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Intel® 910GML/915G/915GM/915GMS/915GV and 910GL Express Chipsets
Intel® Dynamic Video Memory Technology (DVMT) 3.0

White Paper

August 2005

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Revision History

Revision	Description	Date
-001	• Initial Public Release	June 2004
-002	• Updated the default DVMT values, Table 5-1	August 2004
-003	• Updated to include Intel® 916GV Express chipset	August 2004
-004	• Updated to include Intel® 910GL Express chipset	September 2004
-005	• Intel® 910GML/915G/915GM/915GMS products support a maximum of 128MB of DVMT memory	August 2005

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1 *Introduction*

1.1 Purpose

The purpose of this document is to describe the memory allocation and usage model scenarios of an Intel® Graphics Media Accelerator Driver feature, Intel® Dynamic Video Memory Technology (DVMT) for the Intel® 910GML/915G/915GM/915GMS915GV and 910GL Express chipsets. This document will provide details on how DVMT works, configurability options available to the OEM and descriptions of what to expect in certain scenarios of DVMT 3.0

1.2 Scope

This document is intended for readers with an understanding of graphics driver architecture and an understanding of the feature set corresponding to the Intel® 910GML/915G/915GM/915GMS915GV and 910GL Express chipsets.

1.3 Acronyms

Acronym	Description
DLL	Dynamic Link Library
DVMT	Dynamic Video Memory Technology
GMM	Graphics Memory Manager
GTT	Graphics Translation Table
GW	Game Width
IOCTL	I/O Control Packets
SBIOS	System Basic Input Output Service
SMI	Services Management Interrupt
TLB	Translation Lookaside Buffer
VBT	Video BIOS Table

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2 Overview

2.1 Intel® Dynamic Video Memory Technology

Dynamic Video Memory Technology (**DVMT**) is an enhancement of the **Unified Memory Architecture (UMA)** concept, wherein the optimum amount of memory is allocated for balanced graphics and system performance. DVMT ensures the most efficient use of available memory – regardless of frame buffer or main memory size – for balanced 2D/3D graphics performance and system performance. DVMT dynamically responds to system requirements and applications' demands, by allocating the proper amount of display, texturing and buffer memory after the operating system has booted. For example, a 3D application when launched may require more vertex buffer memory to enhance the complexity of objects or more texture memory to enhance the richness of the 3D environment. The operating system views the Intel Graphics Media Accelerator Driver as an application, which uses Direct AGP to request allocation of additional memory for 3D applications, and returns the memory to the operating system when no longer required.

2.2 Memory Allocation Methods

2.2.1 Pre-Allocated Memory

The Intel® 910GML/915G/915GM/915GMS915GV and 910GL Express chipsets support the selection of two different sizes of pre-allocated memory: 1 MB and 8 MB. This amount is chosen via the system BIOS setup as a setup option. OEMs may choose to have this amount fixed via SBIOS and not expose this option in the CMOS setup. This pre-allocated memory selection is supplied for legacy VGA and SVGA graphics support and compatibility.

Upon boot, the System BIOS will pre-allocate the amount selected (1 MB or 8 MB) from the top of the main system memory, which will be dedicated for VGA/SVGA graphics. An example of when VGA graphics memory is needed includes usage for high-resolution games and applications run from a Microsoft MS-DOS∗ or legacy operating system, where there is no Intel Graphics Media Accelerator Driver loaded. Pre-allocated memory is not visible or accessible by the operating system, but only by the graphics driver. The Intel® 910GML/915G/915GM/915GMS915GV and 910GL Express chipsets integrated graphics devices will treat this memory as dedicated graphics memory. If an operating system is booted with an Intel Graphics Media Accelerator Driver loaded, the graphics driver will then reclaim the pre-allocated memory for use, but the operating system may never use this memory, and it is not available to applications except as graphics memory.

