

# Win16 Local Heap Functions

## Overview

In 16-bit versions of Windows (1.x, 2.x, 3.x), each module (application or DLL) typically has its own data segment (DGROUP) limited to 64 KB. This segment contains the stack, the local heap, and the atom table. Local heap functions manage memory within this segment using near pointers (offsets). They are exported by the kernel (KRNL386.EXE). Internally, the local heap is managed through a set of data structures that reside inside the segment itself.

A key part of this management is the Instance Data (also called the NULL segment) located at the very beginning of DGROUP, which holds pointers to the heap, atom table, and stack information. The field at offset 6 (pLocalHeap) contains a near pointer to the HeapInfo structure that heads the local heap. This pointer is set by LocalInit() and must be validated by checking the signature word (li\_sig) at offset 22h (Standard mode) or 28h (KRNL386) within the presumed heap.

The local heap itself is organized as a series of arenas (headers) that precede each block. The two low bits of the la\_prev field in an arena are used as flags: bit 0 indicates whether the block is in use (1) or free (0); bit 1 indicates whether the block is MOVEABLE (1) or FIXED (0). Free blocks are linked via la\_free\_prev and la\_free\_next. For MOVEABLE blocks, a separate handle table (pointed to by hi\_htable in HeapInfo) stores the actual address, lock count, and flags; each handle is an offset into this table.

## Internal Structures

### Instance Data (NULL Segment)

The first 16 (10h) bytes of the default data segment (DGROUP) are reserved for system use and are collectively referred to as the Instance Data or NULL segment. This area is present only if the first WORD at offset 0 is zero; otherwise, the structure is not present. The layout is as follows:

Instance Data Structure (offsets relative to DGROUP start)

| Offset | Type  | Field        | Description                                                                                                                                                                                                                                                                                                                                                                             |
|--------|-------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00h    | WORD  | wMustBeZero  | Must be zero for the NULL segment structure to be considered present.                                                                                                                                                                                                                                                                                                                   |
| 02h    | DWORD | dwOldSSSP    | When SwitchStackTo() is called, the current SS:SP is stored here. At other times, may contain the value 5 (from C compiler's _rsrvptrs).                                                                                                                                                                                                                                                |
| 06h    | WORD  | pLocalHeap   | Near pointer to the Local Heap information structure (i.e., the HeapInfo structure). This field is set by LocalInit() and points to the beginning of the local heap management structures. If no local heap exists, this field may be stale (non-zero but invalid). Always verify the heap by checking the signature at offset 22h (Standard mode) or 28h (KRNL386) – see li_sig below. |
| 08h    | WORD  | pAtomTable   | Near pointer to the atom table, set by InitAtomTable(). Zero until atoms are used.                                                                                                                                                                                                                                                                                                      |
| 0Ah    | WORD  | pStackTop    | Near pointer to the end (top) of the stack. For DLLs, this is zero.                                                                                                                                                                                                                                                                                                                     |
| 0Ch    | WORD  | pStackMin    | High-water mark of stack usage. For DLLs, zero.                                                                                                                                                                                                                                                                                                                                         |
| 0Eh    | WORD  | pStackBottom | Near pointer to the beginning (bottom) of the stack. For DLLs, zero.                                                                                                                                                                                                                                                                                                                    |

Important Notes:

The field at offset 6 (pLocalHeap) is the primary way to locate the local heap structures given only the DGROUP selector.

When LocalInit() is called on a globally allocated block (non-DGROUP), the WORD at offset 6 of that block is also set to point to the local heap information structure for that block.

Similarly, if InitAtomTable() is called on a global block, offset 8 points to the atom table, and offset 6 will point to the associated local heap (since atoms are stored in the local heap).

## HeapInfo and LocalInfo

Every local heap begins with an instance of the HeapInfo structure, which is identical to the one used by the global heap and is defined in WINKERN.INC. Its location is given by the pLocalHeap field at offset 6 of the Instance Data. Immediately following the HeapInfo structure are additional fields that, together with HeapInfo, form the LocalInfo structure. The layout of LocalInfo is as follows:

