:

* **Instance Thunk** - a legacy of Win16, solving the binding of callback functions to instance data. * **Generic Thunk** - an elegant but platform-specific solution for Windows NT, allowing 16-bit applications to use 32-bit DLLs. * **Universal Thunk** - a complex but only possibility for 32-bit applications on Win32s to call 16-bit code. * **Flat Thunk** - a powerful, bidirectional mechanism for Windows 95/98, using QT_Thunk and the Thunk Compiler. * **Thunklet** - the low-level “atom” from which all other thunks are built.

Understanding these mechanisms is essential for maintaining legacy systems, reverse engineering, and analysing historical code. Modern versions of Windows (starting with 2000) do not support any of these thunks (except emulating MakeProcInstance as a stub).

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