Note: The BIOS pre-allocates memory that the OS is not aware of, nor is the OS capable of reclaiming this memory. The Intel Graphics Media Accelerator Driver requests allocation of memory, from the OS, through OS supported memory allocation methods.

Note: Intel® Smart 2D Display Technology (one of the methods of additional power conservation for mobile systems) requires at least 8 MB of pre-allocated memory.

Note: High Resolution Splash Screen support also requires at least 8 MB of pre-allocated memory.

2.2.2 Fixed Memory

Fixed is a memory allocation method addition to the Unified Memory Architecture (UMA) concept, wherein a static amount of page-locked graphics memory is allocated during driver initialization. This fixed amount will provide the total amount of graphics memory available to the system and is intended to provide the user with a guaranteed amount of graphics memory at all times. Once the fixed amount is allocated during OS boot and driver initialization, this system memory amount will no longer be available to the OS. However, the OS will still report total system memory as including this allocated amount (as opposed to pre-allocated).

2.2.3 DVMT Memory

DVMT is an enhancement of the UMA concept, wherein the graphics driver allocates memory as needed for running graphics applications. The graphics driver is cooperatively using this memory with other system components. If a user is not performing any graphics-intensive operations, most of the DVMT memory can be utilized by the operating system for other uses. In an environment where the user is unlikely to run games that require a large amount of memory, the memory will be available for other uses such as database applications etc. In an environment where the user is playing games or may not run any data intensive non-graphics applications, the memory will automatically be used to optimize the graphics. Intel recommends using the DVMT setting for better overall system performance.

2.2.4 "Fixed" + "DVMT" Memory

"Fixed" + "DVMT" is a memory allocation in addition to the UMA concept, wherein a static amount of page-locked graphics memory is allocated during driver initialization and an additional amount of DVMT graphics memory is allocated and de-allocated based upon system need. This new memory allocation addition provides guaranteed amount of graphics memory while providing the capability to scale the amount of available graphics memory to a higher amount needed by applications (up to the maximum supported by the GMCH and system memory installation – see table below). This allocation method, Fixed + DVMT, allows for the static allocation of memory to guarantee a minimum amount over that which is pre-allocated and also allows for a more balanced system performance versus the Fixed only allocation method.

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Figure 2-1. Memory Allocation Methods
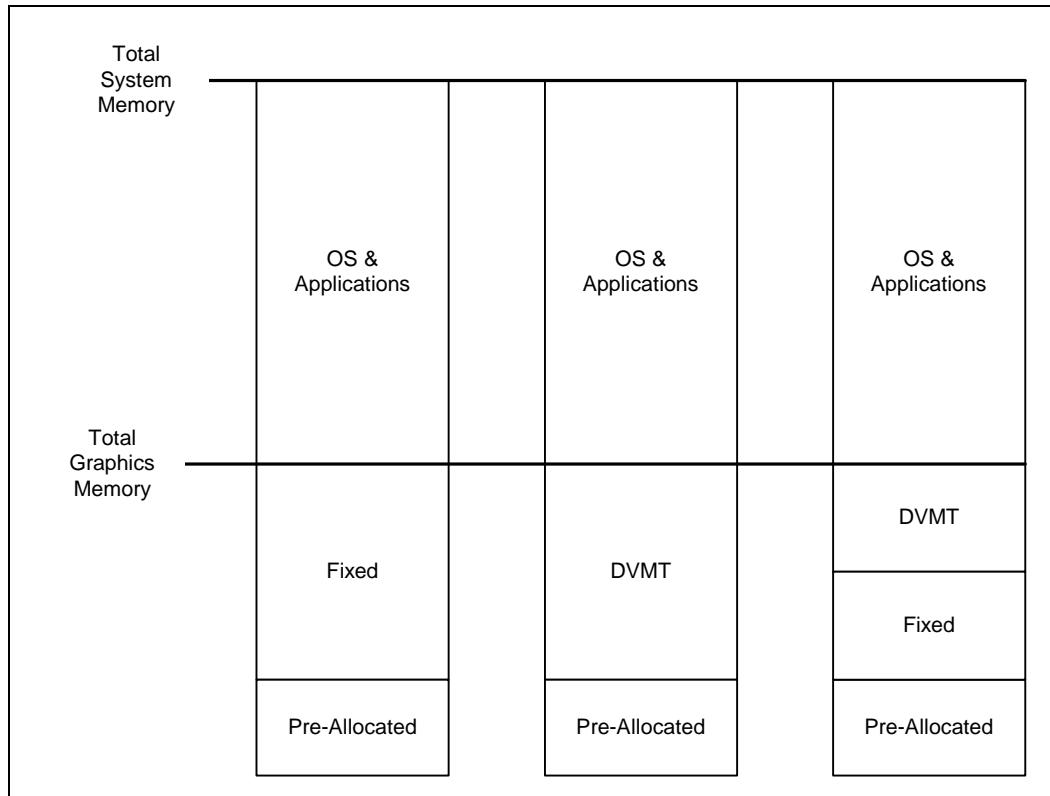
2.3   Graphics Memory Map