### LocalInfo Structure

| Offset | Field      | Description                                                                                                                                                                                           |
|--------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00h    | HeapInfo   | 1Eh-byte structure (see global heap section for field descriptions).                                                                                                                                  |
| 1Eh    | li_notify  | Far pointer to a routine called either when a heap block is about to be moved or discarded, or when the heap is out of memory. Initialized to point at LocalNotifyDefault().                          |
| 22h    | li_lock    | Lock count of the local heap. A non-zero value prevents blocks from moving or being discarded.                                                                                                        |
| 24h    | li_extra   | Minimum amount by which the local heap should be grown when expanded. Default is 200h.                                                                                                                |
| 26h    | li_minsize | Minimum size of the local heap, as specified by the HEAPSIZE line in the .DEF file.                                                                                                                   |
| 28h    | li_sig     | Signature word set to 484Ch ('LH' in a hex dump). Used by various Windows routines to verify heap integrity. This signature should be checked when validating a potential heap pointer from offset 6. |

## Arena Formats

Every block in the local heap is preceded by an arena (header) that contains management information. Arenas always start on a 4-byte boundary, so the two low bits of every arena address are zero. These bits are reused as flags in the la\_prev field of each arena. The two low bits of la\_prev have the following meaning:

Bit 0 (least significant): Set if the block is in use (FIXED or MOVEABLE); cleared if the block is free.

Bit 1: Set if the block is MOVEABLE; cleared if the block is FIXED (only meaningful when bit 0 is set).

Thus, to obtain the real address of the previous arena, the two low bits must be masked off.

There are three arena formats, corresponding to the three possible block states:

## FIXED Block Arena

### FIXED Block Arena

| Offset | Field   | Description                                                                                                                                                       |
|--------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00h    | la_prev | Near pointer to the preceding arena, with flags in the low two bits.                                                                                              |
| 02h    | la_next | Near pointer to the next arena. For a FIXED block, the handle is the address of the block itself. The arena can be found by subtracting 4 from the block address. |

## MOVEABLE Block Arena

### MOVEABLE Block Arena

Offset Field Description 00h WORD la\_prev Near pointer to the preceding arena, with flags. 02h WORD la\_next Near pointer to the next arena. 04h WORD la\_handle Offset of the handle table entry for this block. The la\_handle field provides two-way mapping between a MOVEABLE block and its handle table entry. Given the block address, subtract 6 to get the arena; the la\_handle field gives the offset of the handle entry. Given a handle entry, the first field (lhe\_address) gives the block address.

## Free Block Arena

### Free Block Arena

Offset Field Description 00h WORD la\_prev Near pointer to the preceding arena, with flags. 02h WORD la\_next Near pointer to the next arena. 04h WORD la\_size Size of the block, including the arena. 06h WORD la\_free\_prev Offset of the previous free arena. 08h WORD la\_free\_next Offset of the next free arena. Free blocks are threaded in a doubly linked list using la\_free\_prev and la\_free\_next. The start of this free list is stored in the la\_free\_next field of the first block in the heap (see below).

## The First Local Heap Block

The first block in the local heap is special. It resides in memory before the LocalInfo structure. Although its la\_prev field has the low bit set (indicating a FIXED, in-use arena), the local heap routines treat this arena as if it were free. The la\_free\_next field of this first block points to the first truly free block in the heap.

## Handle Table

For MOVEABLE blocks, handles are offsets into a handle table that resides in its own local heap blocks. The first handle table is located via the hi\_htable field in the HeapInfo structure. Each handle table begins with a WORD specifying how many handle entries follow. After all entries, the last WORD is the offset of the next handle table (or 0 if none). Free handle entries are linked together for quick allocation.

An in-use handle table entry has the following format:

### Format of Handle Table Entries

Offset Field Description 00h WORD lhe\_address Address of the memory block referenced by the handle. 02h BYTE lhe\_flags Flags: 0Fh = LHE\_DISCARDABLE (discard level), 1Fh = LHE\_USERFLAGS (reserved for programmer), 40h = LHE\_DISCARDED (block has been discarded). 03h BYTE lhe\_count Lock count of the block. Non-zero prevents moving or discarding. A free handle table entry contains:

Offset Field Description 00h WORD lhe\_link Offset of the next free handle table entry. 02h WORD lhe\_free Always FFFFh to indicate a free entry.

## Heap Operations

Allocation (LocalAlloc) walks the free list, splitting blocks if necessary, and sets up the appropriate arena. For MOVEABLE blocks, it also allocates a handle table entry.

Compaction (LocalCompact) coalesces adjacent free blocks and may move or discard unlocked MOVEABLE blocks. When a block is moved, its `lhe_address` is updated.

Locking (LocalLock/LocalUnlock) manipulates the `lhe_count` field of the handle entry for MOVEABLE blocks; for FIXED blocks, no count is maintained.

Discarding (LocalDiscard) frees the memory of a MOVEABLE block but keeps the handle entry alive with the `LHE_DISCARDED` flag set.

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