The graphics memory map provides a description of the main components necessary for the implementation of DVMT Technology. Some of the main concepts that help to understand DVMT include Graphics Aperture, Graphics Translation Table and how these concepts relate to other features of the Intel Graphics Media Accelerator Driver. Please see Section 2.3.3, for more details.

2.3.1   Graphics Aperture

The graphics aperture is a contiguous virtual memory space where the Intel Graphics Media Accelerator Driver will initiate access to the graphics memory. Not only will the graphics aperture provide a central location to access the graphics memory, but it also describes the total amount of graphics memory available to the system.

2.3.2   Graphics Translation Table

The Graphics Translation Table (GTT) is a Translation Lookaside Buffer (TLB) used to map the virtual memory space of the graphics aperture to that of the physical address space. The GTT is made up of 4-Byte entries, which map directly to 4-KB page-locked (i.e., non-swappable) pages, located in physical memory.

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> *Note:* When Intel® Smart 2D Display Technology is enabled, the graphics driver will have direct access to the pre-allocated memory space, which bypasses the need for the GTT.

2.3.3   Intel® Smart 2D Display Technology

A power conservation feature that is prevalent with DVMT is what is known as Intel® Smart 2D Display Technology (Intel® S2DDT). Intel® S2DDT is a feature that allows for optimization of the frame buffer display by using the minimum amount of the buffer needed to generate the display image. Due to the optimization of the frame buffer space, the quantity of read events across the memory bus is then decreased. The reduction of memory reads allows for an increase in system performance and a decrease in power consumption by the chipset, which in turn provides extended battery life to the end user.

Figure 2-2. Graphics Memory Map

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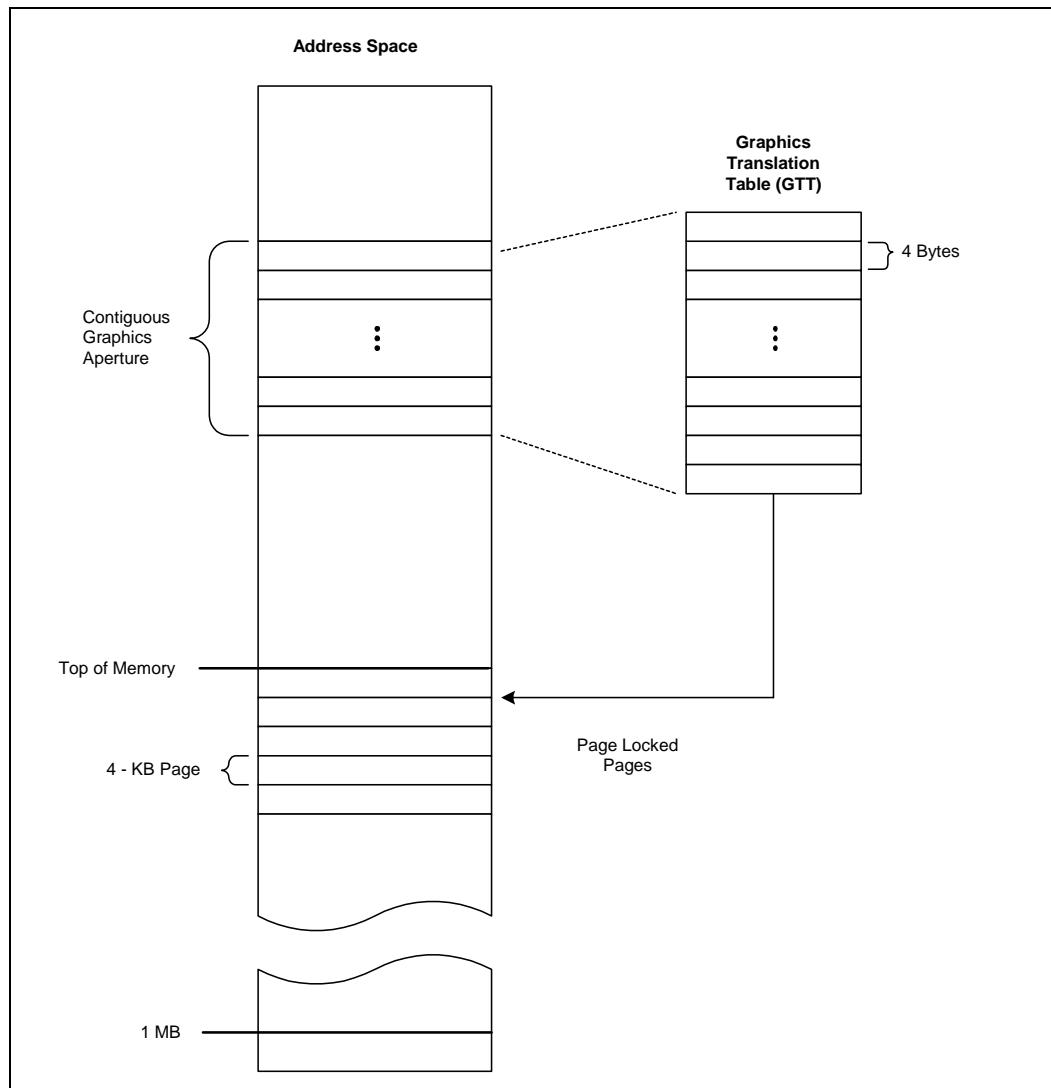
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3 *DVMT 3.0 Graphics Memory Footprint*

Upon operating system initialization, the Intel Graphics Media Accelerator Driver determines the size of memory needed and will make additional memory requests to achieve the amount needed for the display and application graphics memory operational footprint.

3.1 Factors in Footprint Variance

The Intel® 915G/915GV and Intel® 910GML/915GM/915GMS910GL Express Chipsets UMA memory footprint is determined using several factors. It varies widely depending on several key factors. The key factors are system resources and system activity. The Intel® 915G/915GV and Intel® 910GML/915GM/915GMS910GL Express Chipsets memory footprint will vary in size if and only if the defined memory allocation method is dynamic. For example, when running a DVD in a window on the desktop then memory is needed for the DVD and the background desktop, but when running a DVD full screen then the desktop frame-buffer may be discarded, or allowed to be paged back to disk. This is the most efficient memory utilization.

A DVD is just one of many activities that could effect memory allocation. This section will describe some of the factors that aid in the request made to the OS for page locked memory. The OS does not always grant Graphics driver's memory request.

3.2 Base Allocations

Part of the Graphics memory allocation is independent of system activity. These are base allocations that the driver request at the time it loads. For the Intel® 915G/915GV and Intel® 910GML/915GM/915GMS910GL Express chipsets platforms, the driver allocates memory for driver internal resources such as command ring buffer and cursor/context on all operating systems.

Once loaded, the operating system and Graphics driver allocates the buffers that the driver needs for performing Graphics operations. The total Graphics footprint allocates memory for commands, the frame buffer (resolution), the Z-buffer, GDI data and off-screen memory.

The total graphics footprint in system memory is capped to an upper-limit ensuring the best usability and performance of the OS, Applications and Graphics. The memory allocation limits are documented in Table 3-1.

Table 3-1. Maximum Graphics Memory Allocations

System Memory	Maximum Memory Allocated for Graphics		
	Fixed	**DVMT**	**Fixed + DVMT**
0 MB – 127 MB	Not Supported; Not Validated	Not Supported; Not Validated	Not Supported; Not Validated
128 MB – 255 MB	32 MB	32 MB	Not Supported; Not Validated
256 MB – Max Memory	128 MB	128MB	64 MB + 64 MB

In the following scenarios formulas will be given to help calculate what the driver may request for Graphics memory.

Note: The driver utilizes pre-allocated memory before it makes request to the OS and the memory calculated below is in addition to the 204 KB that is allocated once the driver is loaded.

Maximum DVMT setting not supported on Intel® 915G or Intel® 910GML/915GM/915GMS chipsets

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4 *Driver Initialization*

4.1 Driver Components

The steps needed to initialize the graphics memory subsystem for Intel Graphics Media Accelerator Driver include different interfaces and touch many different components. Some of the main components needed for this task include SMI and IOCTL interface while touching GDI, miniport and SBIOS components.

4.1.1 System Management Interface

The System Management Interface (SMI) is a pre-defined interface required to be used with the Intel Graphics Media Accelerator Driver. The SMI interface provides a standardized interface for both the SBIOS and driver to interact. This allows for the graphics driver and SBIOS to be synchronized with any events that may occur within the system. Please see SMI Specification for more details.

4.1.2 Video Miniport

The video miniport driver is a component of the Intel Graphics Media Accelerator Driver that is responsible for memory mapping, resource management and I/O management. This component provides the interface through which the Graphics Memory Manager will request allocation and de-allocation of graphics memory. Please see Figure 4-1 below for more details.

4.1.3 Graphics Memory Manager

The Graphics Memory Manager (GMM) is a component in which provides all other graphics driver components the ability to access the graphics memory through a pre-defined interface. Due to the capability of the GMM to touch many of the driver components, it is the GMM components responsibility to allocate and free all memory blocks requested by the driver.

The GMM is physically a separate Dynamic Link Library (DLL), but is logically a subcomponent of each driver entity. This provides increased flexibility and compatibility by providing a standard interface for all components to access

4.2 Initialization Steps

1. The GDI driver will initiate the request for driver initialization. The GDI driver initiates an I/O request, which in turn generates an IOCTL through the I/O Manager of the OS to continue the memory initialization.
2. System BIOS receives initialization request via SMI function call provided by the miniport. The SBIOS is then responsible for returning the Pre-allocated memory and driver allocated memory configuration that the user has defined.
3. GMM will then initialize the GTT for creation of the TLB needed to access the graphics memory.

Note:

1. GTT Initialization occurs during miniport initialization routine.
2. If the requested driver allocated memory configuration is "Fixed", the total graphics memory will be allocated during driver initialization.

Figure 4-1. Display Architecture for Microsoft Windows* 2000 and Later

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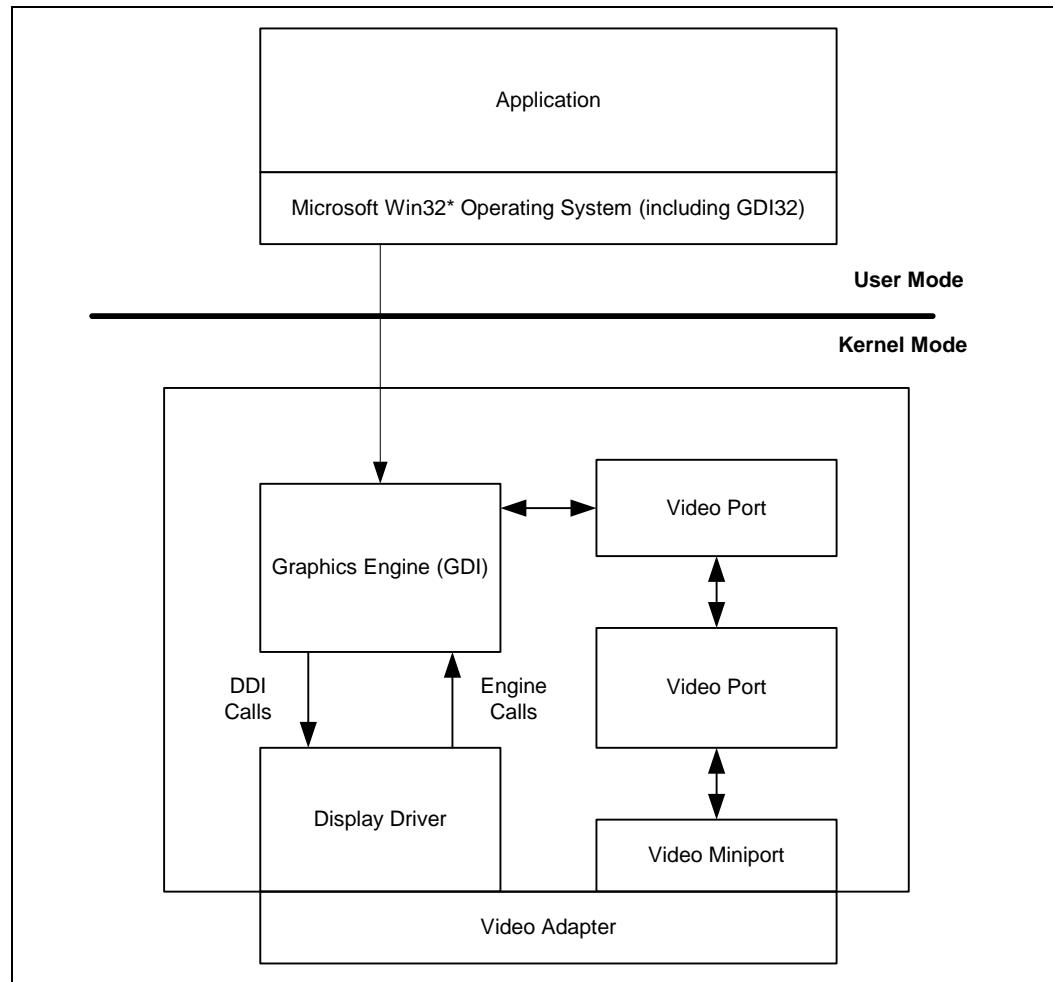
5 *System BIOS Usage Model*

Before driver initialization of the graphics memory subsystem is complete, the OEM must define the memory configuration they wish to enable and provide this appropriate information back to the driver.

5.1 System BIOS Configurations

The SBIOS configurations allows for flexibility in validating and providing many of the memory configurations that are available. The implementation specifics on how OEM's wish to select their memory configuration will be SBIOS dependent. Below is a list of the different memory configurations that are available.

Table 5-1. SBIOS Configuration Options

SBIOS Options				System Memory
Pre-Allocated Memory	Fixed	DVMT	Fixed + DVMT	
1 MB(1)	32 MB	32 MB	NA	128 MB
8 MB	32 MB	32 MB	NA	128 MB
1 MB(1)	64 MB	64 MB	NA	256 MB
	128 MB	128 MB	64 MB + 64 MB	256 MB
	NA	64MB	NA	256 MB
8 MB	64 MB	64 MB	NA	256 MB
	128 MB	128 MB	64 MB + 64 MB	256 MB
	NA	128MB	NA	256 MB
1 MB(1)	64 MB	64 MB	NA	512 MB
	128 MB	128 MB	64 MB + 64 MB	512 MB

NOTES:
1. Intel® Smart 2D Display Technology is not supported with 1 MB pre-allocated memory.

	NA	"Maximum DVMT"	NA	512 MB
8 MB	64 MB	64 MB	NA	512 MB
	128 MB	128 MB	64 MB + 64 MB	512 MB
	NA	"Maximum DVMT"	NA	512 MB

NOTES:
1. DVMT 3.0 Default SBIOS Configurations
   - Pre-Allocated Memory default value will be set to 8 MB
   - Driver default for system memory configurations less than 256 MB will be set to a total of 32-MB DMVT
   - Driver default for system memory configurations greater than or equal to 256256 MB will be set to 128- MB DVMT

2. Please refer to Appendix A for more detailed information regarding configurations.
3. Maximum DVMT setting not supported on Intel® 915G or Intel® 910GML/915GM/915GMS chipsets.
4. When the "Maximum DVMT" option is selected via the system BIOS, the following values will be reported within the CUI for the Maximum Graphics Memory amount:
   - For System Memory less than or equal to 511 MB, the Maximum Graphics Memory reported will be 160 MB
   - For System Memory greater than or equal to 512 MB, the Maximum Graphics Memory reported will be 224 MB

5.2   Upgrade/Downgrade of System Memory

An issue arises with potential of an end user removing or adding system memory to their system. This brings up the question, "What memory configuration should be set?" A potential solution for this issue is to have SBIOS populate a static table containing system memory size, pre-allocated memory size and driver allocated memory size. This solution would allow the SBIOS to pre-define their configurations for their specific platforms and would allow for a seamless transition for the end user. For example, an end user originally purchased their system with 256 MB of system memory. The end-user decides to remove a "stick" of memory for testing purchases and now has a total of 128 MB of system memory. Upon boot of the system, the pre-allocated memory size previously used for the 256-MB system memory configuration is once again enabled, but if the previous driver allocated memory size is not an allowable configuration (e.g., 64-MB DVMT) the SBIOS should return a valid configuration (i.e., 32-MB Fixed or 32-MB DVMT). This solution also allows customers the flexibility to ship multiple memory configurations from the same factory line.

Note: The driver will set the default configuration for all system memory configurations if and only if the configuration returned by SBIOS is invalid. The example provided above is only one of many possible solutions. The SBIOS vendor has the ability to provide any mechanism they desire.

Table 5-2. Example of an SBIOS Memory Table

System Memory Size	Pre-Allocated Memory Size	Driver Allocated Memory
128 MB	1 MB	31 MB DVMT
256 MB	1 MB	63 MB DVMT
384 MB	1 MB	63 MB Fixed
512 MB	1 MB	63 MB Fixed + 64 MB DVMT

The above table depicts the information that SBIOS would potentially like to define for all of their system configurations.

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6 Reported Video Memory

In systems using an Intel Direct AGP chipset, such as the Intel® 915G/915GV and Intel® 910GML/915GM/915GMS910GL Express chipsets with Intel Corporation Display Drivers, end users will be presented with various messages/displays concerning "video memory size". This section describes the messages displayed by the operating system, video BIOS and driver.

6.1 Video BIOS POST Message

Users may first be presented with "video memory size" messaging in the video BIOS "splash" or "boot" message. This message displays the amount of main system memory that will be used solely for video BIOS purposes. DOS, for example, will use only this memory for display. Video BIOS will use 1 MB or 8 MB, based on system BIOS settings. From the operating system perspective, this memory is logically removed from the system so that it is invisible (for example, a 128-MB system using an 8-MB setting in system BIOS will report 120 MB of TOTAL system memory). This is the pre-allocated memory already mentioned in Section 2.2.1.

6.2 System BIOS POST Message

During POST, some system BIOS displays the amount of Local Memory installed in the system. This may be 1 MB or 8 MB depending on pre-allocated memory.

6.3 Microsoft Windows* 2000 and Windows* XP Operating Systems "Display Adapter" Property Page

Microsoft Windows* 2000 and Windows* XP operating systems contain a standard display property page that is displayed when the "Adapter" tab (with NO icon) is selected. This page displays the maximum amount of local, frame-buffer memory possible by the Graphics device. This page will show 32 MB, 64 MB or 128 MB, depending on how much memory you have in the system and what the OEM has defined as their graphics memory configuration. See Table 3-1. Maximum Graphics Memory Allocations for memory requirements.

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Appendix A

A.1   DMVT 3.0 Configuration Test Matrix

System Memory	Pre-Allocated	Fixed	DVMT	Fixed + DVMT	Total Graphics Memory
128MB - 255MB	1MB	31MB	0MB	NA	32MB
	1MB	0MB	31MB	NA	32MB
	8MB	24MB	0MB	NA	32MB
	8MB	0MB	24MB	NA	32MB
256MB – 511MB	1MB	63MB	0MB	NA	64MB
	1MB	0MB	63MB	NA	64MB
	1MB	127MB	0MB	NA	128MB
	1MB	0MB	127MB	NA	128MB
	1MB	0MB	0MB	63MB + 64MB	128MB
	8MB	56MB	0MB	NA	64MB
	8MB	0MB	56MB	NA	64MB
	8MB	120MB	0MB	NA	128MB
	8MB	0MB	120MB	NA	128MB
	8MB	0MB	0MB	56MB + 64MB	128MB
512MB and Larger	1MB	63MB	0MB	NA	64MB
	1MB	0MB	63MB	NA	64MB
	1MB	127MB	0MB	NA	128MB
	1MB	0MB	127MB	NA	128MB
	1MB	0MB	0MB	63MB + 64MB	128MB
	8MB	56MB	0MB	NA	64MB
	8MB	0MB	56MB	NA	64MB
	8MB	120MB	0MB	NA	128MB
	8MB	0MB	120MB	NA	128MB
	8MB	0MB	0MB	56MB + 64MB	128MB

Notes:

    1. Maximum DVMT setting not supported on Intel® 915G or Intel® 910GML/915GM/915GMS chipsets

§128 MB - 255 MB	1 MB	31 MB	0 MB	NA	32 MB
	1 MB	0 MB	31 MB	NA	32 MB
	8 MB	24 MB	0 MB	NA	32 MB

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	8 MB	0 MB	24 MB	NA	32 MB
256 MB – 511 MB	1 MB	63 MB	0 MB	NA	64 MB
	1 MB	0 MB	63 MB	NA	64 MB
	1 MB	127 MB	0 MB	NA	128 MB
	1 MB	0 MB	127 MB	NA	128 MB
	1 MB	0 MB	0 MB	63 MB + 64 MB	128 MB
	8 MB	56 MB	0 MB	NA	64 MB
	8 MB	0 MB	56 MB	NA	64 MB
	8 MB	120 MB	0 MB	NA	128 MB
	8 MB	0 MB	120 MB	NA	128 MB
	8 MB	0 MB	0 MB	56 MB + 64 MB	128 MB
512 MB and Larger	1 MB	63 MB	0 MB	NA	64 MB
	1 MB	0 MB	63 MB	NA	64 MB
	1 MB	127 MB	0 MB	NA	128 MB
	1 MB	0 MB	127 MB	NA	128 MB
	1 MB	0 MB	0 MB	63 MB + 64 MB	128 MB
	8 MB	56 MB	0 MB	NA	64 MB
	8 MB	0 MB	56 MB	NA	64 MB
	8 MB	120 MB	0 MB	NA	128 MB
	8 MB	0 MB	120 MB	NA	128 MB
	8 MB	0 MB	0 MB	56 MB + 64 MB	128 MB

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